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MANUFACTURING METHODS AND TECHNOLOGY. PROJECT SUMMARY REPORT.(U)
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This report contains summaries of 46 projects that were completed under the Army's Manufacturing Methods and Technology (MMT) program. The MMT program was established to upgrade manufacturing facilities used for the production of Army materiel. The summaries highlight the accomplishments and benefits of the projects and the implementation actions underway or planned. Points of contact are also provided for those who are interested in obtaining additional information.

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DEPARTMENT OF THE ARMY
US ARMY INDUSTRIAL BASE ENGINEERING ACTIVITY
ROCK ISLAND, ILLINOIS 61299

16 JAN 1979

DRXIB-MT

SUBJECT: Manufacturing Methods and Technology Program Project Summary Report (RCS DRCMT-302)

SEE DISTRIBUTION (Appendix II to Inclosure 1)

1. In compliance with AR 700-90, C1, dated 10 March 1977, the Industrial Base Engineering Activity has prepared the inclosed Project Summary Report.

2. This Project Summary Report is a compilation of MM&T Summary Reports prepared by IBEA based on information submitted by DARCOM major subordinate commands and project managers. These projects represent a small cross-section of the types of efforts that are being conducted under the Army's Manufacturing Methods and Technology Program. Persons who are interested in the details of a project should contact the project officer indicated at the conclusion of each individual report.

3. Additional copies of this report may be obtained by written request to the Defense Documentation Center, ATTN: TSR-1, Cameron Station, Alexandria, VA, 22314.

J R Gallaugher
J. R. GALLAUGHER
Director,
Industrial Base Engineering Activity

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INTRODUCTION

Background

The Manufacturing Methods and Technology (MMT) Program was established to upgrade manufacturing facilities used for the production of Army materiel, and as such, provides direct support to the Industrial Preparedness Program. The Manufacturing Methods and Technology Program consists of projects which provide engineering effort for the establishment of manufacturing processes, techniques, and equipment by the Government or private industry to provide for timely, reliable, economical, and high-quality quantity production means. The projects are intended to bridge the gap between demonstrated feasibility and full-scale production. The projects are normally broad based in application, are production oriented, and are expected to result in a practical process for production. The projects do not normally include the application of existing processes, techniques, or equipment to the manufacture of specific systems, components, or end items, nor do they apply to a specific weapon system development or a product improvement program.

MMT Program Participation

MMT Programs are prepared annually by DARCOM major subordinate commands. These programs strive for the timely establishment or improvement of the manufacturing processes, techniques, or equipment required to support current and project programs.

Project proposals (Exhibits P-16) are submitted to the appropriate MMT Program Office. A list of offices is provided in Appendix I. Additional information concerning participation in the MMT Program can be obtained by contacting an office listed or by contacting Mr. James Carstens, AUTOVON 793-5113, or Commercial (309) 794-5113, Industrial Base Engineering Activity, Rock Island, IL 61299.

In anticipation of the lengthy DOD funding cycles, projects must be submitted in sufficient time for their review and appraisal prior to the release of funds at the beginning of each fiscal year. Participants in the program must describe manufacturing problems and proposed solutions in Exhibit P-16 formats (see AR 700-90, 4 August 1975, for instructions). Project manager offices should submit their proposals to the command that will have mission responsibility for the end item that is being developed.

Contents

This report contains summaries of 46 completed projects that were funded by the MMT Program. The summaries are prepared from Project Status Reports (RCS DRCMT-301) and Final Technical Reports submitted by organizations executing the MMT projects. The summaries highlight the accomplishments and benefits of the projects and the implementation actions under way or planned. Points of contact are also provided for those interested in obtaining additional information.

The MMT Program addresses the entire breadth of the Army production base and, therefore, involves many technical areas. For ease of referral, the project summaries are grouped into six technical areas. The technical areas are CAD/CAM, Electronics, Inspection and Test, Metals, Munitions, and Non-Metals.

The Summary Reports are prepared and published for the Office of Manufacturing Technology, DARCOM, by the Manufacturing Technology Division of the Army Industrial Base Engineering Activity, (IBEA) in compliance with AR 700-90, Cl.

COMPUTER AIDED DESIGN/
COMPUTER AIDED MANUFACTURING
(CAD/CAM)

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

Manufacturing Methods and Technology project 175 8154 entitled "Computer Aided Die Design and Computer Aided Manufacturing for Extrusion of Aluminum; Titanium and Steel Structural Parts" was completed by the US Army Aviation Research and Development Command in June 1978 at a cost of $185,500.

BACKGROUND

Large numbers of extruded aluminum, titanium, and steel components are used in the manufacture and assembly of military hardware. Most of these components are extruded by conventional hot extrusion techniques. Although the extrusion process has been a viable manufacturing process for more than a generation, with the exception of glass lubrication in high-temperature extrusion, hardly any improvements have been made. Extrusion technology is still based largely upon empirical cut-and-try methods which result in the high cost of extruded products. Most of the tool design and manufacturing work for extrusion is still done by the intuitive and empirical methods. Therefore, extrusion die design and manufacturing is still considered an art rather than a science.

SUMMARY

The overall objective of this manufacturing technology program was to develop practical computer-aided design and manufacturing (CADCAM) techniques for extrusion of aluminum alloys, steels, and titanium alloys. Computer programs were developed to optimize the extrusion process and to design and manufacture extrusion dies. Die design problems such as location and orientation of openings, elastic deflection of the die, and bearing length specification were addressed.

Two programs were developed. The first is for streamline dies for hot extruding steel or titanium structural shapes. The second system is for flat-faced dies for conventional hot extrusion of aluminum. In addition to die design and manufacture, the system developed also makes a production analysis based on criteria specified by the user.

BENEFITS

This project developed extrusion CADCAM technology. Implementation will:

Reduce skill and experience required by designers and draftsmen.

- Increase productivity in production analysis, die design, and die manufacture.

- Improve press operations by fewer die trials and better repeatability.

- Increase material yield by optimum billet size, press selection, and die design.

IMPLEMENTATION

A Government/Industry technical briefing was held at Battelle on 16 Jun 78. Over 100 people attended. Distribution of final reports and participation at appropriate technical meetings will continue.

MORE INFORMATION

Additional information on this project is available from Mr. Gerald Gorline, US Army Aviation Research and Development Command, AV 698-6476, or (314) 268-6476; or Mr. Roger Gagne, US Army Materials and Mechanics Research Center, AV 995-3436, or (617) 923-3436. Reference Technical Report No. 76-12 and TR78-29.

Summary Report was prepared by the Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

Manufacturing Methods and Technology project 674 7497 titled "Extended Use Optical Tooling" was completed by Frankford Arsenal on 1 June 1976 at a cost of $70,000.

BACKGROUND

Present methods of lens manufacture requires eighteen items of special tooling. Some of the tooling can be used on more than one lens within narrow ranges; however, the majority of the tooling is applicable to one lens only. Tooling of more universal nature or tooling that can be progressively modified for new optics would result in more economical lens manufacture.

SUMMARY

This project was initiated in September 1973 and the final report was submitted in June 1976. Early studies in the program indicated that the original approach of designing more universal tooling was not an economical approach. The program objective was then modified to provide the necessary tooling at a lower cost. The methods selected for reducing the cost of the tooling was to computerize the design. This computer model was written and checked for accuracy. The results were documented in Frankford Arsenal report no. FA-TR-76071 titled: "Optical Tools Computerized Design and Manufacture". This effort is continuing under project 675 7497.

BENEFITS

This project has provided a computerized program for the design of tool required to produce lenses by the spot block method.

IMPLEMENTATION

There was no implementation planned for this first part of the effort. Implementation will occur at the end of the follow-on effort 675 7497.

MORE INFORMATION

Additional information can be obtained by contacting the project officer, Mr. D.J. Fischer, AV 880-6714, ARRADCOM, Dover, NJ.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineerng Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

Manufacturing Methods and Technology project R76 3232 titled "Computerized Production Process Planning" was completed by the US Army Missile Research and Development Command in February 1978 at a cost of $244,953.

BACKGROUND

Process planning is the first step in manufacturing and has a major effect on the cost of fabricating goods in the metal cutting industry. Process planning procedures that depend exclusively on skilled or trained production labor are vulnerable to delays, errors, and higher-than-necessary production costs. In recent years the interest in programming computers to generate process plans for manufacturing parts has grown; however, the complexity of machined parts process planning has resulted in computerized process planning remaining in the conceptual stage for some time.

The Computerized Production Process Planning (CPPP) system demonstrated under this project is a system that will assist process planners in planning the fabrication of machined cylindrical parts.

SUMMARY

The three primary program objectives were: (1) describe the CPPP system technology, (2) demonstrate application of the technology for a cylindrical part family, and (3) determine the benefits of computerized process planning in general and CPPP in particular. A five volume report, MIRADCOM Report No. R 76-942625-14 titled "Computerized Production Process Planning" was published describing the approach to and results of this program. Final results showed that computerized process planning is economically and technologically feasible.

The CPPP system is designed to be independent of the production methods or machining processes of a particular manufacturer. Rather than building manufacturing technology into the computer system, process decision modeling is used to express the manufacturing rationale for fabricating a family of parts. This approach lets each workshop program the process decision rules most appropriate for its production procedures and resources. The rules are written in an English-like problem oriented language which are converted into a coded form by a special language processor.

Fully automated process planning for all parts in all workshops is many years off. Even then, full dependence of automatic methods is neither practical nor desirable. Human supervision and intervention must be permitted for a variety of reasons. The CPPP system is designed to provide extensive man-machine interaction capabilities for planning detailed operations. A detailed documentation (fully illustrated) of the man-machine communication procedures was described. It can be used as a manual by process planner to develop a complete understanding of how the process planner can supplement the decision-making capability of CPPP or modify process plans. Also, the process planner can define alternative operations and sequences, then use the analytic capability of CPPP to obtain detailed analysis. Process planners have the option to selectively interact with CPPP at all major decision points. A high-level diagram of the CPPP system is shown in Figure 1.

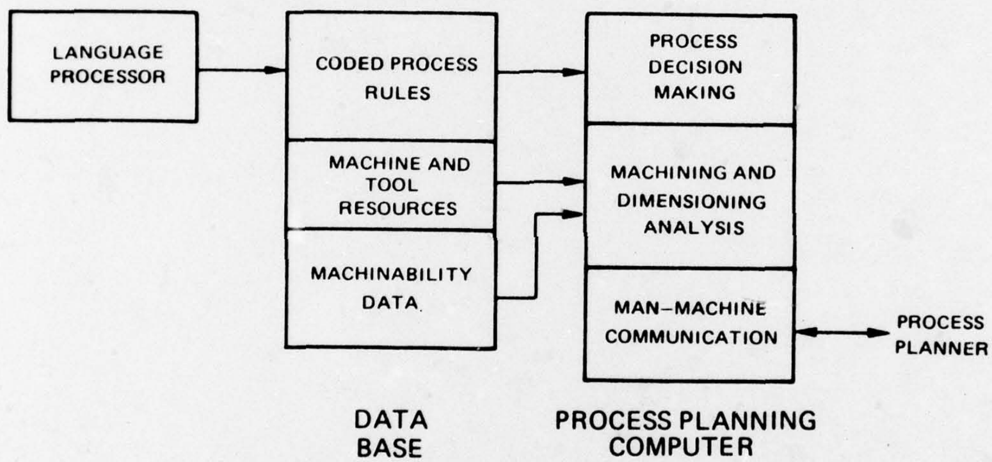

Figure 1 - Overview of CPPP implementation.

BENEFITS

This project was only the first part of the total effort. Therefore, most of the benefits will be accrued after completion of the follow-on project. This project did indicate that Computerized Production Process Planning can be cost effective and it defined equipment and procedures for the follow-on effort.

IMPLEMENTATION

The CPPP system has been partially implemented working at facilities on defense contracts.

MORE INFORMATION

Mr. Richard Kotler, MIRADCOM, Huntsville, Alabama, AV 746-1835, or Commercial (205) 876-1835.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

ELECTRONICS

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

Manufacturing Methods and Technology project 275 9371 titled "Automating Electrode Production for Lithium Cells" was terminated by the Electronics Command after expending $449,200.

BACKGROUND

Lithium cells provide the operational advantages of increased operating temperature ranges, longer shelf life, reduced weight, higher energy density, and higher voltage. These cells, however, present significant manufacturing problems particularly in automated techniques for producing the electrode structures.

SUMMARY

This was a joint Army-Air Force project to develop a pilot line for producing lithium batteries. A contract was let to Power Conversion Incorporated of Mount Vernon, NY, to accomplish the effort. The three basic objectives of this program were as follows:

a. Establish the producibility of the specified hermetically sealed lithium cells and batteries by mass production techniques.

b. Establish and improve quality control surveillance and inspection.

c. Initiate process improvement to minimize overall fabrication costs and time.

This effort was terminated on 14 Sep 78 due to projected cost overruns and the ability of already existing commercial sources to provide the required production rate for these batteries. Figure 1 is a cross section of a lithium cell.

The cathode material proposed for these cells contained carbon and polyetrafluorethylene (PTFE). The separator material was polypropylene and the electrolyee was sulfur dioxide, organic solvent and lithium salt.

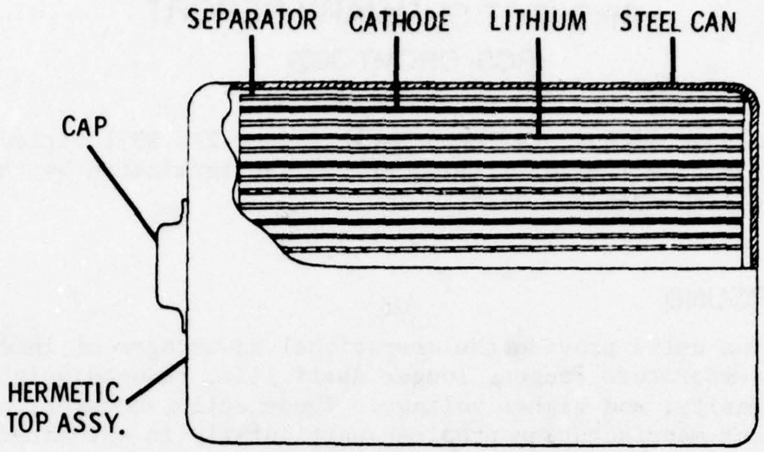

Figure 1 - A cutaway of a typical lithium battery showing its principal components.

BENEFITS

The availability of these types of batteries from commercial sources precluded the attainment of any worthwhile benefits from this project.

IMPLEMENTATION

Implementation is no longer required because lithium batteries are commercially available.

MORE INFORMATION

Mr. Gabriel I. DiMasi, Ft. Monmouth, NJ, AUTOVON 995-4281.

Summary Report prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

METALS

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 173 8046 titled "Small Cooled Axial Turbine Blade, Vane, and Disk Fabrication" was completed in May 1977 by the U.S. Army Aviation Systems R&D Command (AVRADCOM) at a cost of $794,000.

BACKGROUND

The turbine blade assembly of an axial turbine engine is the most critical operational area and has the highest replacement rate. Turbine disks and cooling plates for the T700 engine are produced from René 95, a highly alloyed, precipitation-strengthened, nickel-base superalloy.

This project investigated an improved powder metallurgy production process for manufacturing premium quality hot isostatically pressed (As-HIP) T700 engine turbine hardware. The AVRADCOM Applied Technology Laboratory and the General Electric Company, producer of the T700 turbine engine, developed this process technology. Prior to this effort, René 95 turbine disks and cooling plates were forged from powder metal compacts and cast ingots. Because of high alloy content, René 95 was difficult and expensive to produce by this method. The greatest cost element was the forging cycle.

SUMMARY

This project emphasized two important developments: shape-making and post-compacting thermal processing for processing As-HIP powder metal superalloy components.

The shape-making techniques were developed by iteratively fabricating compacts, evaluating dimensional tolerances, and modifying the mild steel can design. The procedure reduced the size of the compact as much as possible while maintaining an acceptable 1/8-inch envelope around the part shape. The procedure resulted in eliminating the forging steps and reducing material quantity by 50 percent.

An extensive post-compacting thermal processing optimization process was developed utilizing solution heat treating, quenching, and aging treatment. The resulting material exhibited equivalent rupture and fatique properties with slightly lower tensile strengths as compared to the original wrought material.

As-HIP turbine disks and cooling plates were fabricated in quantity for the demonstration of production capability and testing. Following successful spin testing and verification of mechanical properties, these components were qualified on T700 turbine engine tests. Figure 1 shows the T700 disks (upper) and cooling plates that were submitted for engine tests.

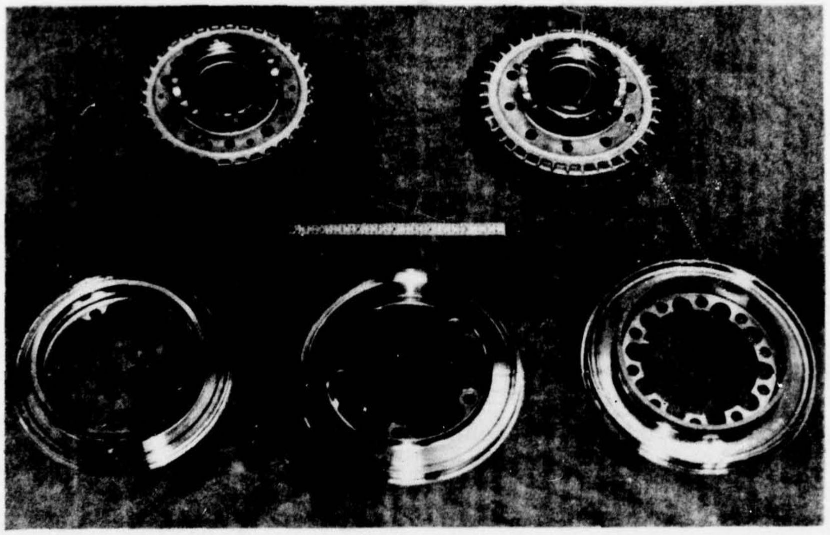

Figure 1 - T700 Disks and Cooling Plates Machined From As-HIP Preforms.

BENEFITS

The development of the forgeless HIP process has resulted in a cost savings of more than $3,000 per T700 engine.

Other nonmonetary benefits include an expanded knowledge of cooling rates in quenching and established ground rules for reheat treating parts. This technology is applicable to commercial turbine engines. Also, this project has initiated other programs that build on this technology. These joint Army/Air Force programs deal with clean superalloy powder and dual property turbine wheels for small engines.

IMPLEMENTATION

The results of this project have been implemented in the production of T700 turbine engine disks and cooling plates.

MORE INFORMATION

Additional information on this project is available from Mr. Jan Lane, Applied Technology Laboratory, US Army Research & Technology Laboratories, (AVRADCOM), Ft. Eustis, VA 23604, AV 927-2771. The project is reported in USA AMRDL Technical Report TR-76-30, "Development of Hot Isostatically Pressed René 95 Turbine Parts", May 1977.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

Manufacturing Methods and Technology project 373 3035 titled "Processing Procedures for Adjacent and Intersecting Welds on Missile Components" was completed by the Army Materials and Mechanics Research Center for the Army Missile Command in December 1974 at a cost of $109,000.

BACKGROUND

The welding of thin high-strength steel rocket and missile cases often requires close proximity parallel and intersecting welds. The properties of a weldment can be degraded by the as-cast structure of the weld deposit and temperature influence on the parent metal microstructure near the weld. Often, overwelding is used to compensate for these negative effects. The need for improved welding procedures was encountered during the production of Hercules and Hawk missiles.

SUMMARY

The objective of the program was to determine the minimum weld buildup required for adjacent and intersecting welds and determine the effects that spacing between parallel welds might have on weldment properties. This project was the second phase of a three phase effort. This study investigated joint geometries, surface preparation, and problems associated with seam welds and combination seam and butt joints. The materials used in this phase of the program were sheets of AISI 4130 and 18% nickel maraging steel and filler wires designated as Linde 140, airco AX-140, Linde 71, and 18% nickel maraging steel. Gas tungsten arc welding was used throughout the program. The welding setup is shown in Figure 1. Pre- and post weld heat treatment data was collected that would produce a tensile strength of approximately 250,000 psi. When this project was completed process parameters for heat treating, welding and testing of sheets containing parallel welds were being documented for 1.2 inch and 3/4 inch weld spacing. The problem of cracking and lack of penetration just after the intersection of parallel welds on laboratory test sheets was eliminated by grinding the parallel weld beads at a 45° angle at each intersecting joint and dressing the faying surfaces of the sheets with a file.

BENEFITS

The anticipated benefits from this project would be a reduction in material and labor costs in items requiring close proximity welds.

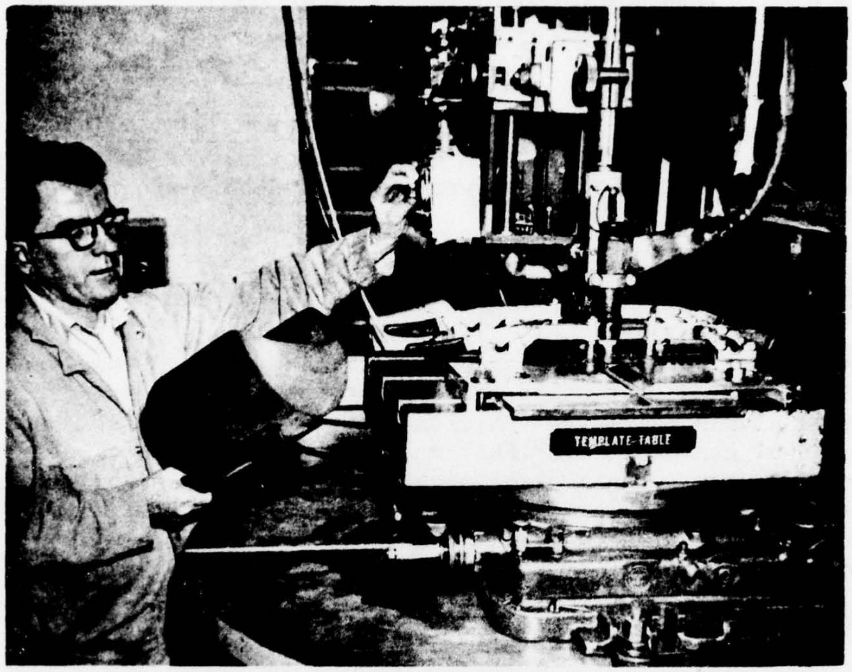

Figure 1 - Gas Tungsten Arc Welding Setup for Parallel and Intersecting Welds.

IMPLEMENTATION

The investigation of parallel and intersecting welds will be continued in project 374 3035. No attempt was made in this effort to weld missile or rocket cases as originally planned. The data and information learned from this project is being applied in the follow-on project.

MORE INFORMATION

Additional information on this project is available from Mr. Francis Quigley, AMMRC, Autovon 955-3113 or (617) 923-3233. Reference AMMRC Technical Report TR 76-42, December 1976 for the final program report. Reports are available from the Defense Documentation Center. Reference Ad. No. A034169.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, Il 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

Manufacturing Methods and Technology (MMT) projects 474 4330, 475 4330, and 476 4330 titled "Fabrication of Aluminum Armored Vehicles by the Electron-Beam Welding Process" were completed as a program in July 1978 at a total cost of $400,000.

BACKGROUND

As a result of a 1972 study, the U.S. Army Tank Automotive Command (TACOM) concluded that using the electron-beam (EB) welding process to fabricate aluminum armored vehicles offered potential savings over the conventional gas-metal-arc (GMA) welding process. Electron-beam welding provides the advantages of single pass joining capability, adaptability to automation, and increased welding rates. This program was undertaken to provide the manufacturing technology necessary for EB welding aluminum armor joints. Armor joints require materials, plate thicknesses, and joint geometries that are different than conventionally EB welded joints.

SUMMARY

The purpose of this program was to establish the manufacturing procedures required to implement the use of electron-beam welding for mass production of aluminum armored vehicles. Grumman Aerospace Corporation, experts in electron-beam welding, were contracted for this work.

The program was divided into three efforts. The first phase, project 474 4330, consisted of determining welding parameters and armor joint designs for electron-beam fabrication. Phase two, project 475 4330, included setting-up the tooling and fixtures necessary for EB welding a full-size aluminum vehicle hull. During the third phase, project 476 4330, a near full size M113 Armored Personnel Carrier hull was fabricated by the electron-beam welding process.

Grumman developed electron-beam welding parameters for producing ballistic joints in 5083 and 7039 aluminum alloys. EB weldments were successfully qualified and weldments of different joint configurations were ballistically tested. Electron-beam welded 5083 exhibited ballistic impact resistance comparable to GMA welded aluminum. The impact resistance of EB welded 7039 aluminum alloy, the predominant alloy in the M113 vehicle, was found to be inferior to GMA welded material.

Grumman successfully fabricated a near-full size 5083 aluminum M113 armored personnel carrier hull. This hull is shown in Figure 1.

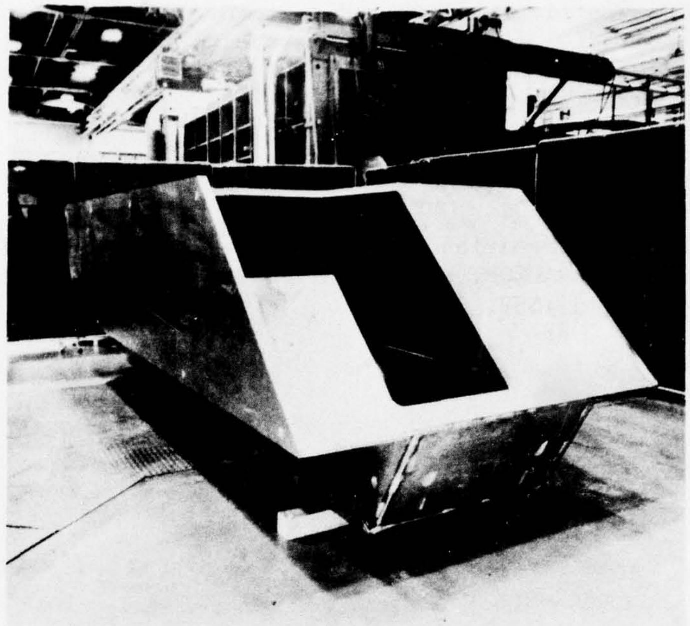

Figure 1 - EB Welded M113 Aluminum Armored Hull

The hull and tooling was specifically designed for EB welding in a vacuum chamber. The hull design used a modular approach. First, subassemblies were EB welded and then the subassemblies were joined to form a complete hull. A total of 23 single-pass welds were required to fabricate the hull. Joints up to 170 inches in length were welded. Welding speeds were 18 inches per minute for 1½-inch-thick joints. By oscillating the electron beam, joints were successfully welded with up to a 0.125 inch mismatch and 0.060 inch gap condition.

A production manufacturing plan was developed which employs three EB chambers, four EB guns and power supplies, and four welding operators. This system would be capable of welding 12 aluminum hulls in two eight-hour shifts.

BENEFITS

This program demonstrated that aluminum armored personnel carrier hulls can be successfully and cost-effectively EB welded. The total cost savings achieved by EB welding in production is approximately 25 to 30 percent compared to GMA welding. This savings is based on a production run of 30,000 aluminum hulls. EB welding offers significant recurring savings in welding time, consumables, and energy. An estimated savings of $500 per hull is readily achievable.

IMPLEMENTATION

The U.S. Army Tank Automotive Research and Development Command reviewed Grumman's final report and documented the work in a technical report for official use only. There are no immediate plans to implement EB welding for aluminum armored vehicle hulls, such as the M113 armored Personnel Carrier hull.

MORE INFORMATION

Additional information on this program may be obtained from Mr. Donald Phelps, TARADCOM, Warren, MI 48090; Autovon 273-1389, or commercial (313) 573-1389.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 473 4391 titled "Isothermal Heat Treatment for High Strength Ductile Iron Castings (Phase I)" was completed by the US Army Tank Automotive Command in June 1976 at a cost of $150,000.

BACKGROUND

Tracked armor vehicle components may be required to operate in temperatures ranging from 125°F to -65°F. Therefore, these components must be fabricated from materials capable of providing the required engineering properties throughout this temperature range. Traditionally, alloy steel forgings have been used for critical vehicular components. The use of ductile iron for parts subject to high loading has been quite limited.

Ductile iron combines the ease of fabrication and economics of gray iron with the material property advantages of steel. However, ductile cast irons have not been used interchangeably with steel components because of decreased ductility at increased yield strengths and decreased toughness at lower service temperature. This project attempted to improve mechanical properties in ductile iron through heat treatment and alloying additions.

SUMMARY

International Harvester Company investigated austempered ductile iron containing nickel as an economical substitution for alloy steel forgings in tracked vehicle components. This project explored production casting and isothermal heat treatment. Two ductile iron alloys containing varying levels of nickel as alloying elements and 24 heat treatment cycles were evaluated. The optimum heat treat cycle selected for ductile cast iron containing 0.75 percent nickel was to austenitize at 1650°F for one hour per inch of thickness, followed by an isothermal quench for one-half hour at 700°F and hold for one hour at 700°F. An improved ductile cast iron resulted with a tensile strength of 135 ksi, yield strength of 97 ksi, and elongation of 11 percent. However, the low temperature (-40°F) Charpy impact toughness was only 3 ft-lbs which did not achieve the toughness capability of forged alloy steel.

Three M113 Armored Personnel Carrier components were cast in green sand molds with shell cores. Track shoes, suspension arms, and sprockets were cast, heat treated, and machined.

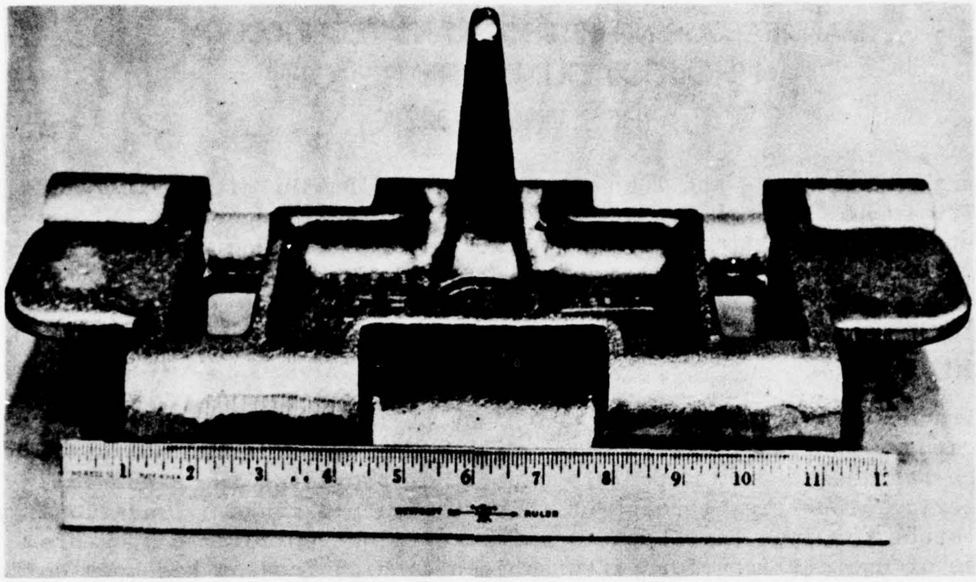

Figure 1 - As-Cast Ductile Iron Track Shoe

A ductile iron track shoe is shown in Figure 1. These components were later field tested in a follow-on project.

BENEFITS

A ductile iron with improved low temperature toughness and fatique properties resulted from this investigation. Also, since these components can be cast to closer dimensions than forged, less machining is required. This results in less costly parts.

IMPLEMENTATION

As a result of this project, this program was continued. The components produced in Phase I were subjected to evaluation tests in follow-on MM&T project 475 4391.

MORE INFORMATION

Additional information on this project is available from Mr. K. Chesney, TARADCOM, Warren, MI, AV 273-2065. Reference TACOM Technical Report No. 12167, June 1976.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 475 4392 titled "Joining Dissimilar Metals (Phase I) was completed in June 1977 by the US Army Tank Automotive Command at a cost of $130,000.

BACKGROUND

Due to the lack of technology for joining dissimilar metals, the Army is limited in designing components from an optimum material consideration. Design engineers are forced to trade off performance criteria of optimum material combinations for types of materials that can be conventionally joined. Different metals can be joined by friction or inertia welding, but these processes are limited to cylindrical components. Pressure roll bonding and explosive bonding techniques can also be used to join unlike metals. These processes are used for producing bi-metal transition strips. A transition strip is a laminate of two metals such as steel and aluminum that can be placed between plates of corresponding metals and welded. However, using transition strips to join dissimilar metal plates posses a problem because of the great difference in the melting points of aluminum and steel.

SUMMARY

This project was conducted in conjunction with the Army Material and Mechanics Research Center's project, "Joining of Dissimilar Metals for Structural Application". The purpose of the Army Tank Automotive Command (TACOM) project was to establish production welding procedures for joining dissimilar types of armor plate using transition strips.

TACOM evaluated various welding procedures for joining different materials to developmental transition strips. The developmental transition strips with a niobium interface were produced by explosive bonding techniques. Two different types of transition strips were used: steel rolled armor bonded to 6061 aluminum, and titanium 6Al-4V alloy bonded to 6061 aluminum. Figure 1 shows a dissimilar metal weldment with a bimetallic transition strip developed by the Army Materials and Mechanics Research Center for joining steel to aluminum.

A 5083 aluminum alloy plate was welded to the aluminum side of the transition strip and steel alloy plate was welded to the steel side.

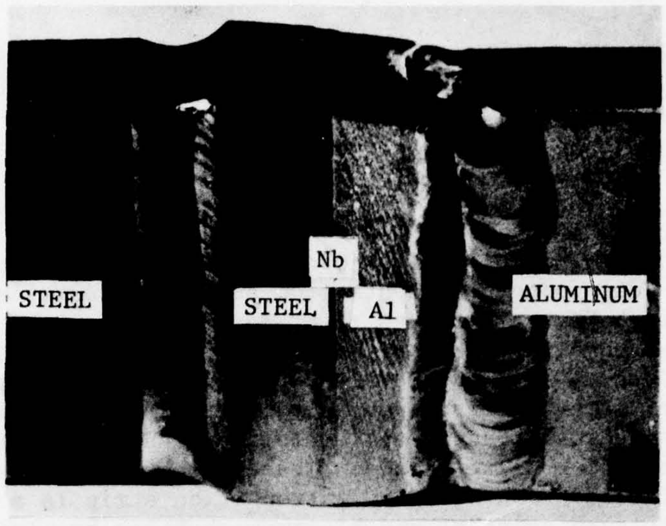

Figure 1 - Dissimilar Metal Joint Produced Using a Bi-Metal Transition Strip with a Niobium Interface.

Gas tungsten arc and gas metal arc welding processes were evaluated for producing the dissimilar metal weldment. Eleven of twelve gas tungsten arc weldment specimens failed within the aluminum welded joint during tensile testing. Figure 2 shows a tensile specimen with a typical failure at the aluminum weld joint. Here, the explosively bonded joint in the transition strip was stronger than the aluminum-to-aluminum weld.

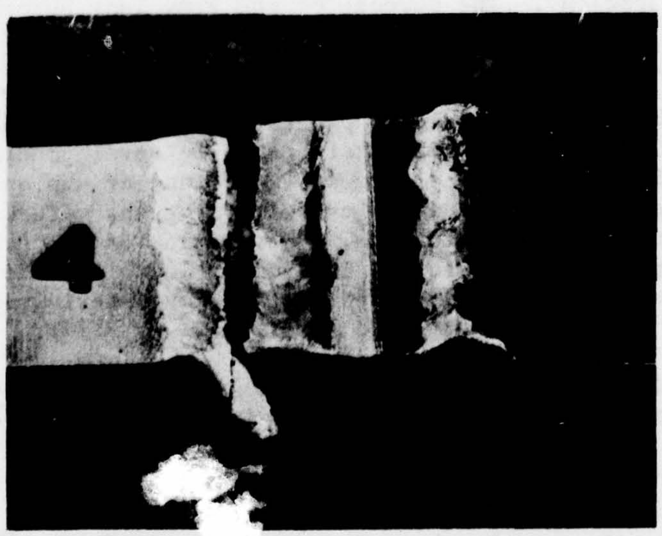

Figure 2-Tensile Specimen of a Dissimilar Metal Joint Produced Using a Transition Strip.

Four of nine gas metal arc welded specimens failed within the aluminum welded joint during tensile testing. The remainder failed either between the niobium interface or in the aluminum base metal of the transition strip.

The effects of high temperatures during welding on the joint strength of transitional materials were also investigated. The tests showed that the niobium bond deteriorated at a temperature of about 600° F. Niobium in the transition strip prevented the use of higher deposition, higher heat input welding.

BENEFITS

Dissimilar metal joining offers the designer greater freedom for improving ballistic protection and reducing weight in armored combat vehicles. Dissimilar metal joining eliminates more costly mechanical fasteners which are subject to failure under ballistic attack. Aluminum armored vehicles can be made less vulnerable in battle by selectively incorporating steel armor in specific areas. Steel armored vehicles can be made lighter and more mobile with aluminum-steel joints.

IMPLEMENTATION

Dissimilar metal joining technology is currently being used by shipbuilders to attach aluminum superstructures and liquified natural gas containers to steel hulls. Other applications may be made for surface transportation equipment and bridge construction. Design concepts of the Main Battle Tank (MBT70) forerunner of the XM1-tank considered using dissimilar metal joining. The General Motors version of the XM-1 also considered using this concept for the engine floor plates.

Work on dissimilar metal joining is continuing on project 476 4392. That phase of the program will verify the use of commercially available transition strips for ballistic joints. Pending the successful completion of this program, dissimilar metal joining requirements may be made for future combat vehicles, including an advanced version of the XM-1 Tank.

MORE INFORMATION

Additional information on this project may be obtained from Mr. Samuel Goodman, US Army Automotive Research and Development Command, Warren, MI 48090. AV 273-1814 or (313) 573-1814. Reference TACOM Technical Report No. 11973, "Welding Dissimilar Metals", January 1975 by Mr. Eugene Balla.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology (MMT) project 476 4585 titled "Evaluation and Application of Weld Penetration Control Equipment to the Welding of Armor", was completed in February 1978 at a cost of $120,000.

BACKGROUND

In process control of gas tungsten arc welding could yield benefits from reduced rejects, improved quality control, and increased service life of welded armor components. The lack of full weld penetration in steel armor produces crack like flaws that are detrimental to ballistic and mechanical properties. Over penetration during welding is wasteful of materials and labor.

Devices that control welding variables that could insure full penetration welds would save time, material, and money. Earlier MMT efforts to control weld penetration with thermocouple sensing devices were not successful. Since the completion of that work, industry has marketed an infrared temperature measuring device that appeared to have potential for application to the control of welding variables.

SUMMARY

The objective of this program was to unite three pieces of equipment; a feedback controlled welder, a weld penetration controller, and an infrared temperature measuring device for the control of weld penetration. This system was evaluated by welding 3/8 inch thick electroslag remelted (ESR) SAE 4340 steel armor.

The US Army Materials and Mechanics Research Center (AMMRC) performed this work for the US Army Tank Research and Development Command (TARADCOM). Figure 1 shows a close up of the welding area with the sensing element of the infrared thermal probe to the right of center and the welding gun, wire feeder, and backup heater in the center of the photograph.

ESR 4340 plates were annealed, cut into 4" X 12" sections, beveled at a 60° angle along the 12"-long side, and preheated to 325°F prior to welding. The infrared thermal probe was mounted in place of the thermocouple sensing device that was used in a previously established welding system. The infrared thermal probe with a focal spot diameter of 0.050" was focused with its center 0.4" from the weld centerline and 0.4" behind the center of the welding electrode. Twelve ESR steel

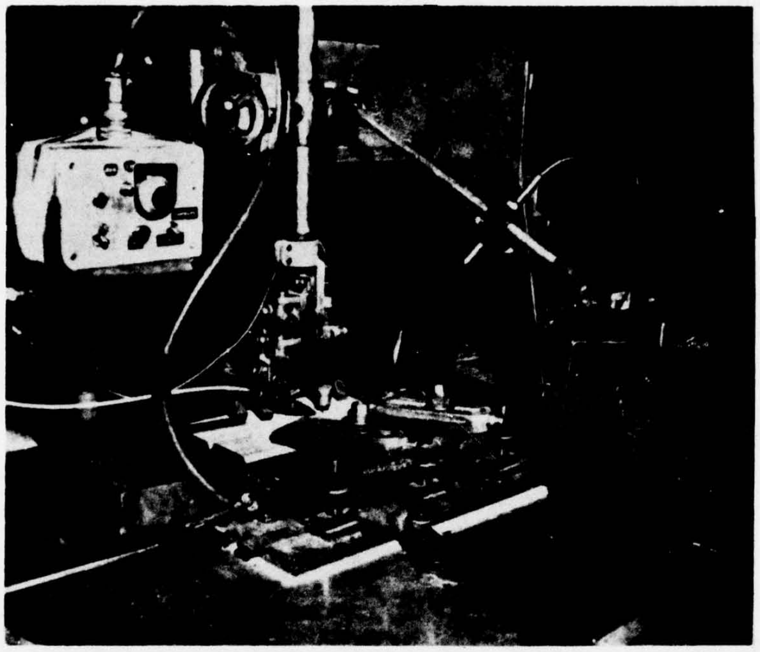

Figure 1 - Close-up View of Weld Penetration Control

armor plates were welded with 0.045" diameter AX 140 filler wire at a wire feed speed of 100 inches per minute. The weld penetration controller regulated the amerage over a range of plus or minus 20% of the 300 amperes initial setting. Welding was performed at a rate of 4 inches per minute.

The infrared temperature probe was an improvement over the thermocouple for measuring the temperature of a spot in a close proximity to an arc moving along a plate being welded. Full penetration welds were obtained by using the weld penetration control system.

BENEFITS

This MMT project provided the hardware and technology for establishing a weld penetration control system. This system represents an advancment in automating gas-tungsten-arc welding.

IMPLEMENTATION

The results of this project were distributed to inform potential users of the procedures developed for weld penetration control.

MORE INFORMATION

Additional information may be obtained from Mr. B.A. Schevo at TARADCOM, AV 273-2467 or Commercial (313) 573-2467. Reference Technical Report AMMRCTR-78-6, February 1978.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

Manufacturing Methods and Technology (MM&T) project 576 3139 entitled "Manufacture of Interconnections for Fluidic Circuits" was completed by the US Army Armament Command in September 1977 at a cost of $145,000.

BACKGROUND

Presently, straight diffusion bonding is used as the final assembly process for fluidic devices, but the combination of high temperature, high interface contact pressure and intimate faying matchup make bonding very difficult as well as costly. Distortion of the aluminum assemblies is a problem because of the necessary pressure and temperature. Fluidic circuit interconnections are required in all fluidic systems. These interconnections often constitute an expensive, time consuming portion of tooling and manufacture.

Project work was accomplished by in-house work at Harry Diamond Laboratories and by contractual work with AVCO Aerostructures Division, Nashville, TN.

SUMMARY

The objective of this project was to investigate and document production techniques determined to be beneficial for improving the production of fluidic interconnections. These techniques could be used as part of an effort to develop systematized production procedures to reliably produce fluidic hardware.

A reliable and predictable method is needed for joining the precision machined elements of fluidic control circuits. The joining method chosen must be applicable to production type operations. The materials used to join the elements must not extrude into the passageways or must extrude into the passage in a predictable manner.

Four brazing processes were considered for metallurgically bonding the fluidic interconnections. Methods of brazing with flux were not considered because of known problems with flux seeping into and remaining in the small passages after brazing. The fluxless bonding processes investigated were aluminum vacuum brazing, aluminum furnace brazing, aluminum semi-solid-state diffusion bonding, and aluminum-copper eutectic bonding. Test plate samples utilizing each process were fabricated and evaluated. Figure 1 shows a typical plot of flow versus pressure for a channel in one of these plates. Results of the brazed test plates indicated a need to carefully control cleanliness, braze filler quantity, and temperature to obtain a leak-proof brazement with minimum intrusion into the channels.

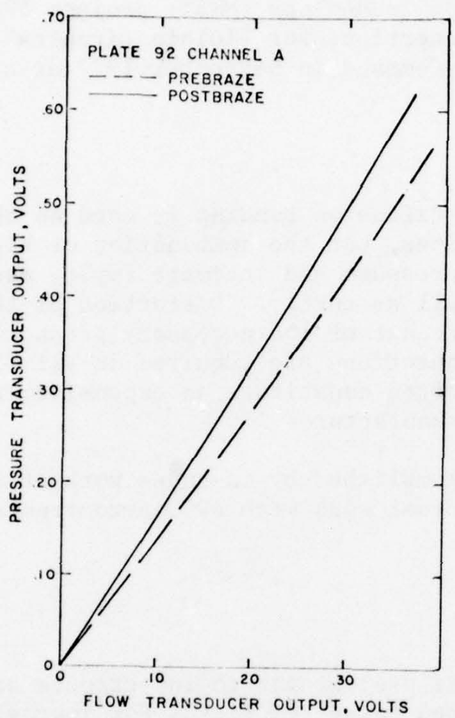

Figure 1 - Plot of transducer outputs showing the efforts of brazing.

The most successful process was the aluminum semi-solid-state bonding using a braze-clad sheet sandwiched between interconnection plates. It was the most successful because there was less tendency for the braze alloy cladding to flow into the passages. Although some problems were experienced in reproducing original characteristics after bonding--such as leakage and impendance changes--it is likely that these problems could be minimized or resolved if tolerances, quality control, and furnace heating parameters were optimized.

Results showed that fluidic controls can be made out of metallurgically bonded aluminum if each joint interface is prepared so that little pressure is required to achieve atomic contact across the interface. With this condition, strict process controls will produce satisfactory results.

BENEFITS

Although this project explored a number of areas, the major benefit was an alternative to straight interatomic diffusion bonding in the assembly of fluidic devices made of aluminum. Commercially available materials can be used without the need for special interface matching or without significantly reduced pressures to achieve contact across the interface. Leakproof and highly leak resistant bonds are formed reliably. The limited scope of this project did not permit the establishement of proven cost reductions for specific applications.

IMPLEMENTATION

Copies of the final report have been provided to government and commercial agencies involved in fluidic technology. The status of the work was reported to the Government Fluidic Coordination Group which was formed to plan, share, and implement fluidic technology. The results of the project will be applied to prototype fabrication and to an incoming MM&T program (Project No. 678 3901) as the assembly technique.

MORE INFORMATION

Additional information on this project is available from J. W. Joyce, HDL, Adelphi, MD 20783, AV 290-3080. A Final Technical Report entitled "Manufacture of Interconnections for Fluidic Circuits," dated 3 Oct 77, ATTN: DRXDO-RCD, Adelphi, MD 20783 is also available.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 674 7481 titled "Engineering Applications of Horizontal Spray Quenching to Heat Treatment of Cannon Tubes" was compled by Watervliet Arsenal in June 1976 at a cost of $100,000.

BACKGROUND

The standard method for quenching tubes is their immersion into a vertical tank of water. This approach requires the provisioning of a large vertical envelope, facilitated by deep pits or high-bay construction, or, more practically, a combination of the two. This technique is prone to poor control of local quenching rates, resulting in a variation in mechanical properties. At the initiation of this project, only this vertical method was allowed by specifications. Experience had shown that horizontal quenching of long tubes had a greater propensity for permanent deflections. Recent industrial experience, however, indicated that the spray quench method could be utilized horizontally with less susceptibility to deflection. Additionally, more uniform properties could be achieved.

SUMMARY

The purpose of this project was to develop a horizontal spray method for quenching cannon tubes to increase quench efficiency, reduce processing time, and eliminate the vertical envelope required for vertical quenching. The program was conducted through three parallel efforts. The first was the construction of a scaled-down in-house facility to compare results of spray and immersion, using reduced size forgings. The second effort involved processing of full-scale forgings using the spray quench system. Finally, the spray quench method was applied to actual cannon tube forgings, using standard processing in all other respects.

The project demonstrated that horizontal spray quenching can be used in place of vertical immersion quenching for heat treatment of gun tube forings. More uniform material properties and a considerable reduction in process time were experienced. Handling of most forgings at 1550^{o}F - 1600^{o}F in a horizontal position should not significantly affect straightness if the forging is handled smoothly.

BENEFITS

Improvement of a procurement base for gun tube forgings is facilitated by a method of quenching allowing reduced vertical envelopes in the plant structure. The variability of yield strength in gun tubes is reduced. The efficiency of the heat treat cycle is increased, yielding a projected savings of $800,000 per year, based on 1976 production schedule.

IMPLEMENTATION

The results of the project were transmitted to the Arsenal Operations Directorate where the process was incorporated into the new Integrated Line. The system, as installed, was bought from Selas Corp. under a modernization project. It was first used for production tubes in December 1977. Figure 1 shows the system as installed in Bldg 135, Watervliet Arsenal.

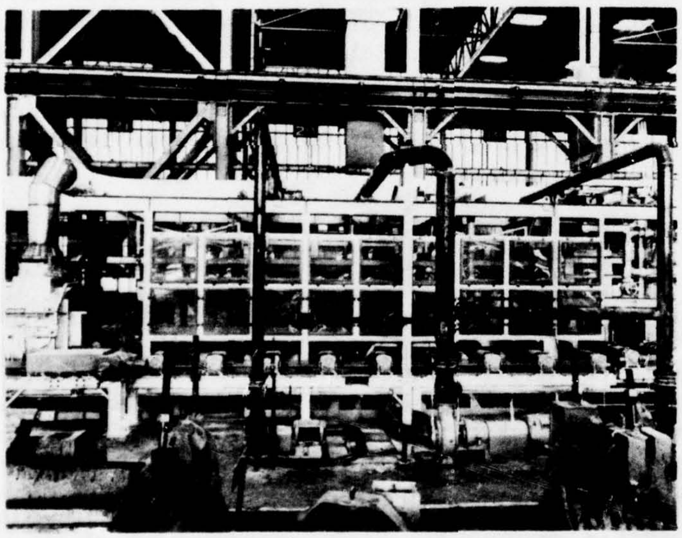

Figure 1 - Selas quenching system is inside the glass enclosure above the conveyor. The quench media is water which is recovered and recycled.

MORE INFORMATION

To obtain additional information, contact the project officer, Mr. Peter Thornton, AV 974-5517.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology (MM&T) projects 772 3513 and 773 3513 entitled "Develop Technology for Production of Blast Resistant Materials for Mine Neutralization System Components" were completed by the U.S. Army Mobility Equipment Research & Development Command in June 1976 at a cost of $130,000.

BACKGROUND

This program was conducted to advance the technology in the fields of casting, forging, vulcanization and composite joining. It was to enhance the development and production of mine neutralization system components that would be capable of withstanding the explosive effects of 20 charges, each consisting of 25 pounds of explosives. The overall objective of the program was to develop guidelines which would be used by the manufacturer during production of mine neutralization components. Project work was accomplished in-house by USA MERADCOM and contractually by Case Western Reserve University, Cleveland, Ohio and Battelle Columbus Laboratories, Columbus, Ohio.

SUMMARY

The program was divided into two distinct phases. The first phase included the development of technology for production of high impact resistant materials (polymeric) and rubber components which could be fabricated into items such as torsion bars and springs. The materials would not only be resistant to shock but also to low and elevated temperatures and exposure to fuels, lubricants, and weathering. Evaluations were conducted on rubber formulations using base polymers such as propylene oxide (PO) rubber, epichlorohydrin ethylene-oxide/styrene-butadiene rubber (ECO/SBR) blends, and dimethyl siloxane. Formulations using various polymers and blends of polymers were modified by varying polymer ratios as well as plasticizers, fillers, and curing systems. The best candidate materials were fabricated into scaled-down spring models and were evaluated at various temperatures down to -40°F. Spring model formulations that exhibited low temperature serviceability were:

a. Three dimethyl siloxane formulations with service potential from +180°F to -40°F or lower were identified as Si-78, SI-79 and Si-81.

b. An ECO/SBR blend with a service potential from +160°F to -35°F identified as HS-53.

c. A propylene oxide formulation with a service potential from +160°F to -40°F identified as PO-66.

Additional effort was not required since it was felt that the results were sufficient to allow the data to be accurately extrapolated to full-scale components without having to fabricate and evaluate them.

During the second phase, work was conducted to determine the feasibility of forging and casting blast-resistant mine clearing roller wheels. The work was designed to permit evaluation and comparison of prototype roller wheels based on design of wheel shape, composition and properties of various steels, and on forgings versus castings. This requirement arose from the delamination and subsequent shattering under blast conditions of wheels produced from plate. Castings of each of two wheel designs were supplied under contract for a given specification. A total of thirty (30) castings were produced. The specifications covering steel composition, heat treatment, and mechanical properties for medium alloy steels were ASTM A-487, Class 4Q; ASTM A-487, Class 10Q; MIL-S-23008B (HY-80); MIL-S-23800B (HY-100); and for high alloy steel was AMS 5359 the two designs with the exception of the AMS 5359. This particular steel composition presented some melting and casting difficulties and imposes a higher cost of materials and heat treatment.

Based on casting characteristics and economics, steels specified by ASTM 487, Classes 4Q and 10Q and MIL-S-23008B Classes HY-80 and HY-100 are very suitable for casting production in the designs specified. Casting Design B (Figure 2) was less prone to casting problems than Design A (Figure 1).

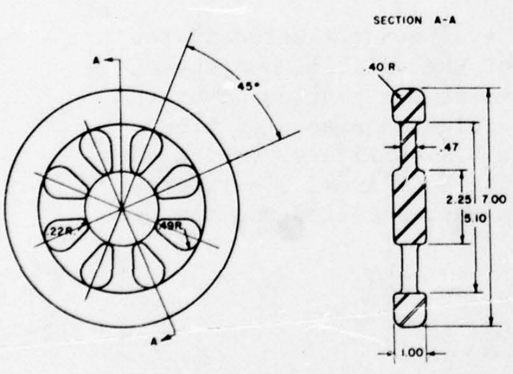

Figure 1 - Design A

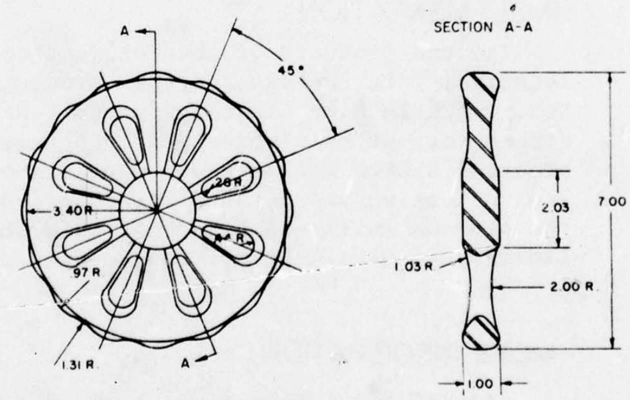

Figure 2 - Design B

Forgings of each of two wheel designs were also supplied under contract for a given specification. These forgings were produced from ASTM 4330, ASTM 8630, HY-100 type steels. The HY-80 and HY-100 steels, conventionally forged and oil quenched, and then tempered to selected hardnesses surpassed the impact energy and yield strength requirements in both the longitudinal and transverse directions. In general, wheel design "A" was more difficult to forge than wheel design "B", using the same steel. The most common problems encountered were radial cracks at the outer diameter of the rim, and die wear.

The results showed that impact resistance equal to or in excess of published measurements of bar and sheet products of the same alloys could be obtained in the mine-clearing roller wheels. The best impact resistance was obtained with HY-80 which exhibited -100 degrees F impact resistance in the range of 52 to 76 ft-lbs., well above the target minimum of 35 ft-lbs. HY-100 exceeded the minimum requirements, 8630 was marginal and neither 4330 nor 4340 achieved the miniumum. In general, forgeability ratings were proportional to impact resistance.

BENEFITS

The fabrication of high impact resistant torsion springs would increase the life cycle of the mine roller as well as increase the operational range to +180°F & -40°F. Savings can be realized in two basic areas; by the reduction of productions costs or critical components since rejection rates and/or high cost manufacturing methods will be minimized; and by the reduction in operating and maintenance costs associated with improved effectiveness and reliability.

IMPLEMENTATION

The end products of this project could have been reflected in the Technical Data Package for the prodcution of the Vehicle Mounting, Nonexpendable Mine Clearing System. However, at the conclusion of the second year of this three year program, a foreign manufactured mine clearing system was found to meet all of the U.S. military requirements and the design was pursued for adoption to the U.S. Army. Therefore, the planned follow-on effort of this program was cancelled and the preliminary results were not implemented.

MORE INFORMATION

Additional information of these projects is available from Mr. Emerson W. Asher, Lab 9000, MERADCOM, AC (703) 664-5126 or AUTOVON 354-5126.

Reports detailing project efforts are Final Technical Report, DA Project No. MMT 7733513, Case Western Reserve University, August 1974, "Blast-Resistant Mine Clearing Wheels (Cast Steel)", and Final Report. ADA019021, Battelle Columbus Laboratories, December 4, 1975, "Feasibility of Forging Blast-Resistant Mine-Clearing Roller Wheels."

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299

MUNITIONS

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

Manufacturing Methods and Technology project 575 1274 titled "White Phosphorus Dry Filling Line" was completed by the Pine Bluff and Edgewood Arsenals in March 1976 at a cost of $575,000.

BACKGROUND

This project was the first phase of a two and one-half year effort totaling $1.8 million to install a prototype white phosphorus (WP) dry filling line at Pine Bluff Arsenal. Before this project was undertaken, the wet filling process posed a hazard to operating personnel and was the cause of a significant amount of water and air pollution. Output per person was low because of the large number of manual operations. The difference between the wet and dry processes is that in the dry process the WP is injected directly into the munition cavity through a nozzle while the wet process involved dipping the entire munition into the WP, thereby wetting the outside of the munitions. The installation of dry fill process would dispell the disadvantages of the wet fill process and would improve productivity by including several automated stations. Dry filling would eliminate the environmental problems of fuming and "phossy water". Work was performed in-house at the Pine Bluff and Edgewood Arsenals. Contracts were let for procurement of parts and materials for fabrication of equipment.

SUMMARY

The objective of this project was to install the dry fill process on the #1 WP line at Pine Bluff Arsenal. A follow-on project would debug and operationally test the line. This line would serve as the prototype for two additional WP lines. The WP line was tooled for the M60 105MM projectile, but it was designed to be easily converted to handle the M302 60MM, M375 81MM, and M156 2.75 in WP munitions.

The existing filling equipment using the height of fill method was replaced with the more accurate volumetric filling equipment. The improved filling head (see Figure 1) loads eight projectiles simultaneously. Nozzles were open six seconds during the fill and a given amount of WP flowed into the projectile. The total fill time, which included the pallet travel time into and out of the filling station was 14 seconds.

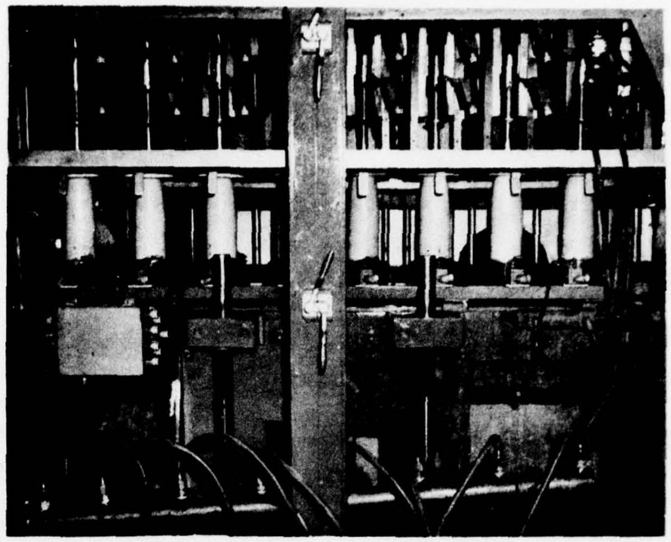

Figure 1 - WP fill station with 8 Fill Nozzles

The level-check station will use thermocouples to determine the height of fill. A detector head using two thermocouples to detect two different levels of fill is planned. The temperature differential between the WP and the air will indicate if the cartridge is filled within tolerance limits. This detector head was still under development as this project was being completed. Tests of the installed line were made during January and February 1976, but the thermocouple detector head was not yet functioning properly so a back-up manual height of fill check system using a back pressure device was used successfully.

BENEFITS

This project will reduce the amounts of air and water pollution generated during the WP filling operations. The WP line will be in closer compliance with OSHA requirements. A reduction in the number of personnel required will make the operation more economical.

IMPLEMENTATION

The FY76 project will automate several other stations, smooth out total conveyor operation and provide for a formal acceptance test of the line. Final Technical Data Package (TDP) on the dry filling station will be used for acquisition of similar stations for additional lines in the future.

MORE INFORMATION

Additional information of this project is available from Mr. Frank M. Stewart, AV 584-2863.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology (MM&T) project 570 4005 entitled, "Development of New and Improved Extruder for Extruding Composition C-4" was completed by the US Army Armament Command in November 1974 at a cost of $170,500.

BACKGROUND

The extrusion of Composition C-4 in the conventional manner is neither efficient nor safe enough to meet production requirements for the expanding demands. Comp C-4 has poor flow properties and extrudes slowly, even under high pressure. Existing systems lack adequate controls to monitor abnormal conditions and perform emergency shutdowns, and are unable to process some lots of Comp C-4 to specification. Excessive maintenance is required with difficulties and hazards involved in the disassembly and cleaning of the units. This project was funded to develop a production extruder that would greatly decrease rejects and successfully process Comp C-4 into an extruded ribbon regardless of the material variables.

Project work was accomplished by in-house work at Picatinny Arsenal and by contractual work by Sperry, Louisiana Army Ammunition Plant (LAAP); by Bonnot Extruder Co., Kent, Ohio; and by Technidyne, Inc., West Chester, PA.

SUMMARY

The purpose of this project was to design, procure, and evaluate a prototype extruder specifically for extruding Composition C-4 in a safe and efficient manner. The extruder would have an improved capability of providing an increased capacity, a more uniform product, a more flexible input capability, and increased safety.

Two concurrent efforts were conducted; one by Picatinny Arsenal and the other by the operating contractor, Sperry, at the Louisiana Army Ammunition Plant. Picatinny Arsenal anticipated benefits could be derived by reducing the friction between the Comp C-4 and the inner surfaces of the extruder die by ultrasonic activation of the extruder die relative to the linear motion of the Comp C-4.

The Sperry effort at LAAP included the concept design for an extruder, the development of preliminary specifications, and a vendor survey of extruder and special process equipment manufacturers.

Picatinny Arsenal's initial effort was the evaluation of ultrasonic activation of Comp C-4 by utilizing a small-scale press. After confirming the safety of this approach, a full-scale die activation system was constructed and installed on a production extruder at Picatinny Arsenal. See Figure 1.

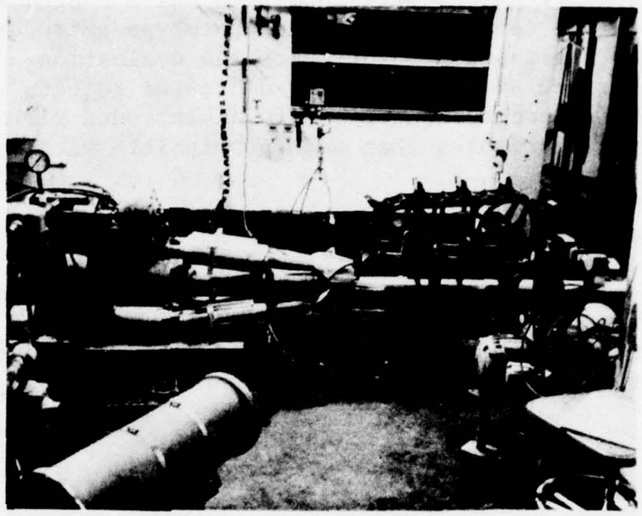

Figure 1 - Ultrasonic die activation system as installed on extruder at Picatinny Arsenal.

Preliminary tests reconfirmed the safety of die activation and demonstrated the anticipated ultrasonic benefits. The system was then installed at the Louisiana Army Ammunition Plant where a series of experimental extrusion runs were completed under production conditions. As a result of these tests, it was determined that the cost and complexity of the ultrasonic die outweighed the improvements it exhibited under production conditions.

The Sperry conceptual design of the prototype extruder was based on correcting the inadequacies and expanding the capabilities of existing production extruders. Some of the design features included:

a. Use of separate drives for the mixing and compression screw augers to increase process flexibility by providing a wide range of speed ratios.

b. A revised vacuum chamber to provide better deaeration and positive material flow.

c. One piece augers to eliminate alignment and sealing problems and prevent explosive migration between joints of a segmented auger.

d. Use of split barrels to simplify disassembly and increase maintainability.

The specifications were submitted and a contract was awarded for the design and fabrication of the prototype extruder. Upon completion, it was installed at LAAP for tests and evaluation. The results disclosed that the extruder greatly decreased rejects and that it would successfully process Comp C-4 into an extruded ribbon regardless of the material variables that were permissible within the Comp C-4 specification.

The density of the extruded blocks from the prototype extruder exceeded the density requirements for the M18 Mine. The prototype unit was also more stable and easier to operate than the existing extruders since it did not require a long period of adjustment after startup nor did it exhibit cyclic process variations. The quantity of rejected blocks, which require reprocessing, was reduced significantly.

BENEFITS

The benefits of this project were twofold: The prototype extruder developed by LAAP was used as a basis for the purchase of two production extruders. These extruders represent the best state-of-the-art available. The quality of the Comp C-4 blocks produced was improved, the number of blocks rejected was reduced, and the cost of producing the blocks was reduced significantly. The Picatinny Arsenal approach showed that ultrasonic die activation could also increase production rates, reduce rejection rates and produce smooth and uniform blocks but at a slightly greater cost.

IMPLEMENTATION

The "H" line at the Louisiana AAP was equipped with two new production extruders which are based on the design and operating specifications developed by this project. The extruders were installed in May 1975 and became operational in August 1975.

MORE INFORMATION

Additional information on this project is available from Mr. F. Strong, (201) 328-3760 or AV 880-3760. A Technical Report No. 4822 entitled "Ultrasonic Extrusion of Composition C-4 Products" dated July 1976, ATTN: SARPA-TS-S, Dover, NJ is also available.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 569 4118, 573 4118, and 574 4118 titled "A Prototype Plant for Continuous Incorporation of Composition B" was completed by the US Army Armament Research and Development Command in May 1977. The project costs were $1,885,000; $2,730,000; and $721,000 respectively for each of the funded years.

BACKGROUND

In modernizing the ammunition production base, the Army is converting current batch processes to continuous processes to take advantage of new developments and improve safety of operations. Holston AAP currently produces RDX and HMX by a series of batch type operations. In the final operation, incorporation, RDX, TNT, and wax are combined to produce Composition B. The current method of incorporation involves first, the melting of a batch of TNT and dumping it into a mixing kettle. RDX and wax are added manually to the kettle which is stirred and heated. Excess water is decanted and the batch is heated until all the moisture is evaporated. The molten Composition B is then dumped to a hold-up pot and then transferred to a casting pot from which it flows onto a cooled moving stainless steel belt in separate streams. After cooling and solidifying on the water cooled belt, the strips of Composition B breakup at the end of the belt and fall off into tote boxes.

SUMMARY

The purpose of the overall effort was the establishment of a prototype continuous Composition B manufacturing line producing at a rate of 7.5 million (M) pounds per month. This project was directed toward the conversion of a batch incorporation facility to a prototype continuous RDX/TNT/Wax incorporation facility.

Two alternate approaches were evaluated. The first process considered continuously mixed wet RDX, wax, and TNT. It was determined that this process had potential safety hazards due to vacuum drying and pollution problems due to TNT contamination of water.

In the second process, RDX in a water slurry was coated with molten wax. The wax coated RDX was designated Composition A-7. The bulk of the water was filtered from the A-7 and residual water removed by drying. Molten TNT and the A-7 were then incorporated to form Composition B. Using this procedure eliminated the safety and pollution problems which developed in the first continuous process. This process was selected for the prototype line.

Following process selection, design of the prototype line commenced. A schematic drawing of the continuous incorporation process is shown in Figure 1. Following design, procurement of the prototype equipment was initiated. Equipment purchased included an EIMCO belt filter, three Wolverine Jetzone Driers, a Kenics static mixer, a casting belt, automatic packaging equipment, and an automatic palletizer. Additional equipment included conveyor systems to connect the various buildings utilized in the continuous process.

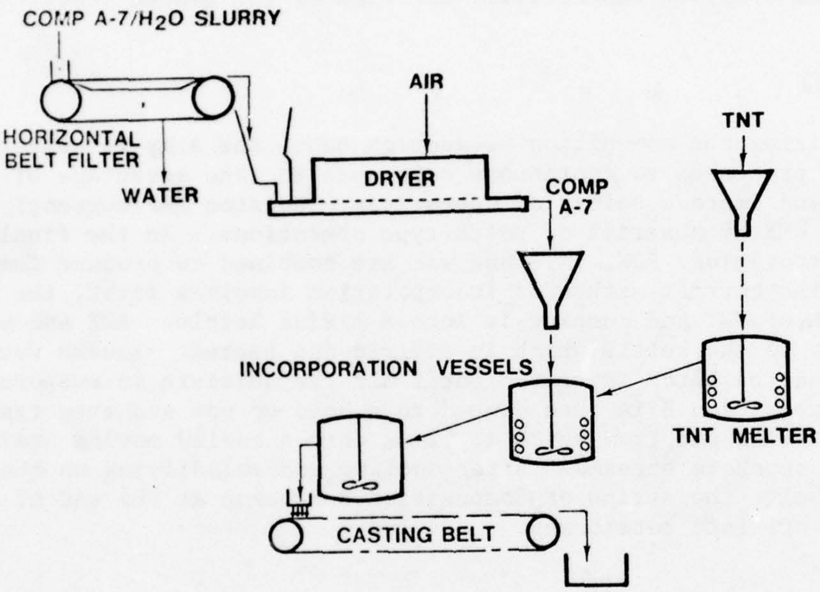

Figure 1 - Continuous Filter/Dry A-7 and Composition B Incorporation Process.

The Composition A-7 was formed by adding wax to the RDX water slurry in a Kinec static mixer. The Composition A-7 was fed onto a horizontal belt filter in the filtration/dry building. A pilot scale version of an EIMCO filter had been evaluated and proved successful for this application. After filtering the Composition A-7 to a 8% moisture level, the A-7 fell onto the deck of a vibrating hot air dryer. A pilot scale model of a Wolverine dryer had been evaluated and selected for this purpose. The Composition A-7 was dried to 2% moisture level and conveyed by transfer bins to the Incorporation Building.

In the Incorporation Building, flaked TNT was received and metered into an agitated melt kettle. The molten TNT overflowed to the incorporation vessel. Composition A-7 was automatically metered into the incorporation vessel so that a proper ratio of TNT to Composition A-7 was maintained. The

Composition B formed flowed into a hold-up vessel from which Composition B was fed onto a revolving water-cooled casting belt. Solid Composition B then would fall from the end of the belt into boxes which were pallatized and shipped to storage.

An inert technical checkout of the process was then conducted. This was done using water, corn, and rice. Following inert operation, approximately 12,000 pounds of Composition A-7 was processed and approximately 12,000 pounds of TNT was screened. Portions of the Composition A-7 and TNT were then processed to incorporate over 12,000 pounds of Composition B and 140 boxes of Composition B were packaged and palletized.

BENEFITS

A continuous incorporation process to manufacture Composition B at the rate of 7.5M pounds per month was developed. Benefits for the prototype line include (a) direct labor expenses will be reduced by approximately $1,730,000 per year per line, (b) operating personnel exposure to explosives will be reduced by approximately 50% (174 to 88) per line and (c) increased product uniformity due to continuous operation.

IMPLEMENTATION

The continuous incorporation process is part of the new continuous prototype line recently constructed for manufacture of Composition B explosive at Holston AAP.

MORE INFORMATION

Additional information on this project is available from Mr. S. Dollman, AV 880-3717, or Commercial (201) 328-3717.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 573 4134 titled "Development of Detonation Traps (DT) for Improved Safety in Munitions Process Plants" was completed by US Army Armament Research and Development Command in May 1976 at a cost of $170,000.

BACKGROUND

New concepts in design have been developed and implemented to modernize the ammunition plants. Some characteristic features of the new designs include the continuous and automated processes for the production of TNT and Composition B. These operations utilize pipelines to transport the in-process or final products from one building to another. The probability of propagation and communication of an explosion from one explosive source to another within the process necessitated a means to interrupt and arrest the detonation wave. In order to safeguard against propagation of a detonation through a pipeline, the feasibility of a plug-type detonation trap (PDT-1) system was successfully demonstrated in FY72 under MMT project 5 72 4162. Results indicated that a system could be devised with a suitable sensor that would have a total response time of less than one millisecond. Implementation of this type of detonation trap would improve safety at munitions processing facilities.

SUMMARY

The general objective was to reduce explosive exposure in munitions processing facilities by isolating one section from another by means of protective detonation trap (DT) devices. The approach was the development of one or more prototype DT units which could be installed in production pipelines that carry explosives and result in improved safety in the munitions plant.

The program covered the development and testing of prototype DT and examined other concepts as alternative back-up designs.

Two basic types of DT's were proposed: (1) a plug type trap which closes a line by injecting a barrier perpendicular (radially) to the direction of flow, (2) an open type trap which separates the line and causes a discontinuity in the propagation of the wave.

The first series of tests were conducted with only a single plug type trap (PDT-1) in the system. However, one PDT-1 would not completely arrest the detonation wave but it did reduce the wave to a low

order reaction. A series of tests were then conducted with a two DT system. The DT system evaluated was composed of dual trap units separated by a short length of pipe. The system was tested in the field under simulated operational conditions, using molten Composition B in a one-inch, schedule 40, steam-jacketed pipeline with the detonation initiated 30 feet upstream of the traps.

Figure 1 shows a simplified schematic of the two detonation trap concept. The system consists of dual traps each of which contains an explosive accurator and a detonation arrestor and in addition, a breakwire sensor and an electrical power source. When a detonation occurs in an explosive process, it propagates through the pipeline, framents

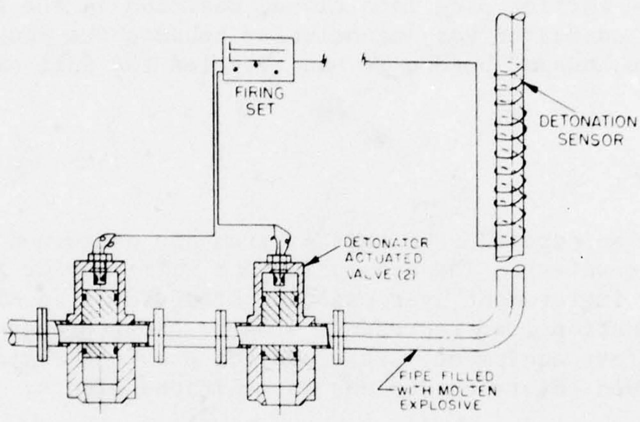

Figure 1 - Detonation Trap Concept

the pipe, severing the breakwire sensor located upstream of the trap. Breaking of the wire causes the firing circuit to energize and initiate the explosive train in the DT. The resulting explosive force drives the plug downward into a conical opening where it is brought to rest by friction and interference of mating parts. As a result of these actions, the plug intercepts the wave, absorbs its energy, and impedes further propagation. The total time interval from severing of the breakwire sensor to trap closure is less than one millisecond.

Results indicated that the detonation wave was always reduced to a negligible or low order reaction by the first DT and the second DT completely stopped the reaction. A prototype two DT system then was successfully developed which effectively sensed (one millisecond) and arrested the detonation of molten Composition B in a one-inch process pipeline.

Relative to the second basic type of DT, the open type of U-shaped trap, studies by IITRI showed that its performance was marginal in that the section of pipe would not drop away fast enough to prevent further propagation of the detonation.

During the second part of the program, alternative design studies were conducted by IITRI. Two new DT designs were recommended and tested with molten TNT. One design, the multi-effect passive trap, subjected the detonation wave to a right angle directional change, loss of confinement, and a reduction of the explosive column size to less than the critical diameter. In two tests the detonation was successfully arrested by the trap. The second design embodied the concept of a self-activating trap in which the detonation wave itself was the force in inserting a barrier plug into closed position in the pipeline. The one test conducted was inconclusive because the plug assembly became wedged in the housing before it had traveled the full closing distance.

BENEFITS

The benefits to be derived from this program are concerned solely with increased plant safety. The accomplishment will provide a significant measure of improvement over existing standards. In effect, a satisfactory detonation trap represents a major breakthrough in state-of-the-art safety equipment. This project provides a means for attaining improved safety conditions in munitions plants.

IMPLEMENTATION

The results of this project will be implemented in the form of technical reports for dissemination. The information in these reports will provide a basis for the follow-on project.

MORE INFORMATION

Additional information on this project is available from Mr. A. Graff, ARRADCOM, AUTOVON 880-3836, or Commercial (210) 328-3836.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 574 4134 titled "Development of Detonation Traps (DT) for Improved Safety in Munitions Process Plants" was completed by the US Army Armament Research and Development Command in May 1976 at a cost of $120,000.

BACKGROUND

As part of the Army's plant modernization program, new continuous and automated processes were developed for transporting explosives from one building complex to another. In order to safeguard against the propagation of an accidental detonation through a pipeline, a plug type detonation trap system PDT-1 was conceived in FY72 by ARRADCOM. During FY73, development and testing of a prototype two trap (PDT-1) system was accomplished. Results indicated that the system was effective in sensing and arresting the detonation of composition B in a one-inch process pipeline within one millisecond. However, munitions process plants utilize 2½ inch pipelines, therefore a program to scale-up and refine the PDT-1 was required.

An alternate back-up design study was conducted by IITRI and resulted in two designs. One a multi-effect passive trap which successfully arrested detonation waves, and the other a self-activating trap, which when tested was inconclusive.

The need existed for a DT of the PDT-1 type which could be used in the larger process pipelines. This program was continued to scale-up a prototype PDT-1 and evaluate its reliability.

SUMMARY

This is the second year effort of a three year program to develop detonation traps (DT). The main objective of this effort was to scale-up the PDT-1 developed previously and perform reliability tests.

The program was composed of two phases. The first phase was a design of the plug assembly. The objectives were to develop optimum plug motion performance characteristics, design a diagnostic "test fixture", and verify the subsequent design. The second phase included the development and testing of the scaled-up prototype DT. The objectives were to design and develop a plug and housing to withstand and arrest the detonation wave.

In the first phase, computer studies for the scale-up DT were performed to closely imitate the characteristic motion of the PDT-1.

A parametric study of the influential performance characteristics was undertaken. From these studies, the following specifications were desired: (a) initial gas pressure load equal to PDT-1, (b) an approximate 1 msec plug closure time, (c) an extrusion of one inch or less for the break extension and (d) impact velocity in the 200 ft/sec range. A test fixture was designed with a 2 3/4" plug to close a 1 3/4" pipeline. A 2 1/2" pipe was reduced in diameter to 1 3/4 to readily decrease the plug closure response time and the surrounding pressure and stress environment. Data from the "fixture" motion studies were used to design the prototype DT.

Two designs were developed and tested for use in a 2 1/2 inch pipeline, one with a 3 1/2 inch diameter plug and the other with a 2 3/4 inch diameter plug (with entering and exiting pipelines reduced to 1 3/4 inches). The 3 1/2 inch plug design was rejected after the housing body failed. The second design tested was composed of a stainless steel housing, maraging steel plug and 2 3/4 diameter plug which functioned successfully in arresting the detonation wave in repeated testing. Although the prototype was successful, modifications and reliability testing would be necessary before final implementation. A schematic drawing of the 2 3/4 inch plug design is shown in Figure 1.

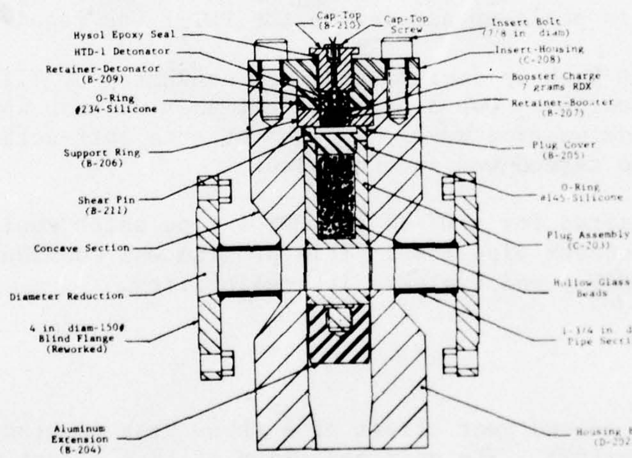

Figure 1 - Detonation Trap, 2 3/4 inch plug diameter with component nomenclature.

The prototype shown consisted of a stainless steel 347 housing assembly and a plug assembly fabricated from maraging steel 250. Additional features included were the 6061-T4 Aluminum brake extension, the housing insert and cap top, the Lexan detonator and booster retainers, and the support ring for the energy package. The shear pin and the captop screw components were the remaining elements.

BENEFITS

The benefits to be derived from this program are concerned solely with increased plant safety. In effect, a satisfactory detonation trap represents a major breakthrough in state-of-the-art safety equipment. This project provides a means for attaining improved safety conditions in munitions plants.

IMPLEMENTATION

The results of this project was implemented in the form of technical reports for general dissemination. The results provided a basis for a follow-on project.

MORE INFORMATION

Additional information on this project is available from Mr. A. Graff, ARRADCOM, AV 880-3836, or Commercial (210) 328-3836.

Summary Report prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 575 4134 titled "Development of Detonation Traps (DT) for Improved Safety in Munition Process Plants" was completed by the US Army Armament Research and Development Command in November 1977 at a cost of $333,000.

BACKGROUND

The overall purpose of this program was to improve munition plant safety through the development of detonation traps (DT) which can be installed in pipelines to halt the propagation of detonation. In FY73, a prototype plug-type DT was developed and tested which arrested the detonation of molten Composition B in a one-inch process pipeline. A follow-on effort in FY74 was performed to scale-up the prototype trap for use in a 2½-inch process pipeline. A prototype DT system was developed and tested successfully on a pipeline reduced to 1 3/4 inches at both the entrance to and exit from the trap. However, additional studies were required to qualify the scaled-up DT system for "duty" in full scale production plants. This required modifying the detonator to make it resistant to electromagnetic radiation and high temperature environments.

SUMMARY

The primary objective of this follow-on effort was to develop an exploding bridgewire detonator which was more resistant to electromagnetic radiation and able to function in an environment of 250°F. This program was accomplished by in-house effort at ARRADCOM and contractual work at Reynolds Industries Inc. and Franklin Institute.

During the in-house monitoring effort of the DT firing circuit, the breakwire sensor was found to be sensitive to stray electromagnetic radiation. A hazards analysis study by the Franklin Institute confirmed this finding. This led to the development of a coaxial crush switch, to replace the breakwire sensor, and silicon controlled rectifier (SCR) switch for the PDT-1 trap circuit. The coaxial crush switch uses the kinetic energy of the exploding pipe and converts it into electrical energy by use of a magnet and keeper coil attached to the pipeline. The electrical energy generated fires the detonators. In order to assure delivery of sufficient current to fire the detonator it was necessary to use four coaxial cables in parallel due to large inductances in the line. The coaxial crush switch performed successfully in sensing a detonation and firing any EBW detonator containing RDX. Hazards analysis studies on the coaxial crush switch

indicated no hazard in the presence of radio frequency or transient fields.

For the high temperature (250°F) environment studies, the RDX used in the EBW detonator would not withstand the trap housing temperature for long periods (one month). Therefore, a two fold approach was pursued. One involved a design in which the EBW detonator was positioned outside the trap housing and its energy after firing was transmitted to the booster in the housing by means of a shielded detonating cord. Tests with this design were successful with closing times slightly over one millisecond or about 100 microseconds longer than the average closing times. This method represented a back-up approach if a suitable high temperature resistant EBW detonator was not attained.

A second approach involved a contract with Reynolds Industries to develop an EBW detonator capable of functioning in a 250°F environment. The program resulted in an actuator loaded with hexanitroazobenzine (HNAB) which functioned successfully after 26 days at 250°F.

BENEFITS

The benefits to be derived from this program are concerned solely with increased plant safety. The accomplishment will provide a significant measure of improvement over existing standards. This project provides a means for attaining improved safety conditions in munitions plants.

IMPLEMENTATION

The results of this project will be implemented in a technical report for general dissemination.

MORE INFORMATION

Additional information on this project is available from Mr. A. Graff, ARRADCOM, AV 880-3836, or Commercial (210) 328-3836.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology (MM&T) project 570 4162 entitled "Automated Line for the Melt-Pour Processing of High Explosives" was completed by the US Army Armament Research and Development Command in January 1976 at a cost of $496,810.

BACKGROUND

The present melt-pour facilities are antiquated; require high concentrations of personnel exposed to large volumes of explosives. This project was part of a five-year funded effort to alleviate this problem by designing and testing an automated production line utilizing improved processes and techniques for melt-pouring explosives.

SUMMARY

The objective of this project was to design and test new or improved processes and techniques for melt-loading high explosives. This project initiated the design and construction of prototype equipment to be installed in a pilot melt pour facility located at Picatinny Arsenal. This pilot plant would consist of equipment for explosive preparation, conveying, melting, mixing, casting, cooling, cast finishing, scrap rework and post cycle heating.

The major thrust of this project was in the area of melting and scrap rework. In an attempt to design a high rate melter system heat transfer studies were conducted on a modified steam jacketed kettle to determine if an increase in internal heating surface area could melt explosives on a continuous basis. Results indicated that additional heat transfer surface area was required. Therefore, investigations into other melters were initiated.

One method of decreasing the processing time in any explosive melter would be to preheat the explosive. Thus, investigations into equipment to perform this function was initiated. A convection type dryer, with air heated by steam coils and forced through a perforated vibrating conveyor was tested as a preheater and appeared to be the best approach, see Figure 1. This preheater was used to heat the explosive from ambient to approximately 125^{o}F.

For the modern melt-pour line, it was deemed desirable to house the explosive operations in a single story structure. To achieve this goal, a method of pumping molten explosive had to be developed. A review of different type pumps revealed that the peristaltic and

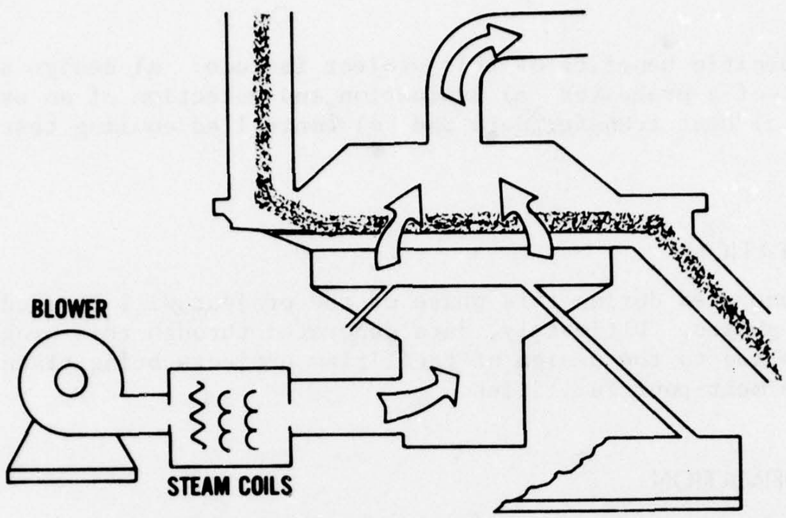

Figure 1 - Preheating explosives in a convection-type dryer.

diaphragm tube types had the most potential. Test results indicated that both performed satisfactorily. However, the LAPP diaphragm pump was selected because it required less maintenance and could sustain higher pressures.

Design studies were initiated to determine an efficient method of recycling riser and drill scrap. Experiments conducted using 190^{o}F water concluded that a hot water spray could melt three times the explosive three times faster than a hot water bath. A riser melter pilot system utilizing the hot water spray concept was constructed and successfully operated on a batch basis.

Efforts initiated in other areas include microwave/dielectric energy studies, controlled cooling experiments and improved casting methods. An in-house effort was conducted to determine frequency, power requirements and limiting factors pertinent to the application of microwave/dielectric energy. The study indicated that the use of microwave/dielectric energy for melting explosives was possible. This resulted in a contract being awarded to investigate the complex parameters of this process. Additional work in this area will be accomplished in future projects.

An investigation was initiated to determine if multi-zone cooling would reduce the time required to cool and post cyclic treat large caliber shells. Experiments were conducted to determine the effect cooling mediums would have on the explosive cast at various temperatures. The results of these tests were used to develop a controlled cooling test program in a subsequent funded project.

BENEFITS

Some specific benefits of this project include: a) design and development of a preheater b) evaluation and selection of an explosive pump c) heat transfer data and d) controlled cooling test program.

IMPLEMENTATION

Data generated during this phase of the project will be used during subsequent phases. Ultimately, data generated through this program will be applied to the design of facilities projects being planned to upgrade the melt-pour facilities.

MORE INFORMATION

Additional information may be obtained from Mr. Curtis Anderson, ARRADCOM, AV 880-3162.

Summary Report was prepared by the Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology (MM&T) project 571 4162 entitled "Automated Line For Melt-Pour Processing of High Explosives" was completed by the US Army Armament Research and Development Command in January 1976 at a cost of $1,897,256.

BACKGROUND

The present melt-pour facilities are antiquated; require high concentrations of personnel exposed to large volumes of explosives. This project was part of a five-year funded effort to alleviate this problem by designing and testing an automated production line utilizing improved processes and techniques for melt-pouring explosives. FY70 funding of this effort resulted in a preheater concept, an explosive pump, a controlled cooling test program and data for use in this project and subsequent phases of the program.

SUMMARY

The objective of this project was to design and test new or improved processes and techniques for melt-loading high explosives. This project continued the design and construction of prototype equipment to be installed in a pilot melt-pour facility. This pilot plant will consist of equipment for explosive preparation. conveying, melting, mixing, casting, cooling, cast finishing, scrap rework and post cycle heating.

The major thrust of this project was in the areas of controlled cooling, scrap rework, and cast finishing. Results of previous controlled cooling studies were used to initiate a test program for the 175MM projectile. From this program, a two level water cooling procedure was developed which produced acceptable casts. This procedure consisted of a six hour conditioning cycle with water temperature of 145°F - 150°F and a steam coil surrounding the riser. An acceptable procedure for controlled cooling of the 175MM projectile was developed, but because this round was to be phased out, the study was redirected to the 105MM, 155MM, and 8-inch projectiles.

Work on a riser scrap rework system continued under this project. Layout and installation drawings were completed for the riser melter system. This system consists of a Corra-Trough conveyor feeding explosive scrap continuously into the melter. Molten explosive is drawn off from the melter and poured onto a stainless steel casting belt where it is reflaked. The explosive/water overflow is recycled to remove the explosive. This explosive is then recycled to the melter.

Work in the cast finishing area concentrated on funnel and riser removal experiments. Tests were conducted to determine the force required to remove the explosive filled funnel from the projectile and eject the riser. Results indicated that tapering the funnel neck and providing air escapement holes reduces the force required to extract the funnel. These findings will be incorporated into a modified funnel design.

Concept design of the funnel pull and riser ejector machines were completed. Final design, fabrication, and testing of these machines will be accomplished under subsequent projects.

This project continued efforts initiated by project 570 4162 in all phases of the melt-pour system. Additional accomplishments under this project included placing contracts for prototype equipment and pilot plant construction, procurement of components for the mixer system and initiation of tests on a microwave/dielectric energy melter. Work in these and all other areas of the melt-pour system will continue under succeeding projects.

BENEFITS

Successful execution of subsequent phases of this program will result in new equipment, processes and operating procedures for automatic melt-loading of high explosives. Specific benefits of this project includes a controlled cooling procedure for the 175MM projectile, layout, and installation drawings for a riser scrap rework system, a modified explosive funnel and conceptual drawings for funnel pull and riser ejector machines.

IMPLEMENTATION

Data generated during this phase of the project will be used during subsequent phases. Ultimately, data generated through this program will result in facilities projects being planned to upgrade the melt-pour facilities.

MORE INFORMATION

Additional information may be obtained from Mr. Curtis Anderson, ARRADCOM, AV 880-3162.

Summary Report was prepared by the Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 571 4165 and 573 4165 titled "Prototype Facility for Recovery of HMX from RDX/HMX Admixtures" were completed by the US Army Research and Development Command in September 1976. The project costs were $385,000 and $31,500 respectively for each of the funded years.

BACKGROUND

Currently HMX is produced by the Bachmann Process which involves the nitration of hexamine. Process parameters are modified to produce a high concentration of HMX with comparatively little RDX. However, this results in an expensive product. During the production of RDX, approximately 10% of HMX is formed as a by-product. Therefore, the development of a process to efficiently recover a by-product HMX instead of producing it by the Bachmann Process would lower the production costs of HMX. In the mid 1960's, laboratory studies were conducted to develop a method of recovering HMX from RDX/HMX admixtures produced by the Bachmann Process. Of the HMX separation methods considered and investigated, a process of preferential RDX growth in spent acetic acid of the RDX/HMX admixture from the nitrolysis process proved to be the system most economical and adaptable to the manufacturing process. Preferential RDX growth in spent acid produced a particle size differential between RDX and HMX adequate for separation in a liquid cyclone system.

The laboratory work was followed by a pilot plant study. This pilot study again grew RDX and HMX in spent acetic acid with a crystal size ratio of RDX to HMX varying from 2:1 to 4:1. The RDX crystal size ranged from 120 to 160 microns and the HMX crystal size ranged from 40 to 60 microns. The pilot study verified the practicality of separating HMX from RDX.

SUMMARY

The overall objective of this project was to design, install, and evaluate a prototype unit for recovery of HMX from the RDX slurries. The initial effort was to emphasize the development of design criteria for a prototype unit followed by a hazards analysis for the entire operation.

The design criteria included the determination of the size of the recovery facility. A bench-scale equipment layout was designed, fabricated, and installed to prove the feasibility of using a plug flow cooler-crystallizer to preferentially grow the RDX.

Performance tests of the plug flow cooler proved to be unsuccessfull due to plugging at low flow rates. The decision was then made to design a system around tank crystallizers since they had proven their ability to preferentially grow RDX under previous work. A design criteria was developed for constructing and evaluating a 50,000 pound per month prototype recovery facility. The locations for the facility would be buildings D-5 and E-4 at Holston AAP. A process block diagram for the planned HMX recovery (batch) facility is shown in Figure 1.

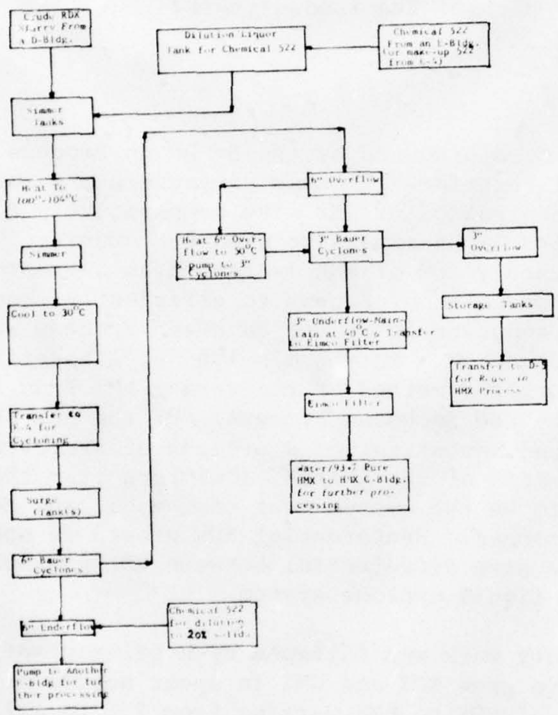

Figure 1 - Process Block Diagram of the HMX Recovery Facility.

A general description for the HMX recovery process in Buildings D-5 and E-4 is as follows:

Simmered RDX slurry and Chemical 522 (60% Acetic Acid) were received at Building D-5 and mixed in a given ratio in a simmer tank. The RDX slurry and Chemical 522 were heated to 100°C (373°K) in the simmer tank and cooled at a given rate to preferentially grow the RDX in the RDX/HMX slurry. The cooled, preferentially grown RDX slurry was pumped to the Building E-4 feed storage tank. The preferentially grown RDX slurry was pumped through the primary cyclone separators to separate the large particles (RDX) from the fines (HMX). The primary cyclone underflow (RDX-522) was pumped to Building E-3 for normal production processing. The primary cyclone overflow was heated to 45°C (318°K) and pumped through the secondary cyclones to separate the fine material (HMX) from the Chemical 522. The secondary cyclone overflow was transferred to an EIMCO traveling belt filter for washing. The washed HMX slurry was pumped to the G Building for further processing. The secondary cyclone overflow (Chemical 522) was transferred to a storage tank for recycle to Building D-5 or transferred to primary distillation for acid recovery operations.

The process design and the equipment to be utilized for the growing of RDX and HMX crystals in spent acid with subsequent separation of the HMX from the RDX/HMX admixture was examined with respect to the potential hazards of each operation. Although each operation, namely, simmering explosives in spent acid, utilizing hydrocyclones to separate different size particles, and using a traveling belt filter to isolate crystalline explosive particles from an acid media have all been performed at HAPP, these operations have never been used for the separation of the HMX from RDX/HMX admixtures. Therefore, a hazard analysis was required for the entire operation. In this analysis, the interface between each of the operations as well as the operations themselves were investigated. Upon completion of this investigation, it was decided that the process, as designed, was acceptable.

BENEFITS

A prototype facility was designed for recovering HMX from production grade RDX at the rate of 50,000 pounds per month. A hazards analysis was accomplished on the equipment and operations for the prototype facility.

IMPLEMENTATION

Completion of this project served as the basis for equipment procurement, equipment installation, and prove out of the prototype recovery facility under follow-on projects 574 4165 and 575 4165.

MORE INFORMATION

Additional information on this project is available from Mr. S. Dollman, ARRADCOM, AV 880-3717, or Commercial (201) 328-3717.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology projects 574 4165 and 575 4165 titled "Prototype Facility for Recovery of HMX from RDX/HMX Admixtures" were completed by the US A ny Research and Development Command in June 1978. The project costs were $1,198,000 and $495,000 respectively for each of the funded years.

BACKGROUND

This effort is the continuation of the development of a process to recover HMX as a by-product of RDX manufacture instead of by separate nitration. This new process is expected to lower the production cost for HMX. Previous laboratory work was conducted by Holston AAP to investigate several methods for recovering HMX from RDX/HMX admixtures. The process selected involved the preferential growth of RDX in spent acetic acid from the RDX nitrolysis process with the separation of the fine HMX by cycloning. The HMX would be then purified by an extraction process.

During FY71 and FY73, the design of the prototype facility was completed. The design production rate was determined as 50,000 pounds per month. A hazards analysis was accomplished on the equipment and operations for the prototype facility.

SUMMARY

The objective of the FY74 and FY75 effort was to procure equipment and complete the building modifications and equipment installation.

The equipment needed for preferentially growing RDX over HMX in spent acetic acid and separating HMX from RDX by means of liquid cyclones was procured. The equipment included (a) simmer, feed, and hold-up tanks; (b) agitators, 100 RPM and 75 RPM for the simmer tanks; (c) cyclones, four 6" cyclones and eight 3" cyclones; and, (d) minor equipment such as slurry pumps, panel boards, instrumentation and all the manual valves. Minor modifications were made to the cyclones by Holston AAP.

The production equipment in Buildings D-5 and E-4 was used and/or modified where possible and new equipment installed. In Building D-5, four preferential growth (simmer) tanks equipped with constant speed agitators were installed. The simmer tanks were equipped with nitrogen purge lines and vent condensers leading to a modified scrubber system. A tank formerly used as a dilution liquor tank was modified to be used as a Chemical 522 (60% Acetic Acid) feed tank. The second floor of the building was modified to accommodate a slurry receiver tank. A new panel board was installed to monitor and control various steps of the preferential growth operation.

In building E-4, three former simmer tanks were modified with agitators and drives for use as cyclone feed and overflow tanks. A new slurry receiver tank with agitator and drive system was installed. A 480 gallon acid wash tank was installed to provide recirculating acid wash in the operation of the EIMCO traveling belt filter. The cyclones together with the overflow and underflow tanks and pumps were installed along with its control panel and the EIMCO traveling belt filter.

Installation of equipment and building modifications were completed in December 1976.

The Standing Operating Procedures for Bldgs. D-5 and E-4 and sampling plan were approved. The Data Processing Group completed a computer program to record samples and perform material balances for the prototype operation. A training program was conducted for the operators, foreman and shift engineers on operations pertaining to the newly developed HMX recovery prototype equipment and process.

Each piece of equipment was water tested and calibrated. Testing and debugging of the pilot plant was to be performed in the follow-on effort.

BENEFITS

The installation of a prototype facility for recovering HMX from production grade RDX was completed.

IMPLEMENTATION

The prototype facility for recovery of HMX from RDX/HMX admixtures will be operated and debugged in the follow-on efforts of projects 576 4165 and 57T 4165.

MORE INFORMATION

Additional information on this project is available from Mr. S. Dollman, ARRADCOM, AV 880-3717, or Commercial (201) 328-3717.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology projects 576 4165 and 57T 4165 titled "Prototype Facility for Recovery of HMX from RDX/HMX Admixtures" were completed by the US Army Research and Development Command in August 1978. The project costs were $475,000 and $400,000 respectively for each of the funded years.

BACKGROUND

The project is the continuation of the development of a process to recover HMX as a by-product of RDX manufacture instead of by separate nitration. This new process is expected to lower the production cost for HMX. The FY71 and FY73 projects involved the preparation of the design of a prototype facility capable of a production rate of 50,000 pounds per month. The FY74 and FY75 efforts supported equipment procurement, building modifications, equipment installation, equipment calibration/checkout and operator training.

The follow-on efforts were planned to prove-out the operations of the prototype facility.

SUMMARY

The three primary objectives of these two projects were (a) to operate and debug the prototype facility, (b) perform process parameter studies, and (c) perform continuous endurance runs.

Process operations for the HMX recovery prototype facility began in February 1977. Initially the process was operated on three shifts per day, seven days/week, averaging one process batch (1,700 lbs) per shift. After familiarizing the operators with the process and proving the reliability of the equipment, process conditions were studied and optimized. The specific areas studied were: (a) cooling rates to obtain the best preferential growth, (b) optimizing the operating conditions of the primary cyclones to provide best separation of RDX from HMX, (c) optimizing the operating conditions of the secondary cyclones to provide the best separation of HMX from Chemical 522 (60% Acetic Acid), and (d) operating conditions of the EIMCO traveling belt filter for separations of HMX from Chemical 522 and wash water. The HMX facility was operated until June 1977. During the prototype studes, regular operating conditions were used. Initially one batch was run per shift with three shifts per day. This was followed by two batches per shift and finally by eight batches per shift. A schematic of the recovery process is shown in Figure 1.

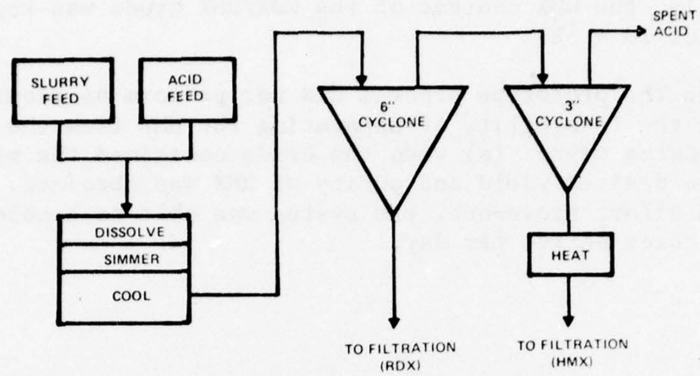

Figure 1 - Prototype HMX recovery process installed at Holston AAP.

During this period of time, more than 410,000 lbs (185,900 Kg) of crude RDX were processed. The purity of the HMX recovered ranged from 60 to 99%. The maximum yields obtained during prove-out was 29%. These variations in the purity and yields of HMX during the prove-out of the prototype were much less than what was expected. The success of the process was based on an expected consistant minimum yield of 40% HMX with a 98% minimum purity.

It was previously established that in order to get a good separation of the HMX from the RDX, the average particle size of the RDX would have to be 140-160 microns and the HMX 40-60 microns. If this average particle size differential was not attained in the preferential growth process, the separation would be difficult and the yields of HMX poor. The prime difficulty encountered during the prove-out was the variation of the HMX content in the crude RDX product. The variation of the HMX in the crude directly affected the preferential growth of the RDX. There exists a limiting factor for the separation of different size particles with a liquid cyclone. In this case a 100 micron differential in the size of the crystals was essential for a good separation of HMX from RDX/HMX admixtures.

The problem caused by variation of the HMX content in the crude RDX/HMX, was not observed in pilot plant study. Under the pilot plant conditions, it was possible to select the RDX crude to be used.

Inadvertently, the HMX content of the RDX/HMX crude was kept within the limits of 10 + 3%.

Although the prototype process did not perform as required, it did demonstrate the feasibility of separating the HMX from the crude RDX/HMX in the following ways: (a) when the crude contained the proper HMX content, the desired yield and purity of HMX was obtained. (b) during the maximum effort prove-out, the system was able to handle eight runs per shift, three shifts per day.

BENEFITS

Engineering design data and processing parameters were obtained which provide a means for recovering HMX from RDX/HMX admixtures.

IMPLEMENTATION

This MM&T project was self implementing. Equipment for the recovery of 50,000 pounds per month of HMX from RDX/HMX admixtures was installed and operated. Recovery efficiencies of 29% were obtained.

MORE INFORMATION

Additional information on this project is available from Mr. S. Dollman, ARRADCOM, AV 880-3717, or Commercial (201) 328-3717. A Final Engineering Report, HDC-42-78, was completed and published by Holston AAP.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 571 4205 titled "The Processing of Spent Acid from RDX/HMX Reaction for Recovery of Explosives and Acid" was completed by the US Army Armament Research and Development Command in December 1977 at a cost of $110,000.

BACKGROUND

RDX and HMX are manufactured at Holston AAP by suitable adaptations of the basic Bachmann Process. Hexamine, ammonium, nitric acid and acetic anhydride are reacted under controlled conditions in an acetic acid medium to produce RDX or HMX in separate reactor systems. During nitrolysis and the filter/wash steps large amounts of dilute acetic acid are generated. These dilute acids are recovered and reconstituted to glacial acetic acid by evaporative processes in which a primary distillation process is used to produce a solids free distillate and an azeotropic distillation step to reconstitute the recovered aqueous acid to glacial acetic acid. The primary distillation process consists of five basic steps, (1) caustic neutralization of nitric acid, (2) acetic acid recovery by evaporation, (3) conversion of ammonium nitrate to sodium nitrate and residual explosives, (4) sodium nitrate recovery and (5) ammonia recovery. The main disadvantages of this process are the high operating costs associated with step 2, the high costs for sodium hydroxide in step 1, and excessive steam consumption.

Therefore, a program was initiated to perform modifications that would reduce neutralization costs or reduce the evaporative load in the acid and/or by-product recovery streams which would offer significant savings in operating and material costs.

SUMMARY

The objective of this project was to identify potential improvement areas in the present acetic acid recovery process and to test modifications which offer cost or safety advantages over existing systems. To attain the objectives, various unit operations used in the acid recovery system were examined with bench-scale equipment, beginning with the treatment of incoming feedstreams to the recovery of acetic acid and the handling of by-product sludges.

Improvements for reducing both material and steam costs for processing spent acid were investigated and are reported in the following paragraphs.

The acetic acid content was increased from 60% to 80-90% in the spent acid in an effort to reduce the amount of water which had to be evaporated. This effort resulted in reducing the evaporative load for the primary evaporator, increasing the explosive load to the Acid Recovery area, and creating an inbalance between dilution liquor generation and usage rates.

Various neutralizing and causticizing agents were studied in an effort to find a less expensive material to accomplish nitric acid neutralization and destruction of explosives in the spent acid recovery process. Of the various alternatives, ammonia was satisfactory as a neutralizing agent and calcium hydroxide (lime) as a causticizing agent. The use of lime in the neutralization step resulted in sensitized, recovered explosives because of the presence of sulfate and silicate impurities. The combination of ammonia as a neutralizing agent and calcium hydroxide as a causticizing agent offered cost advantages relative to using sodium hydroxide.

The use of inorganic salts for partial vapor phase dehydration of the acetic acid-water distillate from the primary evaporator was explored. This resulted in the dehydration of acetic acid from 60% to 90%. Calcium chloride appeared most effective relative to magnesium acetate, calcium acetate, magnesium nitrate and calcium nitrate. The technique was not recommended due to salt regeneration cost or the tendency of the salts to lose water of hydration at process temperature.

A study of dilution and/or cooling effects offered significant reductions in the dissolved explosives loads carried in spent acids from nitrolysis. Dilution from 60% acid to 30% acid precipitated approximately 70-75% of the dissolved explosives in RDX acids and about 60-70% in HMX acids. Dilution of 80% acid to 60% acid removed up to 50% of the dissolved explosives. A combination of dilution and cooling (-10 to +5^{o}C) of spent acids precipitated 75-98% of the initial explosives. However, the use of dilution resulted in a significant amount of water added to the present system which increased the evaporative load.

Treatments with activated carbon in fixed beds were tested for their ability to remove dissolved explosives from spent acids. The adsorptive capacity of the carbon was higher in dilute (30%) spent acids than in stronger (60%) acids. Based on these results, the adsorption with carbon should be accomplished after the dilution step for maximum efficiency.

A counter current/liquid-liquid extraction method with n-propyl acetate was employed to reduce the evaporative load caused by the use of dilution. This method produced an extract containing about 96% of the available acetic acid in the feed-stream with 4-14% water, and a raffinate containing relative small amounts of solvent and acid. A major disadvantage of this process was the distribution of essentially all of the explosives and traces of sodium and ammonium nitrate (about 80 to 160 ppm) in the solvent-rich phase (extract). Additional treatment of the extract would be necessary to remove the explosives and residual nitrates to acceptable levels before distillation of the stream to produce glacial acetic acid.

As an operation for treatment of primary sludge the liquid-liquid extraction using n-propyl acetate was effective in recovering about 100% of RDX and HMX with a solvent to sludge ratio of 0.6 to 1 and three equilibrium stages. Concentration of 80 to 160 ppm of ammonium nitrate and sodium nitrate were found in the extract.

Based on the results obtained during the laboratory phase, the number of processing steps involved and the inter-dependency of the steps, additional laboratory work was required to further develop and optimize the final process before proceeding to a pilot scale. The approach was to evaluate the most promising results obtained previously on a bench-scale B-line approximating conditions found during production. The equipment was designed and fabricated by Holston AAP and installed by October 1974. Several runs were completed establishing baseline conditions and data for neutralization experiments with ammonia and lime. This portion of the project was not completed because of termination of the effort by ARRADCOM.

BENEFITS

The results of this project find application in the spent acid recovery area at Holston AAP. However, proven cost reductions cannot be made until process changes are implemented into production operations.

IMPLEMENTATION

None of the aforementioned process changes have been recommended for implementation into production operations because the disadvantages outweigh the advantages in all cases.

MORE INFORMATION

Additional information on this project is available from Mr. L. Sotsky, ARRADCOM, AV 880-2160, or Commercial (201) 328-2160.

Summary Report was prepared by the Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 574 4205 titled "The Processing of Spent Acid from RDX/HMX Reaction for Recovery of Explosives and Acid" was completed by the US Army Armament Research and Development Command in June 1978 at a cost of $70,000.

BACKGROUND

During the manufacture of RDX and HMX at Holston AAP, large amounts of dilute (spent) acetic acid are produced. These spent acids containing RDX and HMX both suspended and dissolved are pumped to the primary distillation area, B line where the acetic acid is recovered. Since the spent acid contains RDX/HMX, the B line buildings are considered as explosive hazard buildings. Based on quantity-distance regulations, the load limit for a B line building is 5,000 pounds, Class 7 explosives. Studies indicated, however, that up to 22,000 pounds of Class 7 explosives were accumulating in B line building prior to a scheduled cleanout.

Based on this information, a project was initiated to plan to reduce the load limit from 15,000 pounds (waiver request) to 5,000 pounds per building.

SUMMARY

The objective of this effort was to minimize explosive precipitation in the feed tank to the primary evaporator when recovering RDX, HMX and acetic acid from spent acid. It was determined that heating of the solution in the feed tank was the best method for eliminating the settling of explosives. By heating the contents of the feed tank, the suspended explosives would dissolve into solution.

The plan was to install a heating and circulating loop (external heat exchanger) on the primary evaporator's feed tank. It was determined that steam condensate from the evaporator and reactors in the same building would serve as a heat source for this external heat exchanger. Figure 1 depicts the basic arrangement of the equipment.

The operation of the tank heating system was initiated in February 1977. The primary control parameter was the heat exchanger inlet temperature. During normal operation, this temperature was varied between 100-120°F. The range was a function of the change

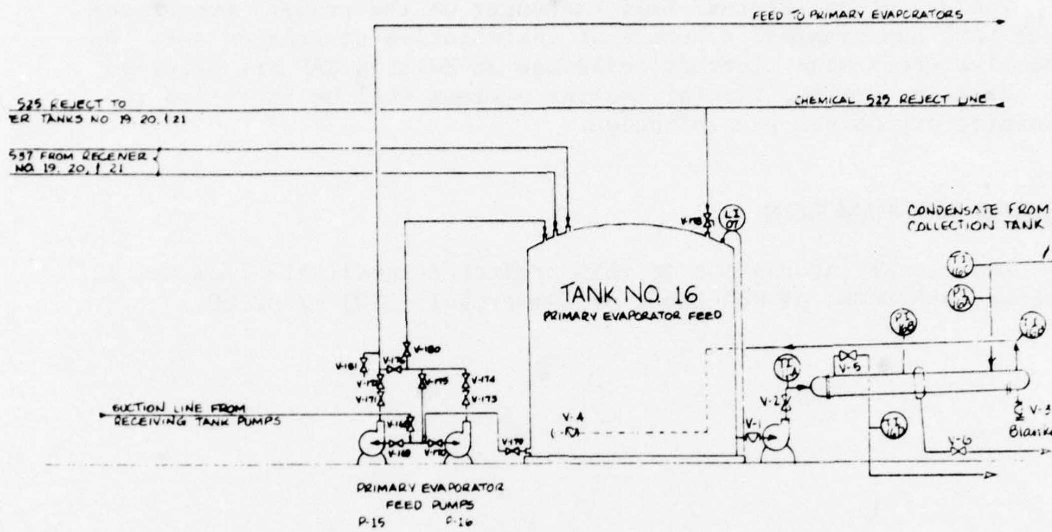

Figure 1 - Schematic of flow streams entering and leaving the feed tank for the primary evaporator.

in the level in Tank 16. As cooler material was transferred from the receiver tanks, the temperature of Tank 16 dropped. Following the completion of the transfer, the temperature would rise until either the next transfer was begun or until heat losses from the tank equalled the heat input. If the temperature of the tank rose significantly above 120°F (during warm weather), the spent acid in the tank would begin to evaporate. When this occurred, some steam condensate was diverted, bypassing the heating system.

The system operated successfully for one year with no significant down time. Scheduled inspections of the primary feed tank indicated no explosives precipitation.

BENEFITS

As a result of this project the explosives load limit of B-line at Holston AAP was reduced to 5,000 pounds. Added benefits include a steam cost savings of $11,000/year since the heat from the steam condensate is now recovered in the form of preheated feed. In addition, the use of hot feed in the feed lines has prevented the buildup of crystallized RDX on the pipe walls thereby eliminating the need for periodic cleaning.

IMPLEMENTATION

The use of an external heat exchanger on the primary evaporator feed tank has remained a permanent installation at Holston AAP. As inactive spent acid recovery buildings at Holston AAP are returned to operating status, similar heating systems will be installed to minimize explosives precipitation.

MORE INFORMATION

Additional information on this project is available from Mr. L. Sotsky, ARRADCOM, AV 880-2160, or Commercial (210) 328-2160.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

Manufacturing Methods and Technology Project No. 573 4245, "Development of a Deluge System to Extinguish Fires Following Accidental Detonation on Conveyor Handling Bulk HE" was completed on February 29, 1976 at a cost of $175,000. The Southwest Research Institute at San Antonio, Texas carried out the work for ARRCOM.

BACKGROUND

Previous test results of conveyor separation distance requirements for 55 lb TNT boxes showed that detonations were propagated at distances of 8 feet or less. Burning of adjacent boxes, however, occurred at distances up to 16 feet. In order to meet production requirements, a separation distance of 12 feet was recommended. At this separation distance (12 feet), there is a safety requirement for a deluge system to extinguish fires resulting from a detonation. Prior to this project, there was no known system that would remain operable following exposure to detonation of a 50-60 lb box of HE on a conveyor.

SUMMARY

A program was conducted by the Southwest Research Institute to design and experimentally test a rapid response water deluge system. A prototype deluge system has been developed that can sustain a high-order detonation from 60 lbs of Composition B and remain operable. The system will also provide an effective means of extinguishing a fire following an accidental explosion.

The planned system has the water lines encased in reinforced concrete at or below ground level. The water supply would be from the plant systems, normally at or about 50 psig. A signal from the detectors would open an explosive deluge valve, and since the downstream piping would already be full of water, flow would be established very rapidly.

Earlier tests indicated that the optimum design for water delivery at maximum stream range would be a solid stream nozzle. Further tests using three of these nozzles indicated that the optimum pressure head was between 15 to 25 psig. At this pressure level, a coarse droplet spray over a reasonable range and area coverage was produced.

The basic elements of the prototype system design are illustrated in Figure 1: (1) a UV detection system with fail safe control circuitry, (2) fast reaction explosive valving, (3) a blast resistant water supply line, (4) straight stream water delivery nozzles, (5) valving and plumbing to allow operational proof testing of the system, (6) excess flow valves, and (7) sufficient flexibility of design to enable zoning operations.

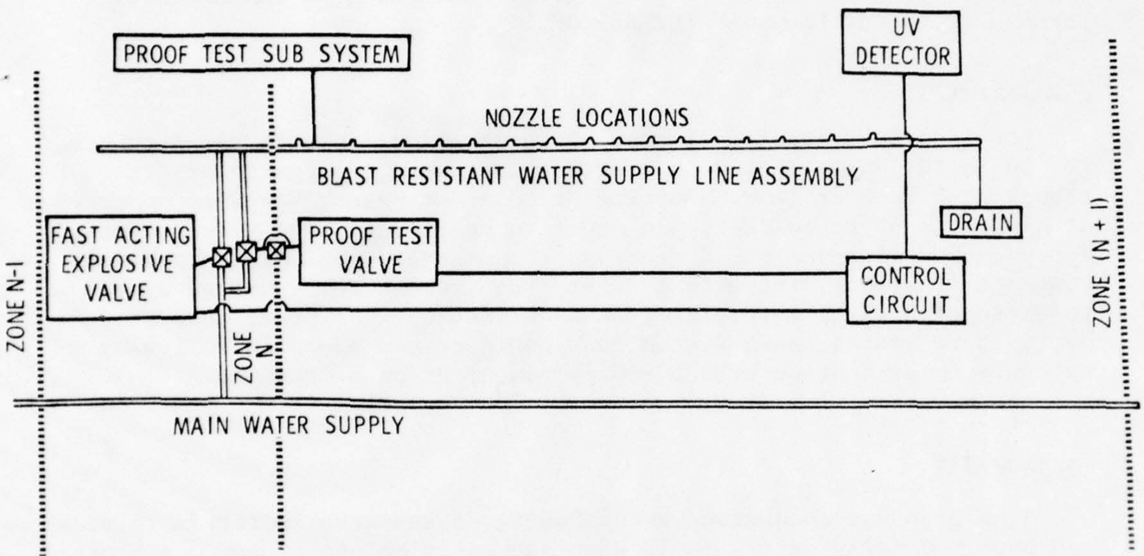

Figure 1 - Basic elements of the water deluge prototype system.

BENEFITS

The benefits to be derived from this program are increased plant safety and reduction of loss or production capability following an accidental detonation of bulk HE on a conveyor. This project will be useful to all operations using explosive materials which would be transported on conveyors.

IMPLEMENTATION

This work is being continued in a follow-on project 575 4245. An evaluation of a full-scale prototype deluge system for effectiveness and reliability in extinguishing a fire following a detonation will be performed. Particular emphasis will be placed upon optimizing the system through design simplicity and inexpensive component parts.

MORE INFORMATION

Additional information may be obtained from Richard Rinder, AV 880-3828 or (201) 328-3828. Technical Report TR 4889 covering the results of this effort was completed, reviewed and published (August 1975).

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 575 4247 titled "Use of Crude RDX in Composition B" was completed by the US Army Armament Research and Development Command in February 1977 at a cost of $200,000.

BACKGROUND

Currently, crude RDX is recrystallized from cyclohexanone in order to remove occluded acid, and to obtain the required particle size distribution. The recrystallized RDX is incorporated with TNT in a 3:2 ratio to produce Composition B. The particle size of the RDX is retained during this incorporation phase. The purpose of the project was to determine whether the crude RDX obtained by crystallization from spent acid could be used directly for incorporation into Composition B without adverse effects on the product loading characteristics and the compatibility of the Composition B in the loaded item. Implementation of this modified manufacturing method of crude RDX would result in significant cost savings by eliminating the recrystallization operation, one of the most time consuming operations in the Composition B manufacturing process.

SUMMARY

The original objective was to develop a process for crystallizing crude RDX using different simmering techniques and acid concentrations. However, because of a change in management priorities, the objective of this project was changed to developing a process for producing Composition B using RDX that was recrystallized from spent acid.

The following is a general description of the procedures used to manufacture crude RDX at Holston AAP. The simmer tanks in two nitrolysis buildings were used for the crystallization operations. After distributing the RDX slurry among the simmer tanks, weak acetic acid was transferred from the filter/wash building and added to each simmer tank to obtain a 3:1 weight ratio of acid to RDX slurry. After adding the acid, the mixture was heated to 100°C, held for 30 minutes, then cooled to 30°C using intermittant heating and cooling cycles. When the batches reached 30°C, samples were taken to be filtered, washed, dried, and incorporated to produce Composition B. If the trial incorporations produced Composition B meeting viscosity specifications, the batch was transferred to the filter/wash building. The product was then filtered and washed twice with water to remove the excess acetic acid. After this operation, the RDX was treated as a normal production run. Figure 1 shows a flow diagram of the normal and modified processes used to manufacture Composition B.

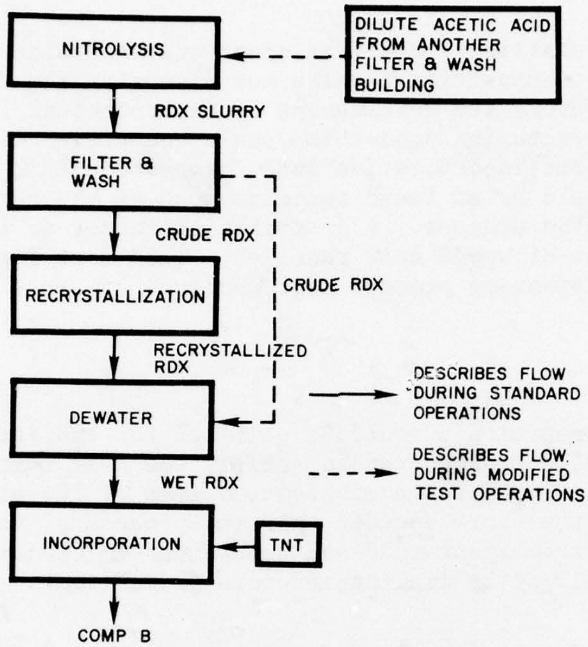

Figure 1 - Flow diagram for production of Composition B.

Holston AAP facilities produced six batches of RDX crystallized from spent acid medium. The acid crystallization provided RDX crystals that met the particle size distributions as specified for nominal Class I RDX. However the acid content which usually exceeded 0.2% by weight did not meet the specified value of 0.02% by weight. The acid-crystallized RDX was incorporated into Composition B using Holston AAP production facilities and was referred to as Comp B/AA.

Comp B/AA and the crystallized RDX were subjected to specification and laboratory tests including composition analysis, viscosity, friction pendulum, impact sensitivity, electrostatic sensitivity, large scale gap and detonation rate by ARRADCOM. The results of these tests indicated no significant difference between Comp B/AA and standard Composition B. However, vacuum stability tests at 120°C for crystallized RDX and Comp B/AA exhibited more than twice the gas evolution as compared to the standard materials.

The Comp B/AA was loaded into 105mm, HE M1 Projectiles and storage tests were begun at Iowa AAP. The normal loading temperature 173°F to 178°F, could not be employed since it resulted in numerous voids for all charges. Acceptable casts were produced by increasing the temperature to 182°F - 189°F and increasing the agitator speed.

BENEFITS

The process of crystallizing RDX from spent acid and directly incorporating it into a new Composition B which met viscosity requirements was accomplished. However, the development of an economical large scale process for manufacturing production scale quantities of spent acid crystallized RDX for incorporation into Composition B is doubtful, since the cost would be at least twice as much as the current solvent recrystallization process. A contributing factor to this high cost is the volume of spent acid required. This cost factor makes the acid crystallization process unattractive.

IMPLEMENTATION

Before the new composition B would be utilized for end items, a costly test program would be required to satisfy the user that the performance of the new Comp B was equivalent to that of the standard Comp B. ARRADCOM has therefore decided that the process of the use of recrystallized RDX from spent acid and subsequent incorporation into composition B will not be implemented into production.

MORE INFORMATION

Additional information on this project is available from Mr. S. Dollman, ARRADCOM, Autovon 880-3717, or Commercial (201) 328-3717.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 574 4249 and 575 4249 entitled "Separation of Fine Explosives from Spent Acid and/or Water Slurries" was completed by the US Army Armament Research and Development Command in May 1977 at a total cost of $163,000.

BACKGROUND

One of the major bottlenecks at Holston AAP in the manufacture of HMX explosive compositions has been the washing and filtering of the fine particle distributions. The present method (Figure 1) of separating of fine explosives from spent acid or water slurries is a very inefficient batch method which requires approximately 16 to 20 hours for each 1,000 pound batch. This is a major limiting factor inherent in the production of HMX.

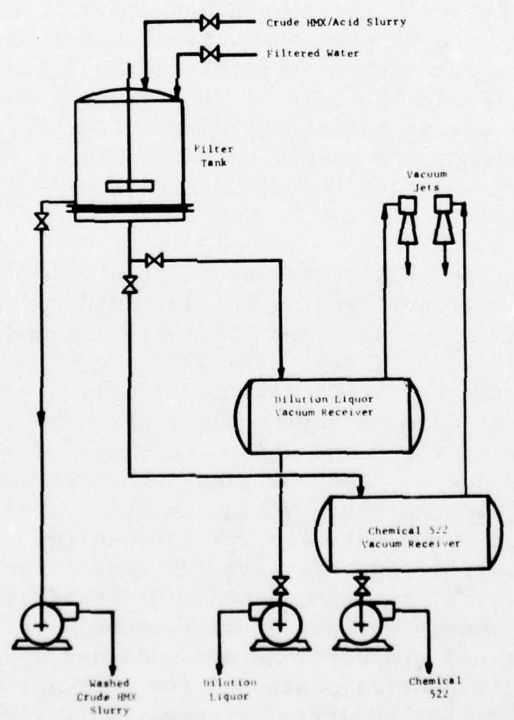

Figure 1 - Schematic Flowsheet of Existing Process for Separation of Fine Explosives from Spent Acid or Water Slurries.

SUMMARY

The purpose of the program was to develop improved methods for separating fine HMX and RDX from spent acid/water slurries and to double the amount of fine HMX and RDX recovered as compared to the present rate. Emphasis was placed on recovery of fine HMX since this represented the most demanding processing conditions. It was assumed that improved recovery of fine RDX required only adaptation of existing traveling belt filter technology.

Previous studies showed that water slurries of fine HMX or RDX and acid slurries of RDX could be efficiently and safely filtered using a horizontal traveling belt filter. Pilot plant tests using the 1 x 12 foot pilot Eimco Extractor demonstrated excellent filtration and displacement washing of crude HMX slurries in the temperature range of 26° to $54^{\circ}C$. Several problems were encountered, however, such as excessive cloth blinding, low HMX purity, and deterioration of the elastomer support belt at process temperatures. HMX purity is normally maintained by removal of the RDX in the liquid phase by filtration at or above the average saturation temperature of $55^{\circ}C$. Chemical resistance tests of the best available elastomers for the support belt indicated that none were suitable for use at these temperatures. Continuing analysis of the crude HMX filtration problem indicated a requirement for filtration equipment capable of filtering crude HMX/acid slurries at temperatures ranging from 55° to $80^{\circ}C$. Various methods of separating fine solids from liquids were surveyed for efficiency and safety with respect to explosives processing. The most promising techniques and equipment were evaluated on a laboratory scale.

Several separation techniques were tested and rejected for various reasons. Counter-current leaching was examined and rejected because high local velocity turbulance and thermally induced eddy currents resulted in excessive fines carryover and little or no HMX separations. A dense phase extraction method achieved little or no separation since the solids tended to form an intermediate phase at the liquid interface without entering the dense phase. A visual evaluation of a slit bowl centrifuge indicated that the internal construction, such as metal to metal contacts, unacceptable welds and blind crevices, did not meet the safety standards necessary for HMX processing. Hydrocyclones were considered as a possible substitution for centrifuges, however, they were unsatisfactory in operation because of low centrifugal force fields which resulted in excessive loss of fine material. A combination of an inertial filter and hydrocyclone was considered but was rejected because of excessive pumping costs and the need for an additional final filter for the HMX underflow slurry. Bulk flotation was evaluated and found unacceptable because of low separation efficiency and high equipment costs.

A detailed analysis of the aforementioned techniques with respect to safety, economy and reliability indicated that the use of a horizontal traveling belt filter was the preferred method of recovering

fine HMX and RDX from water or acid slurries.

An equipment survey was then made to locate a horizontal belt filter that did not require a rubber drainage belt. This led to the consideration of the Bird-Pannevis filter which had been used in Europe for several years to filter many diverse products. Laboratory tests, observations of operating Bird-Pannevis filters, and prior experience indicated that this type of filter should be successful for filtering fine HMX. A design criteria for this type of filter was completed and future year efforts were planned which would procure and install this filter equipment for evaluation.

BENEFITS

An analysis of various separation techniques resulted in the conclusion that the Bird-Pannevis horizontal filter was the preferred method for recovering fine HMX and RDX from water or acid slurries.

IMPLEMENTATION

Follow-on projects for FY7T and FY76 were planned for the procurement, installation and evaluation of the Bird-Pannevis Filter.

MORE INFORMATION

Additional information on this project is available from Mr. S. Dollman, ARRADCOM, AV 880-3717, or Commercial (210) 328-3717.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

Manufacturing Methods and Technology project 575 4267 titled "Continuous Process for Granular Composition B" was completed by the US Army Armament Research and Development Command in February 1977 at a cost of $80,000.

BACKGROUND

Granular Composition B has been designated at an alternate fill for Composition A-5 for use is munitions. The present process for making granular Composition B is the batch water slurry process. Composition B is melted in a water slurry and using vigorous agitation, cooled below the solidification temperature of TNT and wax to effect granulation. The slurry is then filtered and the granular Composition B dried to a product in prilled form. The main disadvantages associated with this batch granulation process are the limited regulation and control available to change granulation size, particle distribution, cooling and agitation rates, and throughput capacity.

SUMMARY

The objective of this project was to develop a continuous method for producing granular Composition B with more efficient control of process parameters, granulation and bulk density.

A laboratory investigation was conducted by Holston AAP on various methods of producing granular Composition B. These methods included spray drying, coating pan, extruding, continuous water slurry, and prilling.

Spray drying techniques were found to be unsuitable because the granule size obtained was too small relative to specification requirements.

Coating pan techniques involved gradual cooling of molten Composition B to below the solidification temperatures in a rotating drum. Problems included lack of granulation control and sticking of the product to the coating pan.

In the extrusion process, molten Composition B just above the melting point was forced through a small orifice. The strands or threads formed were then broken into granules. Solidifying and plugging of the extrusion orifices made the process unsuccessful.

The continuous water slurry process required separate feeds of RDX, TNT, wax and recycled red water to a cascading tank system. TNT and wax were kept molten (90°C) in the first tank, this molten slurry flowed to the second tank (75°C). Composition B solidified and formed granules in the second tank while being agitated. The slurry then flowed to the third tank where it was cooled to 70°C. The slurry was then filtered and dried in Jetzone driers. This process had the disadvantage of limited throughput capacity.

Prilling or spray congealing involved feeding molten Composition B through an orifice, atomized by jets of air, and allowing it to fall through a cylindrical tower against a countercurrent flow of air to solidify the Composition B into prills or granules.

As a reslut of the preceding laboratory studies, the prilling method was determined to be the best method for producing large quantities of granular Composition B. A prilling tower was constructed at the pilot plant (Figure 1).

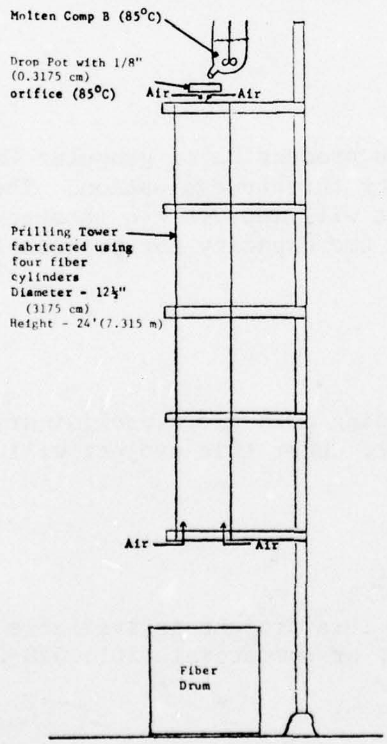

Figure 1 - Laboratory Prilling Tower for Granular Composition B.

The tower, composed of four fiber cylinders, was 12-1/2 inches in diameter and 24 feet high. The melt vessel and drop pot at the top of the tower was steam heated to 85°C. Molten Composition B was fed to the drop pot to maintain a 0.5-inch melt head, and was discharged through a 0.125-inch orifice into the top of the tower. The stream of Composition B was atomized by jets of air and cooled by falling through a counter current flow of air to produce prills of Composition B.

Scale up of the prilling process was then contracted to Niro Atomizer Inc., since there was a lack of adequate test facilities at Holston AAP. Since the contractor did not have explosive type facilities, an "inert Composition B" was used for the tests. During the tests, two types of atomizers were evaluated, the centrifugal wheel and hydraulic nozzle. Results from these tests indicated that the hydraulic spray nozzle was more successful in producing the particle size of granular Composition B desired than the centrifugal wheel. As part of the contract effort, Niro Atomizer prepared a design based on the hydraulic atomizer which was modified after being reviewed at Holston AAP. Several areas of the process identified as potential hazards will be evaluated by a hazards analysis in the follow-on effort.

BENEFITS

A prilling process for the production of granular Composition B was selected as a candidate for further evaluation. The successful completion of this development will improve the throughput, lower operating costs, and increase the capacity for producing granular Composition B.

IMPLEMENTATION

A technical report containing data and a preliminary design was prepared. Information obtained under this project will be utilized in the follow-on effort.

MORE INFORMATION

Additional information in this project is available from Mr. L. Sotsky, ARRADCOM, AV 880-2160, or Commercial (201) 328-2160.

Summary report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

Manufacturing Methods and Technology (MM&T) project 576 4284 entitled "Programmable Fluidic Control System for LAP Machinery" was completed by the US Army Armament Research and Development Command in June 1977 at a cost of $160,000.

BACKGROUND

The most suitable presently available control media for use in simple loading, assembling & packaging (LAP) equipment is moving part logic pneumatic systems and fluidic logic systems. Well designed logic components of either of these types are very reliable and inherently safe in explosion hazard environments. However, these systems become very cumbersome if more than 50 to 75 logic elements are required. For more complex control systems, the most suitable presently available is electronics in the form of programmable controllers and minicomputers. They are reliable and easy to maintain, however, they are expensive and represent an explosion hazard if not properly packaged. This project was funded for the development of a fluidic programmable controller that controls systems comprised of 20 to 500 logic elements, more efficiently than any available control technique, and without explosion hazards. Project work was accomplished by in-house work at Picatinny Arsenal and by contractual work by EMX Engineering Inc., Cedar Grove, NJ.

SUMMARY

The purpose of this project was to investigate and develop fluidic control systems that are capable of being applied to a wide range of LAP equipment. A portion of this investigation included the collection, categorization and comparison of sensing hardware that is available and applicable to the Army's Plant Modernization Program.

Engineering efforts were directed toward the evaluation of available fluidic systems and components. The data would be used to prepare specifications prior to contract awards of prototype systems in the future. The contractor designed and fabricated a display panel for the purpose of demonstrating a representative sample of sensors available on the market today and also to show their advantages and disadvantages. The entire display system is self-contained (See Figure 1). The system was demonstrated to show that this type control can be applied to LAP production lines. It was operated under conditions closely resembling a production environment.

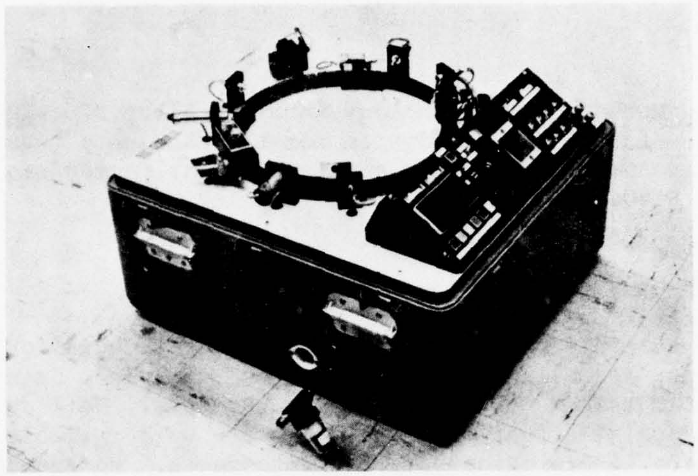

Figure 1 - Sensor display control panel with lid off.

BENEFITS

The project did not directly result in cost savings in that the control system developed was only for demonstration purposes and was not to be directly applied to the production line. Adaptation of the fluidic controller would result in better maintainability, more flexible control systems and improved adaptability for computer control. The display panel demonstrated some of the sensors that are readily available. The Sensors & Controls Handbook provides a reference for the selection of available sensors and controls together with the manufacturers.

IMPLEMENTATION

This information was compiled into a document entitled, "Sensors & Controls Handbook", and can be used to assist engineers in the proper selection of control hardware. The Sensors & Controls Handbook was distributed to ammunition load plants and other interested personnel. The display panel is at ARRADCOM for demonstration purposes. Final reports have been distributed to other government installations and demonstrations have been given for personnel from PM, PBM&E.

MORE INFORMATION

Additional information on this project is available from S. Bernhardt, ARRADCOM, Dover, NJ, (201) 328-6507 or AUTOVON 880-6507. A Technical Report ARLCD-TR-78034 entitled "A Guide to Sensor Selection" dated September 1978, Attn: DRDAR-TSS, Dover, NJ is also available.

Summary Report was prepared by the Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Projects 574 6551 and 575 6551 entitled "Improved Methods for Spherical Propellant Manufacture" were completed on December 15, 1977 for ARRADCOM at costs of $235,000 and $231,000 respectively.

BACKGROUND

A major operation in the manufacture of ball propellant is the actual formation of the spherical particle. This is currently done by means of a batch agitator-induced breakup of a large irregular lacquer suspended in a solvent-aqueous medium. The best yield achieved for usable particle sizes has been less than 60% of the feed. Future modernization plans and mobilization requirements suggest exploration of improved sphere-formation methods to minimize or eliminate this inefficiency.

Two widely different "shock" processes were selected for study. These are (1) Shock-Gel and (2) Shock-Nitration. The Shock-Gel approach uses previously prepared nitrocellulose (NC) and a solvent but Shock-Nitration starts with cellulose and nitric acid (HNO_3).

SUMMARY

Shock-Gel

Briefly, the Shock-Gel process consists of dissolving fibrous nitrocellulose in a water soluble solvent to form a syrup. The syrup is then forced through a multi-perforated plate to form streams which break up into spherical droplets and fall into a gelling bath. There the NC precipitates out of solution and forms a spherical membrane with the syrup trapped inside. When the gels are dried, they shrink irreversibly into dense balls of hard, horny NC.

Four NC-solvent, Shock-Gel systems have been studied:

a)	12.6% Nitrogen (N)	diethylene glycol (DEG)
b)	13.15% N (by blending)	DEG/diethylene glycol monomethyl ether (MEC)
c)	13.15% N (directly nitrated)	DEG/MEC
d)	13.4% N	MEC

The 13.4% N MEC System was found to be superior. A preliminary flow sheet for a continuous Shock-Gel process is shown in Figure 1.

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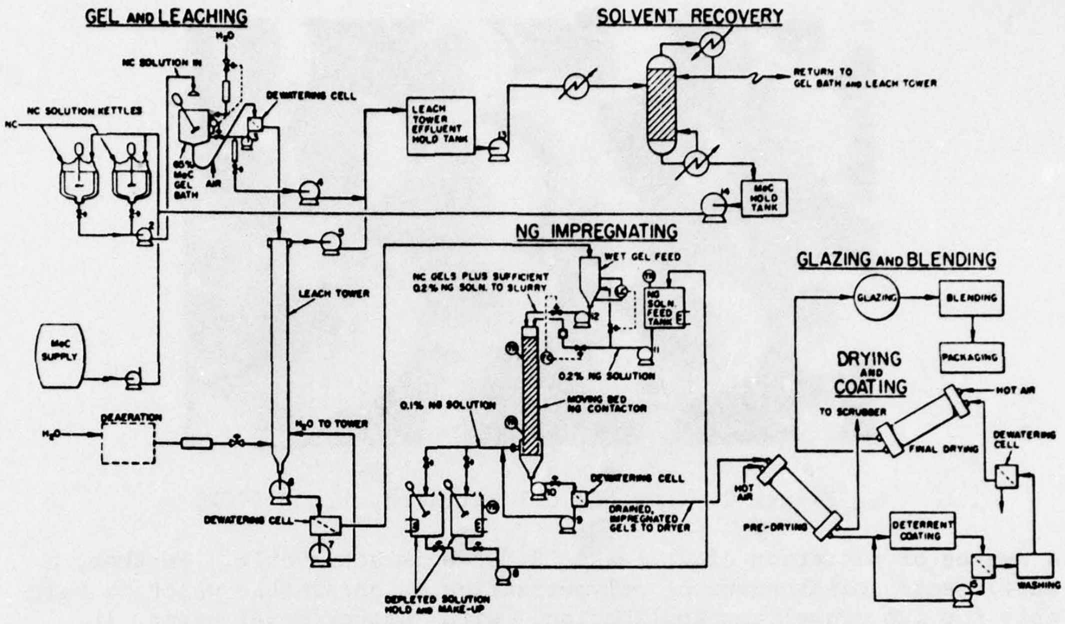

Figure 1 - A schematic for the continuous Shock-Gel process.

The project studies have proved that Shock-Gel is a feasible processing technique. In fact, it appears to be the most economical alternative to the present system at the moment. However, it does still require a ballistic-tailoring program to make a reproducibly acceptable product. An advantage of the process is that it is unlimited with respect to particle size. It is literally possible to produce a range of sizes from angstroms to millimeters in diameter.

Shock-Nitration

Since it is so different, Shock-Nitration represents a rather radical departure in small arms propellant processing technology. It consists of mixing white fuming nitric acid (WFNA) and a slurry of cellulose in 75-85% HNO_3 at a controlled rate and temperature. As the two components mix, a solution of Nitrocellulose in Nitric Acid of the desired initial acid concentration is formed. The nitrocellulose is recovered by first forcing the solution through orifices in a "streaming" head. The resultant droplets fall into a gelling bath where the nitrocellulose precipitates out. Figure 2 shows the good sphericity obtainable from this process.

Shock-Nitration studies advanced to the point where a continuous process was designed and set up. Only two continuous gel nitrations could be conducted with available funding. The basic mechanism by which fluctuating nitration levels occur is not fully understood but continuous gel nitration is definitely possible. Nitrocellulose with

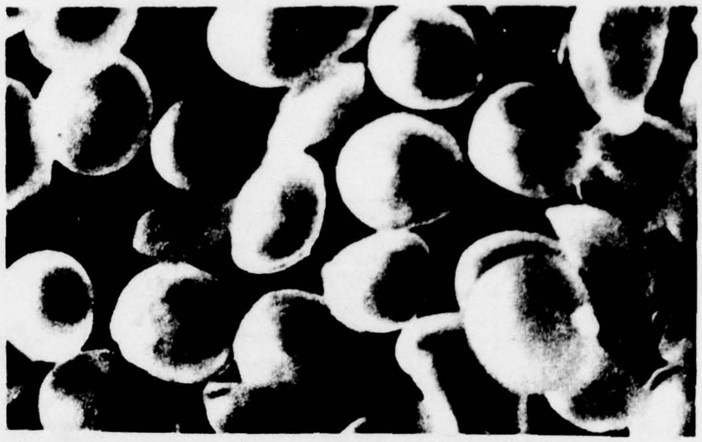

Figure 2 - Dry NC, Gel nitrated, 12.5N (20X)

a degree of nitration of at least 13.39% N is achievable. Further, a sufficiently high degree of polymerization is obtainable which is suitable for gun propellant application. With further development, it should prove capable of producing a uniform, highly nitrated product.

BENEFITS

In a sense, the projects were successfully completed. If grass roots facilities were needed to meet expanded small caliber propellant requirement, both of the continuous "shock" processes investigated, especially Shock-Gel, would be competitive with the existing batch process. However, some additional development would be required for each one.

IMPLEMENTATION

There appears to be no immediate need for additional small caliber propellant facilites. An economic analysis showed that the least expensive alternative, at the moment, would be to retain the existing process at Badger virtually intact. Hence, there is no plan for implementation in terms of facilities at present.

MORE INFORMATION

Additional information on this project is available from Messrs. Joel M. Goldman and Robert M. Pizzola, AV 880-4615.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

NON-METALS

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

Manufacturing Methods and Technology projects 373 3044 and 374 3044, titled "Production Methods for High Temperature Solid Propellant Motor Nozzles" were completed by the US Army Missile Command in July 1976 at a cost of $281,000.

BACKGROUND

Current solid propellant rocket nozzles are multi-component structures joined together by various techniques. Research in advanced refractory materials has resulted in the possibility of using one-piece nozzles. The advantage of one-piece nozzles are lower production times and cost because of the reduced number of machining operations. The object of the project was to make available the processing techniques for one-piece solid propellant rocket nozzles. Operating conditions that the nozzles must withstand are a maximum combustion temperature of 6,000^{o}F, a motor operating pressure of 2,000 p.s.i., and a nozzle flow rate of 100 lb/sec., all for a period of 20 seconds.

SUMMARY

Phase I of the project developed the manufacturing techniques and testing for prototype nozzles. One carbon-phenolic and two carbon-carbon nozzles were fabricated and tested in sub-scale firings.

Two fabrication techniques were developed for the carbon-carbon nozzles: chemical vapor deposition (CVD) and resin cloth densification. The carbon-carbon nozzle with the resin densified cloth was found to be superior to the CVD carbon-carbon nozzle.

The densification method begins with a base material of graphite cloth prepeg resin. The layup pattern was in a radial-circumferential plane to reduce interlaminar cracking. After the layup, the resin underwent a pressure cure at 300 - 400^{o}F. The density is increased by successive carbonization and resin impregnation cycles. The first cycle is the most critical because rapid expansion and shrinking can damage the nozzle. Gases evolved must escape without causing damage. The final cycle results in a density greater than 1.45 g/cm3 and a final resin impregnation that is not carbonized.

The CVD method (Figure 1) deposits a carbon matrix in the carbonized felt by thermal decomposition of a hydrocarbon gas.

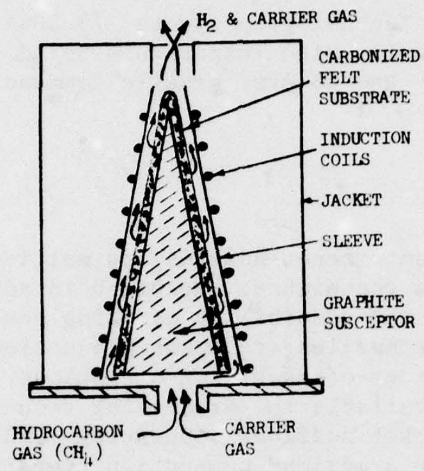

Figure 1 - Chemical Vapor Deposition is a continuous method for densifying carbon-carbon rocket nozzles.

A temperature gradient formed by inductive heating induces initial deposition on the inner surface. This is a continuous process with deposition steadily progressing outward as the densified substrate becomes inductively heated.

Phase II of the project was the development and testing of two full scale carbon-carbon nozzles made by resin cloth densification. One of the nozzles is shown in Figure 2.

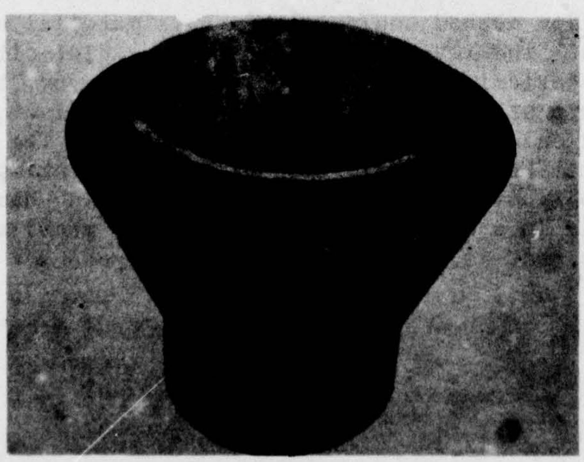

Figure 2 - Full scale carbon-carbon nozzle made by resin cloth densification.

During the initial carbonization cycle, both nozzles developed interlaminar cracks. These cracks filled somewhat during subsequent densification cycles. The full scale nozzles underwent a graphitization at 5,000°F after the final resin impregnation. After machining, X-rays detected cracks in one nozzle and cracks were visible to the naked eye in the second.

A full scale test was conducted in December 1975. The nozzle was able to withstand a severe motor environment with an acceptable erosion rate. Cracks occurred in the aft end section and some material was ejected from the exit cone.

The work was accomplished with in-house work by the U.S. Army Missle Command and contractural work by Hercules, Inc.

BENEFITS

Development of a one-piece solid propellant nozzle has resulted in an increase in knowledge in the production areas of suitable materials, layup methods, densification and graphitization.

IMPLEMENTATION

Copies of the final report have been distributed to the appropriate missile system project managers. This information has been made available to the Defense Advanced Research Project Agency Support Office, the Advanced Missile Systems Concepts Office, and the Defense Documentation Center.

MORE INFORMATION

Additional information on this project is available from Mr. William S. Crownover, US Army Missile Command, AUTOVON 746-5821 or (205)876-5821.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

Manufacturing Methods and Technology project 573 4906 entitled "Effect of Varying Processing Parameters in the Fabrication of Adhesives Bonded Structures" was completed by Picatinny Arsenal in June 1976 at a cost of $55,000.

BACKGROUND

This project was initiated to develop new and improved process control procedures which would significantly improve the reliability and durability of adhesive bonds used in the production of conventional and nuclear materiel. During the past few years limited work relating to process studies has been done utilizing R&D funds. The results illustrated the extreme criticality of lapsed time between surface treatment of adherends and adhesive bonding. It was also apparent that most bonding operations are dissimilar which then requires a specific set of process conditions adapted to accommodate such factors as type adherend, geometrical configuration of the joint, magnitude of anticipated joint stress, type adhesive, and type of surface preparation. Process controls fail for the most part to consider these dissimilarities.

SUMMARY

The objectives of this effort were the development of improved adhesive bonding methodologies, the solving of current and potential bonding problems for advanced Army applications, and the improvement of numerous military end items whose construction already places heavy reliance on adhesives and sealants. This program was accomplished by in-house effort at Picatinny Arsenal and contractual efforts by Boeing Company and Stevens Institute.

The effort included a comparison of the effect of various pretreatments on the durability of metallic adherends when bonded together using adhesives common to military usage. Outdoor stressed exposure and controlled-environment stressed exposure of single lap shear specimens were the basic approaches used. Specimens were continually made and exposed to the various environments in order to predict how adhesive-bonded joints would withstand atmospheric and climatic conditions such as temperature, humidity, wind, and rain. The adhesive-adherend systems evaluated were chosen on the basis of various military uses such as in helicopter paneling or in munition items.

Two types of lap shear specimens were prepared. Those for outdoor exposure contained a 1.27cm x 1,27cm bonded area. Those for the controlled environment contained a 1.27cm x 2.54cm bonded area. All adherends were fabricated from 0.159cm sheet stock except for the copper which was 0.318cm thick. The specimens were bonded under air pressure in a "mini-clave", a clam shell type autoclave, in an electrically heated hydraulic press. The metallic adherends used in this program were 2024-T3, 5052-H38, 6061-T6, 7075-T6aluminum alloys; copper alloy, 302 stainless steel, CP and 6.4 titanium alloys. Adhesives used were primarily film type Reliabond 7114, liquid type Loctite 308, film type AF 126-3, and paste type EC 2214 R. A typical durability curve is shown in Figure'1.

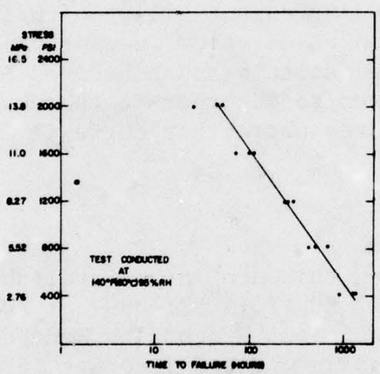

Figure 1 - Durability Curve AF 126-2 Adhesive, Acid Etched Stainless Steel

Some of the results of the program are as follows:

a. Bonds to aluminum adherends which have been properly chromic acid anodized and sealed can withstand outdoor aging for periods of five years without any substantial loss of strength.

b. The bonds to phosphate-fluoride-treated titanium are more durable than those to alkaline-cleaned titanium.

c. The bonds of the phosphate-fluoride-treated 6.4 titanium are sensitive to stress during the outdoor aging period and generally show a decrease in strength which is a function of the stress level under which the specimens were aged.

d. Joints in which 7075-T6 aluminum are bonded to 4340 steel with EC 2214 R adhesive show very good durability.

BENEFITS

On the basis of this program, the relationship of process variables, strength, reliability, and useful life of bonded items, the design allowables for bonded and sealed structures can be more accurately fixed. Thus, more efficient structures can be produced at significantly lower cost, requiring less maintenance, and having longer life. Quality production can be insured by employing adequate process controls during production.

IMPLEMENTATION

This program provided a basis for revision of several specifications to incorporate provisions and/or compatibility with/for adhesive bonding. A complete processing handbook (see below) was prepared for the production of components utilizing sealants and adhesives bonding. Military specifications will be revised to incorporate the new developments and to establish bonding procedures where they currently do not exist.

MORE INFORMATION

Additional information on this project is available from Mr. William C. Tanner, Picatinny Arsenal, AC (201) 328-3807 or AUTOVON 880-3807. Technical Report No. 4883 entitled "Processing Handbook on Surface Preparation for Adhesive Bonding", dated December 1975 and Technical Report No. 4917 entitled "Durability of Adhesive Bonds to Various Adherends", dated June 1976, discuss this program in more detail.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 773 3524 titled "Modular Synthetic Light-weight Camouflage Screens" was completed by the U.S. Army Troop Support Command in June 1975 at a cost of $1,135,000.

BACKGROUND

This project is the last phase of a 3-year effort to design and fabricate equipment for manufacture of a new modular synthetic light-weight camouflage screening system. Modular nets can be joined with no break in the camouflage pattern. The existing Standard A burlap garnished cotton twine net has been declared unsuitable and obsolete in view of new operational requirements. This is the only domestic project in existence concerned with the development of any type of camouflage screening system. Military camouflage screens are used in all weather environments for defense against radar, visual and photographic surveillance.

SUMMARY

The objective of this project was to develop new manufacturing methods and techniques for efficient and economical mass production of a new modular synthetic lightweight camouflage screening system. The production tooling includes equipment necessary for producing radar scattering garnish, application of garnish to netting in prescribed patterns and simplified production of support hardware and transport cases. Production tooling was designed and developed for automatic fabrication.

The camouflage net is made radar active by the incorporation of steel fibers. A radar passive net can also be made by not including the steel fibers.

The matrix distribution machine (MDM), Figure 1, is the center of the system. Its main function is to apply and affix conductive fibers in a random orientation to a porous spun-bonded nylon substrate. The substrate with the fibers attached makes up the radar active camouflage net. Radar waves in X and Ku bands interact with the steel fibers, which prevents the shape of the object under the net from being distinguished. The MDM system is probably the most important and most complex of the manufacturing systems for lightweight camouflage screening systems. But the basic technology is drawn from the paper making industry and is within the proven state-of-the-art.

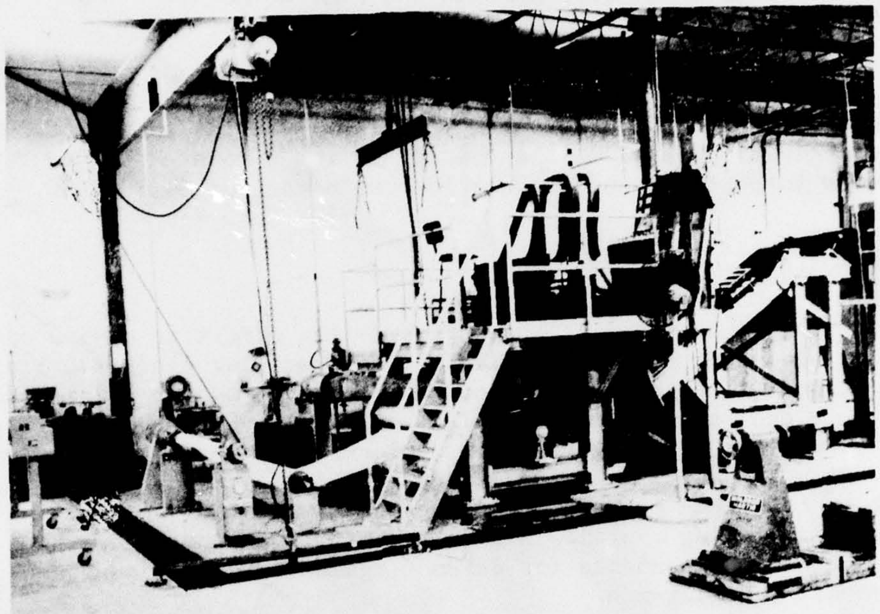

Figure 1 - The matrix distribution machine randomly applies and affixes conductive fibers to a nylon substrate.

Previously, vinyl coatings impregnated the nylon fibers resulted in a low tear strength. The newly developed double transfer process does not impregnate the nylon fibers. Therefore, each fiber must be broken individually resulting in a much higher tear strength. The double transfer process also has a more even coating than other coating methods.

A microwave monitor was installed to provide in-process measurement of the microwave properties of coated netting. The system has the ability to measure transmission and reflection at top conveyor speed of 60 ft/min. A fault marking system is incorporated to mark any out of specification material.

BENEFITS

The completion of this project resulted in production tooling which is capable of producing 65,000 screen modules per year. The new camouflage nets have a life of two years compared to the Standard A burlap nets which had a life of six months. Previously, nets were manufactured by hand, with a corresponding high cost.

IMPLEMENTATION

The camouflage screening net is now in production. Equipmen producing 20,000 units is in operation at the Brunswick plant in Deland, Florida. There is another set of equipment producing the same quantity at Devil's Lake, North Dakota.

MORE INFORMATION

Additional information on this product is available from Mr. K. L. Whiteside, Countersveillance and Topographic Division, Military Technology Dept., MERADCOM, AV 354-5517.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

APPENDIX I

ARMY MM&T PROGRAM OFFICES

ARMY MM&T PROGRAM REPRESENTATIVES

HQ, DARCOM US Army Materiel Development and Readiness Command ATTN: DRCMT 5001 Eisenhower Avenue Alexandria, VA 22333	C: 202 274-8284/8298 AV: 284-8284/8298
IBEA US Army Industrial Base Engineering Activity ATTN: DRXIB-MT, Mr. James Carstens Rock Island, IL 61299	C: 309 794-5113 AV: 793-5113
ARRADCOM US Army Armament R&D Command ATTN: DRDAR-PML, Mr. Donald J. Fischer Dover, NJ 07801	C: 201 328-6714 AV: 880-6714
ARRCOM US Army Armament Materiel Readiness Command ATTN: DRSAR-IRB, Mr. August Zahatko Rock Island Arsenal Rock Island, IL 61299	C: 309 794-4485/3730 AV: 793-4485/3730
AVRADCOM US Army Aviation Systems R&D Command ATTN: DRDAV-EXT, Mr. Robert Vollmer 12th & Spruce Streets St. Louis, MO 63166	C: 314 268-6476 AV: 698-6476
CERCOM US Army Communications & Electronics Materiel Readiness Command ATTN: DRSEL-LE-R, Mr. Martin Ides Fort Monmouth, NJ 07703	C: 201 532-4950 AV: 992-4950
CORADCOM US Army Communications R&D Command ATTN: DRDCO-PPA-TP, Mr. Al Feddeler/Sam Esposito/Burton Resnic Building 2700 Fort Monmouth, NJ 07703	C: 201 535-4262 AV: 995-4262
ERADCOM US Army Electronics R&D Command ATTN: DELET-DS, Mr. Joseph Key/Bernard Reich Fort Monmouth, NJ 07703	C: 201 535-4829 AV: 995-4829
MERADCOM US Army Mobility Equipment R&D Command ATTN: DRDME-U, Mr. S. O. Newman Fort Belvoir, VA 22060	C: 703 664-4221 AV: 354-4221

MIRADCOM
US Army Missile R&D Command
ATTN: DRDMI-EAT, Mr. Ray Farrison C: 205 876-1835
Redstone Arsenal, AL 35809 AV: 746-1835

MIRCOM
US Army Missile Materiel Readiness Command
ATTN: DRSMI-NSS, Mr. Alfred H. James C: 205 876-3025
Redstone Arsenal, AL 35809 AV: 746-3025

NARADCOM
US Army Natick R&D Command
ATTN: DRDNA-Z, Mr. Edward F. Levell C: 617 653-1000, x2793/4
Natick, MA 01760 AV: 955-2349/2351

TARADCOM
US Army Tank-Automotive R&D Command
ATTN: DRDTA-KP, DRDTA-RCK, Mr. J. Chevalier C: 313 573-2065/1814/2467
Warren, MI 48090 AV: 273-2065

TARCOM
US Army Tank-Automotive Materiel Readiness Command
ATTN: DRSTA-EB, Mr. Basel Armstead C: 313 573-2485
Warren, MI 48090 AV: 273-2485

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US Army Test & Evaluation Command
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APPENDIX II

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PM, DCS (Army) Communications Systems, Attn: DRCPM-COM (ERADCOM)
PM, Division Air Defense (DIVAD) Gun, Attn: DRCPM-ADG (ARRADCOM)
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PM, Fighting Vehicle Armament, Attn: DRCPM-FVA (TARADCOM)
PM, Fighting Vehicle Systems, Attn: DRCPM-FVS (TARADCOM)
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PM, M60 Tank Development, Attn: DRCPM-M60TD (TARCOM)
PM, M60 Tank Production, Attn: DRCPM-M60TP (TARCOM)
PM, M110E2, 8-Inch Howitzer, Attn: DRCPM-M110E2 (ARRCOM)
PM, M113/M113A1 Family of Vehicle Readiness, Attn: DRCPM-M113 (TARCOM)
PM, Mobile Electric Power, Attn: DRCPM-MEP (Springfield, VA)
PM, Multi-Service Communications Systems, Attn: DRCPM-MSCS (CORADCOM)
PM, Munitions Prod. Base Mod. and Exp., Attn: DRCPM-PBM-DP (ARRADCOM) (6 cys)
PM, Navigation Control Systems (NAVCON), Attn: DRCPM-NC (ERADCOM)
PM, Nuclear Munitions, Attn: DRCPM-NUC (ARRADCOM)
PM, PATRIOT, Attn: DRCPM-MD (MIRADCOM)
PM, PERSHING, Attn: DRCPM-PE (MIRADCOM)
PM, Remotely Monitored Battlefield Sensor Systems (REMBASS), Attn: DRCPM-RBS (ERADCOM)
PM, 2.75 Rocket System, Attn: DRCPM-RK (MIRADCOM)
PM, SATCOM, Attn: DRCPM-SC (ERADCOM)
PM, Selected Ammunition, Attn: DRCPM-SA (ARRADCOM)
PM, Signal Intelligence/Electronic Warfare (SIGINT/EW), Attn: DRCPM-SIEW (CERCOM)
PM, Single Channel Ground and Airborne Radio Subsystem (SINCGARS), Attn: DRCPM-GARS (CORADCOM)
PM, Smoke/Obscurants (SMOKE), Attn: DRCPM-SMK (APG)
PM, Special Electronic Mission Aircraft (SEMA), Attn: DRCPM-AE (TSARCOM)
PM, Stand-off Target Acquisition System, Attn: DRCPM-STA (ERADCOM
PM, STINGER, Attn: DRCPM-MP (MIRADCOM)
PM, TOW-DRAGON, Attn: DRCPM-DT (MIRCOM)
PM, Training Devices, Attn: DRCPM-TND (Orlando, FL)
PM, US ROLAND, Attn: DRCPM-ROL (MIRADCOM)
PM, VIPER, Attn: DRCPM-VI (MIRADCOM)
PM, XM-1 Tank System, Attn: DRCPM-GCM (TARADCOM)

<u>Project Officers:</u>
PO, Joint Services Interior Intrusion Detection System (J-SIIDS), Attn: DRSTS-KJ
PO, M60A1 Tank Camouflage Pilot Program, Attn: DRXFB-RT
PO, SLUFAE/SLUMINE, Surface Launch Unit Fuel Air Explosive (SLUFAE) Mine Neutralization System/Surface Launched Unit Mine (SLUMINE) Dispensing System, Attn: DRDME-NS (Ft. Belvoir)
PO, Stand-Off Target Acquisition/Attack System (SOTAS), Attn: DRSEL-CT
PO, Test, Measurement, and Diagnostic Equipment, Attn: DRCRE-T (DARCOM)
PO, Tactical Shelters, Attn: DRXNM-UBS

<u>Major Subcommands:</u>
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Cdr, ARRADCOM, Attn: DRDAR
Cdr, ARRADCOM, Attn: DRDAR-TDA, Mr. Joe Blick
Cdr, AVRADCOM, Attn: DRDAV
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Arsenals:
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Cdr, Hawthrone AAP, Attn: SARHW
Cdr, Holston AAP, Attn: SARHO
Cdr, Indiana AAP, Attn: SARIN
Cdr, Iowa AAP, Attn: SARIO
Cdr, Kansas AAP, Attn: SARKA
Cdr, Lake City AAP, Attn: SARLC
Cdr, Lone Star AAP, Attn: SARLS
Cdr, Longhorn AAP, Attn: SARLO
Cdr, Louisiana AAP, Attn: SARLA
Cdr, McAlester AAP, Attn: SARMC
Cdr, Milan AAP, Attn: SARMI
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Cdr, Corpus Christi Army Depot, Attn: SDSCC
Cdr, Hawthorne Army Depot, Attn: SDSHW, Hawthrone, NV 89415
Cdr, Letterkenny Army Depot, Attn: SDSLE
Cdr, McAlester Army Depot, Attn: SDSMC, McAlester, OK 74501
Cdr, New Cumberland Army Depot, Attn: SDSNC
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- Cdr, Pueblo Army Depot Activity, Attn: DRXPU
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DARCOM Labs, Schools, and Other Army Installations/Activities:
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- Cdr, Army Maintenance Management Ctr., Attn: DRXMD
- Dir, Army Management Engineering Training Acty. (AMETA), Attn: DRXOM
- Dir, Army Materials and Mechanics Research Ctr. (AMMRC), Attn: DRXMR, DRXMR-M (3 cys)
- Cdr, Army Research Office (ARO), Attn: DRXRO-AO
- Cdr, Army Weapons Support Ctr, Crane, IN 47522
- Dir, Automated Logistics Management Systems Acty. (ALMSA), Attn: DRXAL-A
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- Cdr, Joint Military Packing Training Ctr., Attn: DRXPP-A
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Cdr, NAVAIR, Attn: D. S. Henderson, Code ESA-824
Cdr, NAVELEX, Attn: C. A. Rigdon, Code ELEX-504512
Cdr, Naval Surface Weapons Ctr/White Oak Lab, Attn: Code CM-42
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Cdr, AFSC/PPD, Andrew AFB
Cdr, AFSC/PPDE, Andrew AFB
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