

ADA021752

12
B.S.

AD
AOD-TR-75-001

COLD ROTARY FORGING OF SMALL CALIBER GUN BARRELS

DECEMBER 1975

TECHNICAL REPORT

D.D.C.A.
APPROVED
MAY 16 1976
MAGUIRE



ARSENAL OPERATIONS DIRECTORATE

DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

PREPARED BY

ARSENAL OPERATIONS DIRECTORATE
ROCK ISLAND ARSENAL
ROCK ISLAND, ILLINOIS 61201

DISPOSITION INSTRUCTIONS:

Destroy this report when it is no longer needed. Do not return to the originator.

DISCLAIMER:

The findings of this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

The citation of commercial products in this report does not constitute an official indorsement or approval of such products.

ACQUISITION BY	None	<input checked="" type="checkbox"/>
STIS	None	<input type="checkbox"/>
DTIC	None	<input type="checkbox"/>
UNCLASSIFIED		
DECLASSIFICATION		
BY		
REASON/STABILITY CODE		
DATE		
AP		

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM	
1. REPORT NUMBER 14 AOD-TR-75- 101	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle) 6 Cold Rotary Forging of Small Caliber Gun Barrels.		5. TYPE OF REPORT & PERIOD COVERED 9 Technical Report, 1 Dec 74-1	
6. AUTHOR(s) 10 John/Jugenheimer		7. PERFORMING ORG. REPORT NUMBER 6737300	
9. PERFORMING ORGANIZATION NAME AND ADDRESS Arsenal Operations Directorate, SARRI-PR Rock Island Arsenal Rock Island, Illinois 61201		8. CONTRACT OR GRANT NUMBER(s) 16 DA-6737300	
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMS CODE 3297-06-7300		11. REPORT DATE Dec 1975 12/2p	
11. CONTROLLING OFFICE NAME AND ADDRESS CDR, Rock Island Arsenal Arsenal Operations Directorate, SARRI-PR Rock Island, Illinois 61201		12. NUMBER OF PAGES 13	
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		13. SECURITY CLASS. (of this report) Unclassified	
		15. DECLASSIFICATION/DOWNGRADING SCHEDULE	
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release, distribution unlimited.			
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)			
18. SUPPLEMENTARY NOTES			
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) 1. Rotary Forge 4. Chambering 2. Pilot Line 5. Production Process 3. Rifling 6. Barrels			
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The objective of this program was to provide an improved method of manufacturing military gun barrels ranging in bore size from .22 to .50 caliber. During this project, suitable equipment was purchased, and a pilot line for cold rotary forging of barrels was established. Excellent bore qualities, reproducibility, reduced process time and reduced tooling costs were demonstrated. By rifling, chambering, and simultaneous exterior contouring, many conventional machining operations were eliminated with a gain in production			

AB

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

20. CONT.

rate. The cold rotary forging of gun barrels has been implemented as a production process for the Rock Island Arsenal. Greater utilization will occur when engineering design is more closely correlated to the manufacturing process.

UNCLASSIFIED

PREFACE

This project was accomplished as part of the US Army manufacturing technology program. The primary objective of this program is to develop, on a timely basis, manufacturing processes, techniques, and equipment for use in production of Army materiel.

The cooperation and assistance received from Michael Tanaka, former project officer, and from Jack Hogan, forge shop foreman, is gratefully acknowledged.

FINAL PROJECT STATUS REPORT (RCS AMCRD-127)
US ARMY ARMAMENT COMMAND/ROCK ISLAND ARSENAL
Rock Island, Illinois 61201

DATE: 1 June 1975

1. PROJECT NUMBER. 6737300 BUDGET CODE. PW A3297
2. PROJECT TITLE. MM&T: Cold Rotary Forging of Small Caliber Gun Barrels
3. MAJOR END ITEMS SUPPORTED.
 - a. MAJOR END ITEMS. Small arms weapon systems.
 - b. COMPONENTS SUPPORTED.
 - (1) 7.62mm M219 machine gun barrel
 - (2) 7.62mm M134 mini gun (Gau barrel)
 - (3) .30 caliber machine gun barrel
 - (4) 5.56mm M16A1 rifle barrel
 - (5) 50 cal. M8C spotting rifle barrel
 - (6) 7.62mm M14 National Match rifle barrel
 - (7) other small arms weapon barrels
4. FACILITIES SUPPORTED. Rock Island Arsenal (GOGO)
Arsenal Operations Directorate
US Army Armament Command
Rock Island, Illinois 61201
5. TECHNICAL AREA(S) SUPPORTED. Small arms barrel manufacturing technology.
6. MILESTONE CHART. None (Project completed)
7. LOCATION OF WORK.
 - a. In-house and contract.
 - b. Rock Island Arsenal, Rock Island, Illinois 61201
GFM, Steyr, Austria
8. PERIOD COVERED. 1 Dec 74 to 1 June 75
9. STATUS OF FUNDING.(as of 1 June 75)

	<u>In-house</u>	<u>Contract</u>	<u>Total</u>
a. Funds Authorized	\$120,00	\$380,000	\$500,000
b. Funds Obligated	142,123	357,877	500,000
(1) 74-F-0313		14,647	
(2) 74-M-2189		1,100	
(3) 74-M-2479		2,109	
(4) DAA F01-73-C-0173		331,561	
(5) 74-C-0077		8,460	

Project No. 6737300

	<u>In-house</u>	<u>Contract</u>	<u>Total</u>
c. Funds Expended	\$142,522	\$349,417*	\$491,939

*All that remains to be expended in the final billing and payment for spare parts under Contract NO. 74-C-0077.

d. Percent (%) of Physical Completion	100%	100%	100%
---------------------------------------	------	------	------

10. PROJECT OFFICER. John Jugenheimer, Ext. 4135

11. ACCOMPLISHMENTS. An evaluation of the configurations of different caliber small arms rifle barrels was made in conjunction with the rotary forging process. From this, a purchase description was written and submitted for bid for a horizontal barrel forging machine. GFM Machines, Inc. (Steyr, Austria) was awarded the contract for a Model SHK 10 Barrel Forging Machine. The GFM machine has the capabilities of hot or cold forging, rifling, and chambering with simultaneous exterior contouring to precision tolerances. The equipment was installed in the Forge Shop at the Rock Island Arsenal.

The project implemented and tested a pilot line for the cold rotary forging of several small arms barrels ranging from .17 to .50 caliber. Tooling in the form of tungsten carbide mandrels and forging hammers was provided by GFM. Barrel preforms were fabricated from GFM design at the Rock Island Arsenal. Conventional chromium-molybdenum-vanadium barrel steel of hardness Rockwell C25-30 (per Mil-S-1195) was used. Preform design parameters were programmed into a Hewlett Packard Model 9830A programable calculator. The print-out includes final preform drawings and data that can be used directly in machine set-up.

During the project, .22 caliber M16 (heavy walled configuration), 7.62mm M219 machine gun, 7.62mm M134, .50 caliber M8C spotting rifle, 7.62mm M14 National Match (with double taper exterior contouring) barrels were successfully rifled. Additional rifling for .17 caliber (4.32mm) and 5.56mm Mann barrels and rotary forging of super-alloy metal M134 barrels for the Research Directorate was also done successfully.

Twenty-two caliber M16 and 7.62mm barrels were successfully rifled and chambered. These two sizes of barrels were mounted on weapon actions and test fired for accuracy. Both sizes of barrels exceeded military accuracy requirements. The M14 National Match barrels are currently being adapted to receivers to be test fired for accuracy under a development program by the General Thomas J. Rodman Laboratory.

CONCLUSIONS.

a. The rotary forging process is an improved method of manufacturing military small arms barrels.

b. Small arms rifle and machine gun barrels from .17 caliber to .50 caliber inclusive can be successfully rifled on the GFM Model SHK 10 Forging Machine.

c. Rifling and chambering, including simultaneous outside contouring, can be successfully achieved.

d. Rifling is best achieved between a 27% to 29% reduction in cross-sectional area. Rifling with chambering is best achieved between a 37% to 39% reduction.

e. Precision sniper rifle grade barrel rifling occurs in a narrow range of machine settings. The extremes result in either "underfilling" of the lands (represented as rounded corners) or "overfilling" of the lands (represented as tearing or galling) and will drastically reduce mandrel life.

f. Metallurgical analyses demonstrate that rotary forged barrels meet or exceed military requirements. Improved grain structure, increased toughness, better corrosion resistance, and finer surface finish result from the process. In general, the geometry and surface finish of the mandrel are reflected precisely in the barrel bore. Bore finishes of 8 micro inch (arithmetic average) or less are possible.

g. Rotary forged barrels exceed military accuracy requirements.

h. Bore variation is drastically reduced and straightness increased. Variations of less than .00015 inches are common.

i. Greater utilization of rotary forging for barrel production will occur when engineering design is more closely correlated to this process.

12. PROBLEM AREA(S). None

13. FUTURE WORK. None

14. BENEFITS.

a. Any item in the Army Material Plan (AMP) that can be manufactured more economically and/or with better properties by rotary forging will benefit from this project. Military small arms weaponry will be greatly improved by the adoption of this process. The benefits to the Government include: (1) reduced tooling and labor costs and increased production by using one forging operation for rifling, chambering, and exterior contouring, (2) metallurgically improved weapons due to finer micro-structure, (3) much higher production rates for difficult to machine super-alloy barrel materials required for rapid firing weapon systems, and (4) the ability to produce extremely accurate small arms independent of operator skills.

b. No by-product discoveries have been encountered.

c. The enclosed representative cost reductions have been identified during this project (See Inclosure 1)

15. IMPLEMENTATION PROCEDURES. All manufacturing personnel responsible for barrel production have been briefed on the GFM machine and the rotary forging process. A set-up man has been trained in the operation of the machine and set-up procedure. A selection of four different types of barrels was used during a two-week training session. A Methods Engineer worked with the set-up man to develop skills in preparing a program method sheet. A Tooling

Engineer was instructed on parameters for tooling, preforms and template design.

During the training session, a machine set-up and operation guideline was prepared and distributed. Method programs of previously forged barrels of various calibers were included as an aid for future set-ups.

16. REMARKS. The rotary forging process is a revolutionary improved method of rifling and chambering small arms rifle barrels, eliminating much tooling while improving barrel quality. Accuracy data was obtained from barrels that were not chrome plated, however. Future work would have to include the plating process if an accurate comparison is to be made between conventionally machined barrels and rotary forged barrels. Extremely precise dimensions for rifling are obtained in a very narrow range of machine adjustments. Chambering of barrels after rifling requires a good knowledge of the forging process and considerable working experience.

Future trends in rifle production in private industry all point toward this new process. A vast majority of commercial shotgun and rifle barrels manufactured in our country today are a result of rotary forging. Currently, the production of a .50 caliber barrel is being planned at the Rock Island Arsenal. This effort includes the design and fabrication of the tooling (including mandrels) to support the project. Mandrel production is a critical area with only two outside sources being currently available. (Atrex Div. of Wallace Murry Corp., Newington, Conn; and GFM, Steyr, Austria.)


RICHARD L. JOHNSON
Chief
Plant Engineering Division

Inclousure 1 - Representative Rotary Forge Cost Savings

The following cost savings are representative of the magnitude of savings obtainable in producing a rifled and chambered small arms rifle barrel. Additional savings are available in the production of plated barrels through the elimination of the electropolishing operation.

	<u>Tooling costs</u> (Rifled & chambered barrel)	
Convention (Per 1000 barrels)		Rotary Forge (Per 5000 barrels)
Body reamer	\$262.00	Forging mandrels
Second shoulder reamer	\$250.00 (2@ \$450)	\$900.00
Bullet seat reamer	\$200.00	Forging Hammers
Rifling broach	\$608.00	\$2000.00
Bore reamer (3@ \$81.00)	<u>\$243.00</u>	
	\$ 1,563.00	\$2900.00
Tool maintenance costs	<u>4,400.00</u>	<u>0.00</u>
	\$5,963.00	\$2900.00
Tool cost per barrel	\$ 5.96	\$ 0.58
Tool cost savings per barrel	\$5.38	

Operating Costs
(Rifled & Chambered barrel)

Conventional

Rotary Forge

Drill barrel	.0758 Hr	Drill Blank	.0425 Hr.
Rough Turn barrel	.1086 Hr	Turn blank	.2000 Hr.
Rough ream barrel	.0552 Hr		
Finish ream barrel	.0552 Hr		
Broach rifling	.0921 Hr		
	.3869	Forge rifling & chamber	.1167 Hr
Rough in chamber	.1123 Hr		
Semi-finish Chamber	.1193 Hr		
Finish chamber	.1152 Hr		

0.7337 Hr

0.3592 Hr

Operating Time savings

0.3745 Hr Per Barrel

Operating Cost savings @ \$22.00 per Hr.

\$8.24 per Barrel

Operating Cost savings

\$8.24 per Barrel

Tooling Cost savings

\$5.38 per Barrel

Total Rotary Forge Savings

\$13.62 per Barrel

DISTRIBUTION

Copies

A. Department of Defense

Defense Documentation Center
ATTN: TIPDR
Cameron Station
Alexandria, VA 22314

12

B. Department of the Army

Commander
U. S. Army Materiel Command
ATTN: AMCRD-E
AMCRP-I
AMCQA-E
5001 Eisenhower Avenue
Alexandria, VA 22333

1
1
1

Commander
U. S. Army Materiel Command
Scientific and Technical Information Team - Europe
ATTN: AMXST-STL Dr. Richard B. Griffin
APO New York 09710

1

Commander
U. S. Army Armament Command
ATTN: AMSAR-PPI-K
AMSAR-PPI-WW
AMSAR-RDP
AMSAR-SC
AMSAR-QAE
Rock Island, IL 61201

1
1
1
1
1

Director
U. S. Army Materials and Mechanics Research Center
ATTN: AMXMR-M
Watertown, MA 02172

1

Director
U. S. Army Maintenance Management Center
ATTN: AMXMD-A
Lexington, KY 40507

1

DISTRIBUTION

Copies

Commander
U. S. Army Electronics Command
ATTN: AMSEL-PP/I/IM
Fort Monmouth, NJ 07703 1

Commander
U. S. Army Missile Command
ATTN: AMSMI-IIE 1
 AMSMI-PRT 1
Redstone Arsenal, AL 35809

Commander
U. S. Army Tank-Automotive Command
ATTN: AMSTA-RK 1
 AMSTA-RCM.1 1
Warren, MI 48090

Commander
U. S. Army Aviation Systems Command
ATTN: AMSAV-ERE
P. O. Box 209
St. Louis, MO 63166 1

Commander
U. S. Army Troop Support Command
ATTN: AMSTS-PLC
4300 Goodfellow Blvd.
St. Louis, MO 63120 1

Commander
Ballistic Missile Defense Systems
ATTN: BNDSC-TS
P. O. Box 1500
Huntsville, AL 35804 1

Project Manager
Munition Production Base Mod
Picatinny Arsenal
Dover, NJ 07801 1

Commander
Harry Diamond Laboratories
ATTN: AMXDO-RCD
2800 Powder Mill Road
Adelphi, MD 20783 1

DISTRIBUTION

Copies

Commander
Natick Development Center
ATTN: AMXNL-EQ
Kansas Street
Natick, MA 01762 1

Commander
U. S. Army Air Mobility R&D Labs
ATTN: SAVDL-ST
Fort Eustis, VA 23604 1

Commander
Rock Island Arsenal
ATTN: SARRI-PE 1
SARRI-RS Mr. V. Long 1
SARRI-LS 1
SARRI-L 1
SARRI-LPL 2

Commander
Watervliet Arsenal
ATTN: SARWV-PPP-WP 1
SARNV-PPI-LAJ 1
SARWV-QA 1
Watervliet, NY 12189

Commander
Picatinny Arsenal
ATTN: SARPA-MT-C 1
SARPA-QA-T-T 1
SARPA-C-C 1
Dover, NJ 07801

Commander
Edgewood Arsenal
ATTN: SAREA-QA 1
Aberdeen Proving Ground, MD 21010

DISTRIBUTION

Copies

Director U. S. Army Production Equipment Agency ATTN: AMXPE-MT Rock Island Arsenal Rock Island, IL 61201	2
Director USAMC Intern Training Center ATTN: AMXMC-ITC-PPE Red River Army Depot Texarkana, TX 75501	1
Commander U. S. Army Tropic Test Center ATTN: STETC-MO-A (Technical Library) APO New York 09827	1

AD _____ Accession No. _____

UNCLASSIFIED

CDR, Rock Island Arsenal
Arsenal Operations Directorate
Rock Island, Illinois 61201

COLD ROTARY FORGING OF SMALL CALIBER
GUN BARRELS

Report AOD-TR-75-001, Dec 75,
(AMS Code 3297.06.7300) Unclassified Report.

1. Rotary Forge
2. Pilot Line
3. Rifling
4. Chambering
5. Production Process

The objective of this program was to provide an improved method of manufacturing military gun barrels ranging in bore size from .22 to .50 caliber. During this project, suitable equipment was purchased, and a pilot line for cold rotary forging of barrels was established. Excellent bore qualities, reproducibility, reduced process time and reduced tooling costs were demonstrated. By rifling, chambering, and simultaneous exterior contouring, many conventional machining operations were eliminated with a gain in production rate. The cold rotary forging of gun barrels has been implemented as a production process for the Rock Island Arsenal. Greater utilization will occur when engineering design is more closely correlated to the manufacturing process.

DISTRIBUTION
Copies available
from DDC.