

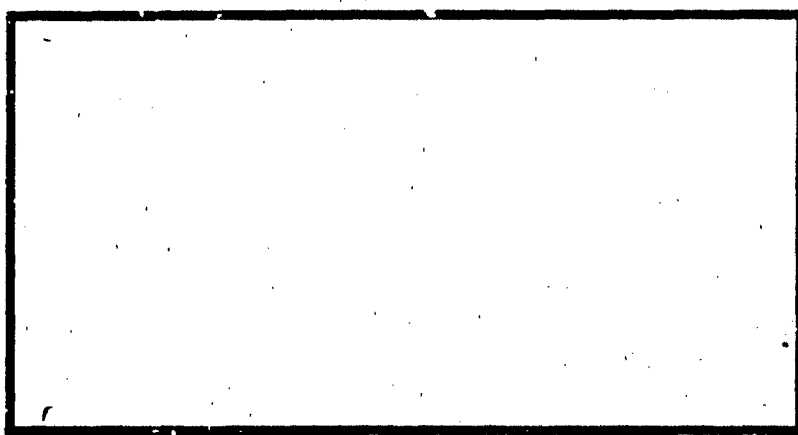
AD-A244 178



1



DTIC
ELECTE
JAN 07 1992
S D D



92-00016

This document has been approved
for public release and sale; its
distribution is unlimited.

DEPARTMENT OF THE AIR FORCE

AIR UNIVERSITY

AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

20000831184

Reproduced From
Best Available Copy

02 1 2 037

AFIT/GCA/ENS/91S-1

1

DTIC
ELECTE
JAN 07 1992
S
D

A MICROCOMPUTER PROGRAM FOR
ESTIMATING PRODUCTION COSTS
OF INJECTION MOLDED PLASTIC
STRUCTURES

THESIS

K. Frederick Byard, Captain, USAF

AFIT/GCA/ENS/91S-1

Approved for public release; distribution unlimited

The views expressed in this thesis are those of the authors and do not reflect the official policy or position of the Department of Defense or the U.S. Government.



Accession For	
NTIS CRA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A-1	

AFIT/GCA/ENS/91S-1

A MICROCOMPUTER PROGRAM FOR ESTIMATING PRODUCTION COSTS
OF INJECTION MOLDED PLASTIC STRUCTURES

THESIS

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Cost Analysis

K. Frederick Byard

Captain, USAF

September 1991

Approved for public release; distribution unlimited

Preface

I would like to express my gratitude to those who assisted in the completion of this research. Special thanks to Mr. William Stoddard and Mr. Rudolph George of Accutech for their invaluable assistance in explaining the technical details of this process. Thanks to Dr. Cain, who repeatedly delayed attacks on Cemetary Ridge to advise and correct me.

My deepest thanks to my wife, Elena, whose expertise in PASCAL saved me from the dread scourge of becoming a computer lizard. Also to my children, Justin, Brenden, and Kate, for never letting me skip bedtime stories, games of catch, or other important stuff to write this.

Thanks to Dave Hollenbach for sharing some of his expertise, Blatchford Sarnemington for his incomparably fine essence, Bertrand Russell, the Cost Weasels, and -of course - The Knights of Zandor.

Table of Contents

	Page
Preface	ii
List of Figures	iv
Abstract	v
I. Introduction	1
General Issue	1
Background	3
Problem Statement	8
Investigative Questions	8
II. Methodology	9
Introduction	9
III. Model Development	11
Cost Drivers	11
Cost Model	15
IV. Program Development	23
V. Conclusions	24
VI. Recommendations For Future Study	25
Appendix A: Program Listing of JOWP	26
Bibliography	44
Vita	46

List of Figures

Figure	Page
1. Illustration of Two-Stage Unit	6
2. Illustration of Reciprocating Screw	7

AFIT/GCA/ENS/91S-1

Abstract

The job of estimating the production costs of injection molded thermoplastic structures requires designers and analysts to produce detailed preliminary drawings and consult machinists with expertise in mold production.

Interviews with injection molding experts produced a scale of part complexity and associated range of labor hours for mold production. This scale is incorporated into a cost estimating methodology which allows the analyst to estimate the cost of the structure without the aid of technicians.

The resulting cost model for the injection molding process is then programmed into an interactive Pascal computer program for ease of use and documentation.

A MICROCOMPUTER PROGRAM FOR ESTIMATING
PRODUCTION COSTS OF INJECTION MOLDED
PLASTIC STRUCTURES

I. Introduction

General Issue

The desire to lower the cost and increase the reliability of aerospace systems has led manufacturers to investigate new materials and fabrication techniques. The unique mechanical properties of thermoplastic composite materials make it possible to produce structures with physical properties (stiffness, strength, heat tolerance, etc.) equal to those of metal, at significantly lower weights (Chew, 1990;1). Thermoplastics are simpler, quicker, and less expensive to produce than like metal structures (Chew, 1990; 1).

Over the past decade, advanced polymer materials have gained widespread use in aircraft design. Most notably, the B-2 "stealth", F-117, and Advanced Tactical Fighter (ATF). Military aircraft have been the primary users of these materials, because the need to improve performance and decrease radar signature in these aircraft outweighed the cost and difficulty of using these materials during their experimental phase (Millbank, 1990; A2B).

However, as advanced polymers become more common in aircraft production, they are finding their way into more

widespread use. Commercial aircraft manufacturers, wanting to gain better fuel economy through decreased aircraft weight, are incorporating polymers into new designs. A report by the National Aeronautics And Space Administration predicts that 65% of all new aircraft will be made of plastics by the end of the decade (Millbank, 1990; A2B). Advanced plastics have even been approved for use in primary structural components of commercial aircraft (Wall Street Journal, 1990a).

Automobile manufacturers have also begun exploiting these plastics. B.F. Goodrich Company announced it was investing \$19 million in a new plant to produce thermoplastic compounds. These compounds will reduce both the fuel consumption and maintenance costs of new cars (Wall Street Journal, 1990b).

Recent studies by the United States Air Force Astronautics Laboratory have shown promising results in the use of advanced polymer materials in the fabrication of rocket (Chew, 1989; 1) and air-to-air missile (Baird, 1990; 16) propulsion systems.

Use of the injection molding production process for thermoplastic structures promises significant gains in cost and simplicity over more traditional production methods. However, estimating of costs for individual parts remains an informal, "off the cuff" process, heavily reliant on the

judgments of machinists and technicians at small fabrication shops (Stoddard, 1991).

As the use of thermoplastic composites increases, with their growing applications in aircraft and rocket design, the need for more formalized and uniform estimating tools will grow.

Background

Injection molding is a process in which a powdered polymer resin is melted and injected into a mold cavity. The polymer cools and takes the shape of the mold. Molded polymers typically require very short periods (less than one minute) to solidify after injection. The resulting part usually requires little or no additional work prior to use (Leopold, 1990; 288).

An injection molding process has two primary components: an injector, to melt the polymer and transfer it into the mold, and a clamp unit to maintain pressure on the mold (Kirkham, 1990; 286).

Two types of injectors are currently in use: the two-stage unit, and the reciprocating screw. The two-stage uses a screw (first stage) to feed melted polymer into an injection plunger (second stage) which transfers the material into the mold (Fig 1). This method has the advantages of superior consistency in the melting of the material, higher pressures and injection rates, and greater

control of the material "shot". The disadvantages of the two-stage method are, primarily, higher equipment and maintenance costs (Kirkham, 1990; 286). The reciprocating screw method (Fig 2), the most commonly used injection process, melts and injects the polymer without the use of an injection plunger. Powdered or pelletized polymer is melted and fed into the mold by the turning action of the screw. The material flows through the screw tip and is deposited inside the mold, in front of the screw. As the polymer accumulates, it forces the screw backwards, out of the mold, until the mold is filled. Advantages of the reciprocating screw method include: quicker cycle time for the process and self-cleaning of the mold and screw (Kirkham, 1990; 286).

Injection into the mold can require material pressures up to 28,000 p.s.i. with the mold cavity filling in half a second (Leopold, 1990; 288). Such pressures require high pressure clamps to hold the mold in place during the injection. Once the mold is filled, the pressure is reduced to between 5,000 and 10,000 p.s.i. This secondary pressure is maintained for 5 to 10 seconds, as the form solidifies.

There are numerous variations and special techniques used to improve the consistency and quality of the particular polymers being used, but the basic processes remain the same.

The polymer material to be molded may contain high volumes of fillers (up to 70% by weight) to reduce cost and/or increase performance by incorporating special material qualities. Common fillers include glass fiber, mineral fiber, clay, wood fiber, and carbon black (Leopold, 1990; 288).

Molds for the part are produced by a machinist, working from detailed drawings of the part design. In addition to creating the shape of the part, the mold must allow for flow of the polymer material into it, and place seams so that the part may be readily ejected from the mold after fabrication (Frank, 1991).

Estimating costs for production of injection molded parts has, to this point, been an informal art, practiced by managers of small businesses and laboratories, the primary users of injection molded thermoplastics (Chew, 1991). Costs for new parts are generally estimated using the judgement of the machinist who will create the initial mold (Frank, 1990). This methodology is non-standardized, and not available to managers or parts designers who do not have ready access to a machinist skilled at making such estimates. At the present, little information is available on thermoplastic fabrication cost estimation (Foley, 1990; 2).

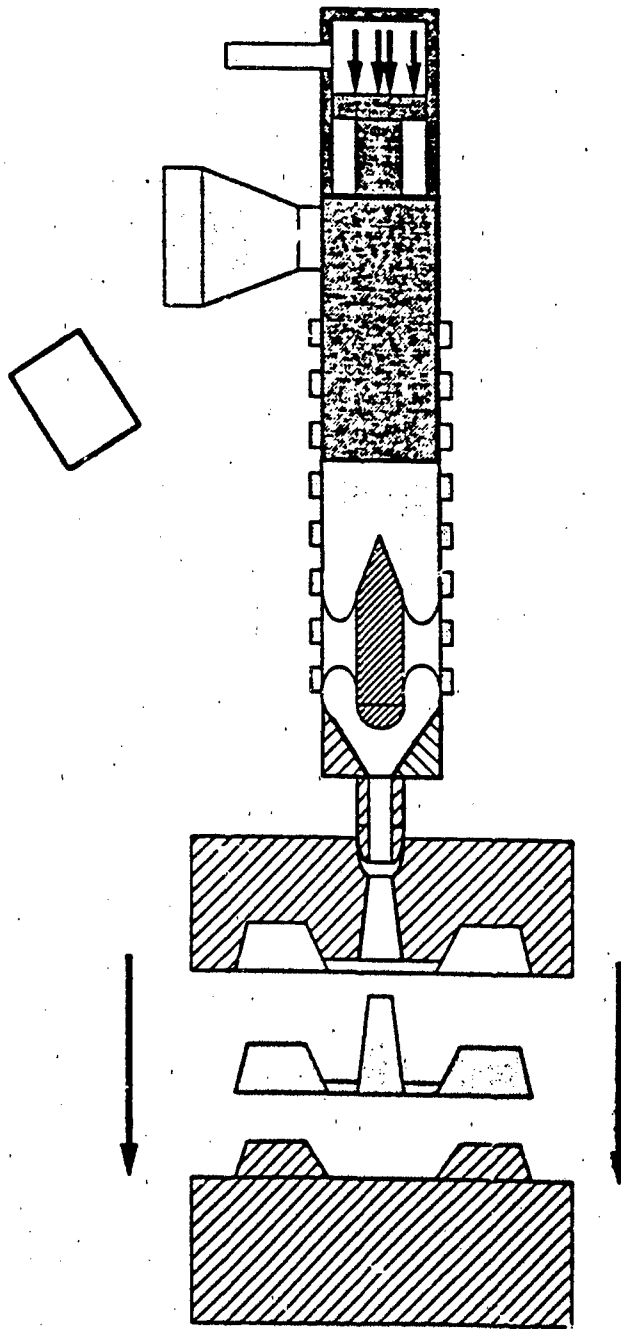


Fig 1.
Illustration of Two-Stage Unit
(Frank 1990; 31)

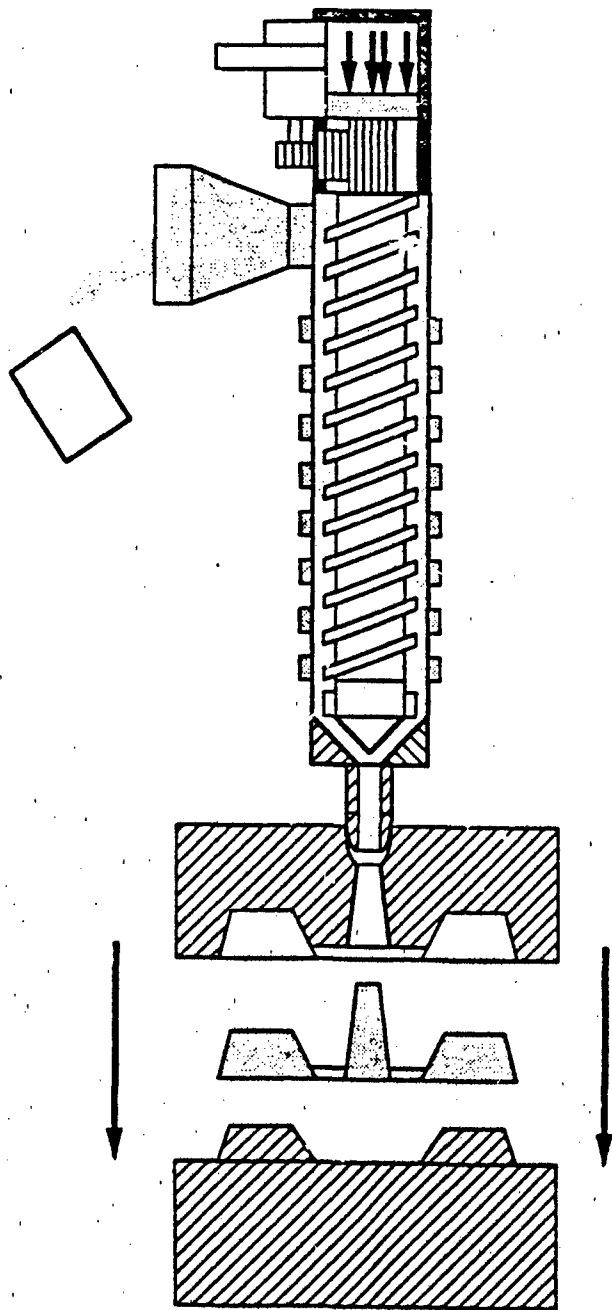


Fig 2.
Illustration of Reciprocating Screw
(Frank 1990; 30)

Problem Statement

Designers of thermoplastic structures lack a reliable, readily available tool for predicting the costs to manufacture those structures through injection molding.

Investigative Questions

1. What are the significant cost drivers in the thermoplastic injection molding production process?
2. How can these cost factors be evaluated and related in a cost estimating model?
3. How can this model be made easily useable by managers needing immediate estimates of production costs for the manufacture of thermoplastic structures?

II. Methodology

Introduction

This chapter will review the procedures that will be used to solve the research problem. One of the methods used to gather information will be the personal interview. From the outset of this research, it was clear that very little formal, written, methodology existed for cost estimation of injection molded plastics. Emory, writing in his book Business Research Methods, states that, "published documents record major events in history, but most of the past data we seek is recent and too limited in interest to be published. Questioning is the only way to secure the information (Emory, 1980; 214)." With most of the production by this process done in small shops and laboratories, costs (especially the critical cost of mold production) are estimated almost exclusively by the expert judgement of machinists. The information gathering process, therefore, primarily involved interviewing injection molding manufacturers to determine the methodologies being used to estimate costs prior to production, significant process cost factors, and the characteristics of the molded part which affected its cost.

Analysis of cost estimates and production data from existing parts was also used, although such data was scarce and typically incomplete.

Once this information was gathered, the methods found in use were seen to be very similar, and the methodology of cost estimation was formalized, and used to write the computer program JOWP.

III. Model Development

Cost Drivers

The first objective of the research was to identify the significant cost factors in the injection molding production process. Interviews with Dr. James Chew of the United States Air Force Astronautics Laboratory at Edwards Air Force Base, California, Dr. Chris Frank of the Air Force Advanced Composites Program Office, and Mr. William Stoddard, President of Accutech Corporation, a commercial injection molding manufacturer in Dayton, Ohio, yielded the following hierarchy of cost factors:

Mold Production. Mold production can require as much as 600 hours of labor by a machinist charging \$65 per hour, in the aerospace industry (Foley, 1990; 9). Once produced, the mold can be used to fabricate an almost limitless number of parts (mold wear being virtually negligible)(Frank, 1991). The most important factor in determining the amount of time needed to machine a mold is the complexity of the part to be molded. The range of labor hours needed to produce the mold may range from 20 hours for a "simple" part, to 600 hours for a "very complex" one (Stoddard, 1991). What makes a part more or less complex is the combination of four characteristics:

Number of Walls. The number of distinct edges and partitions in the part.

Number of Cavities. The number of cavities is equal to the shot weight of the injection molding machine (generally taken to be 80% of the shot capacity of the injection unit) divided by the weight of the part and runner (Frank, 1990; 2).

Number of Holes and Depressions. Holes and depressions in the surface of the part make it more difficult to eject from the mold (George, 1991).

Number and Orientation of Projections. Projections make the part difficult to eject from the mold, especially when they are perpendicular to the opening of the mold. Parts with projections may require additional production steps or ejectors to remove from the mold (George, 1991).

As shall be seen later in this paper, the determination of part complexity is the area of cost estimation requiring the greatest exercise of analyst judgement.

Equipment. Equipment which must be purchased for each new part being molded consist of four "packages":

Mold Base Package. The steel plates and manifolds into which the shape of the part is machined to form the mold. For smaller parts, inserts may be used, so that the majority of the mold base may be reused.

Control Package. Equipment needed to control the pressure and temperature of the injection process.

Includes transformers, power cables, connectors, terminal boxes, and temperature controllers.

Hot Runner Package. A series of nozzle assemblies and heaters typically used only for high volume or higher speed production. The hot runner assembly provides a heated path for the molten polymer to travel from the injector nozzle to the mold.

Support Package. Mold plates, support pillars, and ejector pins, necessary for production of complex parts.

Occasionally, these packages can be reused from previous molds. When this is possible, the purchase price of the equipment can be saved.

Labor. Labor cost will be defined as the average hourly wage rate of workers in the injection molding industry, multiplied by the number of labor hours directly attributable to part fabrication.

Labor Overhead. Costs of overhead include all production costs that are not direct materials or direct labor (Allen and Moriarity, 1991; 66). The overhead cost will be calculated by combining the individual overhead rates into a comprehensive overhead wrap rate, and multiplying it by the number of direct labor hours required to manufacture the mold and produce the part. The selection of the application basis for this wrap rate can have a profound effect on product cost. The use of Direct

Labor Hours is, increasingly, sighted as inappropriate in modern, automated, production processes (Allen and Moriarity, 1991; 67). However, this is still the standard basis in use in manufacturing processes and will be used in this model to reflect the reality of the producers we wish to model.

Materials. The purchase cost of the raw material needed to fabricate the desired part. The total materials cost for a part will be the weight of the part multiplied by the per pound cost of the material. This price must include a 20% excess rate (unused polymer left in the hopper and injector) (Chew, 1990). This excess is the polymer which solidifies in the pathway from the injector to the mold. It is necessary to maintain proper pressure. This excess material breaks off and is discarded when the mold is cleared. Material remaining in the injector and hot runner stays molten and is used during the next injection (Frank, 1991).

Material Preparation. The cost of labor to dry the raw polymer and load it into the hopper of the injection molder. Typically, polymer materials readily absorb water. To be molded, the material must be dried. This drying is accomplished by baking the polymer pellets in an oven or heater in the material hopper. This process requires minimal labor, as the worker need only pour the polymer pellets into the oven and allow them to dry under

automatically timed and controlled heat (George, 1991). The overall effect of a change in this value will be virtually negligible within any reasonable limits. This step is included in the model for the sake of completeness, and in anticipation that future materials may need more elaborate preparation and the model would be prepared to adapt to such a change.

Fabrication. The burdened hourly labor rate, multiplied by the direct labor hours required to produce the part. The time to produce the part is its cycle time; how long the part is in the mold being formed.

Inspection and Finishing. Once produced, the part must be inspected for flaws and, occasionally, trimmed for excess material, although the latter is rare (Stoddard, 1991). Time required for this process is largely dependent on the complexity of the part. Cost for inspection and finishing will be calculated by multiplying the time required to perform it by the burdened labor rate.

These costs are essentially the same as for standard process costing methodologies (Allen and Moriarity, 1991; 68).

Cost Model

The second objective of this research was to combine these factors into a cost estimating model for the injection molding process. This model should be valid for either the reciprocating screw or two-stage processes, as

the differences in the values for the cost drivers between these methods is negligible (Frank, 1990). This model integrates injection molding process information and cost accounting methodology.

The injection molding production process begins with the uninspected raw material and ends as trimmed, inspected parts or subassemblies. To estimate the cost of this process, the model must analyze each step of the process path, calculating all costs associated with each step.

Step 1. Calculate the burdened labor rate (hourly labor rate adjusted for overhead) for the production process. An unburdened rate of \$ 22.00 per hour is given as a default value. This rate is the aerospace industry average for technicians and machinists involved in injection molding production (Foley, 1990; 9). Overhead rates of 114% for facilities, equipment, tooling, and workers not involved in direct labor charged to part production, 41% for fringe benefits, 27% for General and Administrative costs, and 14% for training, other materials will be combined in an overhead wrap rate of 196%. All of these values are average rates for manufacturing facilities in the aerospace industry (Foley, 1990; 9). This will be the default value for the wrap rate for the model. The user may change either of these values as appropriate. Once these rates are set, the burdened hourly labor rate

will be calculated by multiplying the overhead wrap rate by the number of direct labor hours and adding the product to the unburdened rate.

For example, using the default values, an unburdened labor rate of \$22 an hour, multiplied by an overhead wrap rate of 196% yields an hourly overhead cost of \$43.12. This is added to the unburdened cost to achieve a burdened hourly labor cost of \$65.12.

Step 2. Specify the cost of the raw material. A default value of \$ 20.00 per pound is given. This is the purchase price of DuPont Liquid Crystalline Polymer HX4000 (DuPont, 1991). The user may change this value to reflect the cost of the specific polymer in use.

Step 3. Specify the weight of the part. This will be the weight of the finished part, and will be multiplied by 120% to reflect the 20% excess rate (unused polymer left in the hopper and injector) (Chew, 1991). For example, molding a 10 pound finished part will require an input of 12 pounds of raw material.

Step 4. Calculate the total materials cost (CRM). The model will calculate the per unit cost of raw materials by multiplying the weight of the part by the material cost.

Step 5. Set the material preparation time. This will be the time required to load the polymer pellets into the oven for drying, then transfer the dried material to the injector hopper. The raw polymer is packaged in 50 and 100

pound quantities. The time will be the minutes needed to prepare 100 pounds of raw polymer. 100 pounds was chosen both because it is a typical value, and for ease of calculation. A default value of 10 minutes per 100 pounds of raw material is offered (George, 1991).

Step 6. Calculate the material preparation Cost (CP). This will be the burdened hourly labor rate multiplied by the time for material preparation. Using the default values for the burdened hourly labor rate and material preparation time yields a cost of \$65.12 multiplied by .16 hours (10 minutes), or \$10.85.

Step 7. Set the complexity level. The estimator must specify the complexity level of the part to be molded. Specifying the complexity level will set the value for the labor hours required to machine the mold of the part. The number of hours it takes the machinist to produce the mold generally ranges between 20 hours for the simplest parts and 600 hours for very complex structures. Complexity is a function of the number of walls the mold will have, the number and location of any holes and depressions in the part, whether or not the structure has continuous, uniform walls, and whether those walls are in the same direction as the flow of the injected polymer. Any of these factors can increase the amount of time and cost required to produce a mold for it (George, 1991).

In this model, the complexity of the structure will be estimated by assigning the part to one of five categories of complexity, each described by a set of part characteristics:

Very high Complexity (600 Hours Machining Labor).

The part is large and has more than 20 holes and depressions. Projections from the part are perpendicular to the openings of the mold. The mold has more than 20 walls. The part will have inserts, which need to be loaded into it during the molding process. The part has geometries which will make it difficult to eject from the mold.

High Complexity (400 Hours Machining Labor). The

part is large, or has multiple cavities and has 10 to 20 holes and depressions. The part has 10 to 20 walls. The part has narrow, deep grooves or slots, and geometries which will make the part difficult to eject.

Moderate Complexity (120 Hours Machining Labor).

The part is of moderate size and has one or two holes or depressions. The mold has 5 to 10 walls. There are no geometries which will make the part difficult to eject.

Low Complexity (70 Hours Machining Labor). The

part has less than 5 walls. It is of moderate size, with few holes and depressions. No non-circular holes or projections.

Very Low Complexity (20 Hours Machining Labor).

The part consists of a single, continuous, uniform wall in the direction of the flow of the material. The part contains no holes, depressions, grooves, inserts, or projections.

These descriptions and time estimates are made from interviews with Mr. Christopher Frank of the Air Force Advanced Composites Program Office, Mr. William Stoddard, Chief Executive Officer of Acutech, Corporation, and Mr. Rudolph George, Chief Machinist of Acutech.

Step 8. Calculate cost of mold production (CM). The hours required for mold production, as set by the complexity level, are multiplied by the burdened hourly labor rate to arrive at the mold production cost. A complexity level of 2, for example, will set the hours required for mold production at 120 hours. Multiplying these hours by the burdened hourly labor cost of \$65.12 will yield a mold production cost of \$7814.40.

Step 9. Specify the cost of equipment (CE). The cost of parts packages necessary for each new mold. Primarily: the Control, Support, Mold Base, and Hot Runner packages. Default costs for these equipment packages are derived from vendor quotes from the DME Company of Monterey Park, Ca. (Livermore, 1991). Vendor and models were provided by Dr. John Rusek of the United States Air Force Astronautics Laboratory as being the most commonly used supplier,

representative of currently used equipment. The default costs are for packages associated with high volume production of a large part.

Step 10. Specify the fabrication cycle time. This is the time from the instant the material enters the mold cavity until it is ejected as a part (Frank, 1989, 18). A default time of two minutes per part is offered (Stoddard, 1991).

Step 11. Calculate the fabrication cost (CF). The process cycle time is multiplied by the burdened hourly labor rate. Using the default values for the burdened hourly labor rate and fabrication cycle time yields a cost of \$65.12 multiplied by .033 hours (2 minutes), or \$2.17.

Step 12. Set the inspection and finishing time. This will be the time required to inspect and perform post molding operations on molded parts. Parts are typically inspected in large lots, rather than individually, for more efficient processing. In very large production runs, statistically significant samples are inspected to insure quality. A default time of five minutes per 100 parts is offered (Stoddard, 1991).

Step 13. Calculate inspection and finishing cost (CI). Multiply the inspection and finishing time by the burdened hourly labor rate. Using the default values for the burdened hourly labor rate and inspection and finishing time yields a cost of \$65.12 multiplied by .083 hours (5 minutes), or \$5.40.

Step 14. Add the Raw Material, Material Preparation, Mold Production, Equipment, Fabrication, and Inspection and Finishing costs to find the first unit production cost.

The cost of subsequent units will be the Raw Material, Material Preparation, Fabrication, and Inspection and Finishing costs (variable costs) added to the Mold and Equipment Costs (fixed costs) divided by the number of parts produced.

Cost of First Unit

$$CRM + CP + CF + CI + CM + CE$$

Cost of Production Level Units

$$(CM + CE) / \text{Number of Units} + CRM + CP + CF + CI$$

A limited test of the model, using actual production items and mold production hours found that estimators not familiar with the specifics of the injection molding process were able to consistently place the part into the complexity category most closely reflecting the actual labor hours to produce its mold. the data used for this test was, however, incomplete, and the number and scope of the tests would have to be widened to thoroughly validate the model.

IV. Program Development

The final objective of this research is to present the JOWP model to users in a manner that makes it easily usable. To do this, JOWP has been programmed into a Pascal language computer package for use with IBM compatible personal computers. A listing of the program code for JOWP may be found in Appendix A.

JOWP is an interactive program. The user is presented with definitions of each of the process steps and asked to provide values for the variables. The default values for these variables, described earlier, are provided, and the user may use them, or replace them with ones of his own choosing.

JOWP processes these data points as described in the cost model, and presents the user with a first unit estimated cost and per unit and total costs for higher production levels.

JOWP will demand no specialized knowledge of computer commands or programming languages. It operates with the TURBOPASCAL compiler, but is usable with any Pascal compiler system.

V. Conclusions

The JOWP program formalizes and documents the methodology used by injection molding manufacturers to estimate the costs for their products. Interviews with manufacturers and polymer developers identified the significant cost drivers for the process as the cost of mold production, equipment, raw material, labor, and labor based overhead. The program uses these factors in the same manner as is currently used by producers, and has been programmed into an interactive software package which allows an estimator with little technical knowledge of the process to quickly and completely estimate costs. The methodology is consistent with accepted cost accounting standards. The model has been reviewed by injection molding manufacturers and found accurate and simple to use.

Limited testing of the program with actual cost data and estimators with a basic knowledge of cost estimating (but little expertise in plastics production) found the program to be accurate in its prediction of mold production manhours, the principle cost driver of the process, and the one for which the most complete historical data was available.

VI. Recommendations For Future Study

Historical data on the injection molding of plastic parts is hard to find and incomplete. As the process gains wider usage, the JOWP program should undergo a more complete validation.

Use of a pascal compiler other than TURBOPASCAL might allow more simple entry into the program, and should be investigated.

Appendix A: Program Listing of JOWP

PROGRAM JOWP;

VAR

ANSWER:CHAR;
LABORRATE,
OHRATE,
MATCOST,
PRODMAT,
MATWT,
MBCOST,
CONCOST,
PREPCOST,
SUPCOST,
HOTCOST,
MPLH,
FALH,
IFLH,
BLR,
MOLDCOST,
FABLABCOST,
INSFINCOST,
RAWMATCOST,
FUCOST,
PRODCOST,
PRODNUM,
CYCLETIME,
COMP,
TOTCOST,
FIXCOST,
PREPTIME:REAL;

(*.....
**)

PROCEDURE PRINTCOMMENTS;

BEGIN

WRITELN;
WRITELN;
WRITELN;
WRITELN;
WRITELN;
WRITELN;
WRITELN;
WRITELN;
WRITELN;
WRITELN;
WRITELN;

WRITELN(' JOWP');
WRITELN(' Just One Word: Plastics!');
WRITELN('JOWP estimates fabrication costs for polymer
plastic parts');
WRITELN('produced through the injection molding process.
JOWP');

```

        WRITELN('integrates thermoplastic processing knowledge
and process');
        WRITELN('cost accounting information. JOWP calculates
production costs');
        WRITELN('beginning with the raw, unprepared material, and
ending with an');
        WRITELN('inspected and trimmed part.')
```

```

END;
(*****
PROCEDURE PRINTINSTRUCTIONS;
```

```

    BEGIN
        WRITELN('JOWP computes part production costs using input
values for');
        WRITELN('material costs, hourly labor, overhead rates,
part size, and');
        WRITELN('complexity. If values for these variables are
not known,');
        WRITELN('default values, based on industry averages may
be used.');
```

```

    END;
(*****
**)
```

```

PROCEDURE CHECKANSWER;
```

```

    BEGIN
        WHILE (ANSWER<>'Y') AND (ANSWER<>'N') AND
            (ANSWER<>'y') AND (ANSWER<>'n') DO BEGIN
            WRITELN;
            WRITELN('ANSWER MUST BE Y OR N. TRY AGAIN');
            READ(ANSWER);
            WRITE(ANSWER)
        END (WHILE)
    END; (PROCEDURE CHECK ANSWER)
```

```

(*****
***)
```

```

PROCEDURE GETLABORRATE (VAR LABORRATE:REAL);
```

```

    CONST
        GIVENLABORRATE=22.00;
```

```

    VAR
        NEWLABORRATE: REAL;
```

```

    BEGIN
        WRITELN;
        WRITELN('The hourly unburdened labor rate is the wage
paid');
```

```

WRITELN('to a production worker for an hour's labor.
It does');
WRITELN('not include costs for equipment, overhead,
training,');
WRITELN('or fringe benefits. The rate of $22 per hour
is an');
WRITELN('average of injection molding equipment
operators,');
WRITELN('material handlers, part inspectors and
finishers, and');
WRITELN('other technician level workers.');
```

```

WRITELN;
WRITELN('THE UNBURDENED HOURLY LABOR RATE
IS',GIVENLABORRATE:6:2);
WRITELN('DO YOU WANT TO CHANGE THE LABOR RATE? Y OR N.');
```

```

READ(ANSWER);
CHECKANSWER;
```

```

IF (ANSWER = 'N') OR (ANSWER = 'n') THEN
  LABORRATE:=GIVENLABORRATE
```

```

ELSE BEGIN
```

```

  WRITELN;
```

```

  WRITELN ('ENTER NEW UNBURDENED LABOR RATE');
```

```

  READ (NEWLABORRATE);
```

```

  WHILE (NEWLABORRATE < 0) OR (NEWLABORRATE > 100) DO
```

```

BEGIN
```

```

  WRITELN('THE LABOR RATE MUST BE A NUMBER BETWEEN
0 AND 100');
```

```

  WRITELN ('ENTER NEW UNBURDENED LABOR RATE');
```

```

  READ (NEWLABORRATE)
```

```

  END; (WHILE)
```

```

  LABORRATE:=NEWLABORRATE
```

```

  END (ELSE)
```

```

END; (PROCEDURE GETLABORRATE)
```

```

(*****)
```

```

PROCEDURE GETOHRATE (VAR OHRATE:REAL);
```

```

  CONST
```

```

    GIVENOHRATE=1.96;
```

```

  VAR
```

```

    NEWOHRATE: REAL;
```

```

  BEGIN
```

```

    WRITELN;
```

```

    WRITELN('The overhead wrap rate includes all costs
associated');
```

```

WRITELN('with part production not directly chargeable to
the');
WRITELN('part as labor. These costs include equipment,
plant');
WRITELN('floorspace, tooling, facilities, and indirect
labor. ');
WRITELN('The wrap rate also accounts for the costs of
worker');
WRITELN('benefits, General and Administrative costs, and
Support');
WRITELN('Services. ');
WRITELN;
WRITELN;
WRITELN('THE CURRENT OVERHEAD RATE IS', GIVENOHRATE:5:2);
WRITELN('DO YOU WANT TO CHANGE THE OVERHEAD RATE? Y OR
N. ');

```

```

READ(ANSWER);
CHECKANSWER;

```

```

IF (ANSWER = 'N') OR (ANSWER = 'n') THEN
  OHRATE:=GIVENOHRATE
ELSE BEGIN
  WRITELN;
  WRITELN ('ENTER NEW OVERHEAD RATE');
  READ (NEWHOHRATE);
  WHILE (NEWHOHRATE < 0) OR (NEWHOHRATE > 10) DO BEGIN
    WRITELN;
    WRITELN('THE OVERHEAD RATE MUST BE A NUMBER
BETWEEN 0 AND 10');
    WRITELN ('ENTER NEW OVERHEAD RATE');
    READ (NEWHOHRATE)
  END; {WHILE}
  OHRATE:=NEWHOHRATE
END {ELSE}
END; {PROCEDURE GETOHRATE}

```

```

(*****
**)

```

```

PROCEDURE GETMATCOST (VAR MATCOST:REAL);

```

```

CONST
  GIVENMATCOST=20.00;

```

```

VAR
  NEWMATCOST: REAL;

```

```

BEGIN
  WRITELN;
  WRITELN('The Material Cost is the price per pound
of');
  WRITELN('raw, uninspected polymer resin. This price
is');

```

```

WRITELN('the purchase price of the resin, not
including');
WRITELN('delivery, preinspection, or preparation.
The');
WRITELN('default price of $20 per pound reflects a
pure');
WRITELN('polymer resin, unmixed with any other
material. ');
WRITELN;
WRITELN('THE CURRENT MATERIAL COST
IS', GIVENMATCOST:6:2);
WRITELN('DO YOU WANT TO CHANGE THE MATERIAL COST? Y
OR N. ');
READ(ANSWER);
CHECKANSWER;

```

```

IF (ANSWER = 'N') OR (ANSWER = 'n') THEN
  MATCOST:=GIVENMATCOST
ELSE BEGIN
  WRITELN;
  WRITELN('ENTER NEW MATERIAL COST');
  READ (NEWMATCOST);
  WHILE (NEWMATCOST < 0) OR (NEWMATCOST > 1000) DO BEGIN
    WRITELN;
    WRITELN('THE MATERIAL COST MUST BE A NUMBER
BETWEEN 0 AND 1000');
    WRITELN ('ENTER NEW MATERIAL COST');
    READ (NEWMATCOST)
  END; (WHILE)
  MATCOST:=NEWMATCOST
END (ELSE)
END; (PROCEDURE GETMATCOST)

```

```

(*****
***)

```

```

PROCEDURE GETMATWT (VAR MATWT:REAL);
VAR
  WT:REAL;
BEGIN
  WRITELN;
  WRITELN;
  WRITELN('The weight of the part is its finished, trimmed
weight');
  WRITELN;
  WRITELN('ENTER THE WEIGHT OF THE FINISHED PART IN
POUNDS. ');
  READ(WT);
  WHILE (WT < 0) OR (WT > 10000) DO BEGIN
    WRITELN;
    WRITELN('THE WEIGHT OF THE PART MUST BE A NUMBER

```

```

BETWEEN 0 AND 10000');
    WRITELN('ENTER THE WEIGHT OF THE FINISHED PART ');
    END; {WHILE}

    MATWT:=WT
    END; {PROCEDURE GETMATWT}

{*****}
****}

PROCEDURE GETPREPTIME (VAR PREPTIME:REAL);

    CONST
        GIVENPREPTIME=10.00;

    VAR
        NEWPREPTIME:REAL;

    BEGIN
        WRITELN;
        WRITELN('The material preparation time is the time in
minutes, required');
        WRITELN('to make the raw polymer suitable for molding.
This is typically');
        WRITELN('accomplished by heating the polymer to dry it.
Material preparation');
        WRITELN('time should count only minutes of labor, not the
time the polymer is');
        WRITELN('being automatically heated or processed. A
default preparation');
        WRITELN('time of 10 minutes is the current model value');

        WRITELN;
        WRITELN('THE PREPARATION TIME FOR 100 POUNDS OF RAW
MATERIAL IS',GIVENPREPTIME:8:2);
        WRITELN('DO YOU WANT TO CHANGE THE PREPARATION TIME? Y
OR N');

        READ(ANSWER);
        CHECKANSWER;

        IF (ANSWER = 'N') OR (ANSWER = 'n') THEN
            PREPTIME:=GIVENPREPTIME
        ELSE BEGIN
            WRITELN;
            WRITELN ('ENTER NEW PREPARATION TIME');
            READ (NEWPREPTIME);
            WHILE (NEWPREPTIME < 0) OR (NEWPREPTIME > 100) DO
BEGIN
                WRITELN;
                WRITELN('THE PREPARATION TIME MUST BE A NUMBER
BETWEEN 0 AND 100');
                WRITELN ('ENTER NEW PREPARATION TIME');

```

```
        READ (NEWPREPTIME)
        END; {WHILE}
        CYCLETIME:=NEWPREPTIME
    END {ELSE}
```

```
END; {PROCEDURE GETPREPTIME}
```

```
{*****}
```

```
PROCEDURE GETMBCOST (VAR MBCOST:REAL);
```

```
    CONST
```

```
        GIVENMBCOST=8488.00;
```

```
    VAR
```

```
        NEWMBCOST: REAL;
```

```
    BEGIN
```

```
        WRITELN;
```

```
        WRITELN('The injection molding process requires the use  
of');
```

```
        WRITELN('a mold base package, a control package, a  
support');
```

```
        WRITELN('package, and a hot runner package. Default  
costs');
```

```
        WRITELN('for these equipment packages are taken from  
purchase');
```

```
        WRITELN('costs from the DME Company of Monterey park,  
California.');
```

```
        WRITELN('If purchase of any of these equipment packages  
are');
```

```
        WRITELN('not required for production of this part, enter  
a cost');
```

```
        WRITELN('of $0 for that equipment package.');
```

```
        WRITELN;
```

```
        WRITELN('THE      CURRENT      MOLD      BASE      PACKAGE      COST  
IS', GIVENMBCOST:8:2);
```

```
        WRITELN;
```

```
        WRITELN('This is the purchase price for a DME  
2429X-6-37');
```

```
        WRITELN('Semi-standard #3 steel mold base ');
```

```
        WRITELN;
```

```
        WRITELN('DO YOU WANT TO CHANGE THE MOLD BASE PACKAGE  
COST? Y OR N.');
```

```
    READ(ANSWER);
```

```
    CHECKANSWER;
```

```
    IF (ANSWER = 'N') OR (ANSWER = 'n') THEN
```

```
        MBCOST:=GIVENMBCOST
```

```
    ELSE BEGIN
```



```

WRITELN;
WRITELN ('ENTER NEW MOLD BASE PACKAGE COST');
READ (NEWMBCOST);
WHILE (NEWMBCOST < 0) OR (NEWMBCOST/10 > 10000) DO
BEGIN
    WRITELN;
    WRITELN('THE COST OF THE MOLD BASE PACKAGE MUST BE
A NUMBER BETWEEN 0 AND 100000');
    WRITELN;
    WRITELN('This is the purchase price for a DME
2429X-6-37');
    WRITELN('Semi-standard #3 steel mold base ');
    WRITELN;
    WRITELN ('ENTER THE COST OF THE MOLD BASE
PACKAGE. ');
    READ (NEWMBCOST)
    END; {WHILE}

    END {ELSE}
END; {PROCEDURE GETMOLDBASECOST}

```

```

(*****
**)

```

```

PROCEDURE GETCONCOST (VAR CONCOST:REAL);

```

```

CONST
    GIVENCONCOST=6905.00;
VAR
    NEWCONCOST: REAL;

```

```

BEGIN
    WRITELN;
    WRITELN('THE CURRENT CONTROL PACKAGE COST
IS', GIVENCONCOST:8:2);
    WRITELN;
    WRITELN('This is the purchase price for a DME Control
Package');
    WRITELN('consisting of:');
    WRITELN('          1 TK9-1AG Transformer');
    WRITELN('          1 MFP12G Main Frame
Package');
    WRITELN('          1 MPC12-C10G Power Cable');
    WRITELN('          1 TC12C10G T/C Cable');
    WRITELN('          1 PIC12G Input Connector');

    WRITELN('          1 MTC12G T/C Connector');
    WRITELN('          12 CMP15G Temperature
Controllers');
    WRITELN('          1 PTC12TBG Terminal Box');
    WRITELN;
    WRITELN('DO YOU WANT TO CHANGE THE CONTROL PACKAGE COST?

```

```

Y OR N. ');

READ(ANSWER);
CHECKANSWER;

IF (ANSWER = 'N') OR (ANSWER = 'n') THEN
    CONCOST:=GIVENCONCOST
ELSE BEGIN
    WRITELN;
    WRITELN ('ENTER NEW CONTROL PACKAGE COST');
    READ (NEWCONCOST);
    WHILE (NEWCONCOST < 0) OR (NEWCONCOST/10 > 10000) DO
BEGIN
    WRITELN;
    WRITELN('THE COST OF THE CONTROL PACKAGE MUST BE
A NUMBER BETWEEN 0 AND 100000');
    WRITELN ('ENTER THE COST OF THE CONTROL PACKAGE. ');

    READ (NEWCONCOST)
END; (WHILE)

    CONCOST:=NEWCONCOST
END (ELSE)
END;(PROCEDURE GETCONTROLCOST)

{*****
****}

PROCEDURE GETSUPCOST (VAR SUPCOST:REAL);

CONST
    GIVENSUPCOST=2673.00;
VAR
    NEWSUPCOST: REAL;

BEGIN
    WRITELN;
    WRITELN('THE CURRENT SUPPORT PACKAGE COST
IS',GIVENSUPCOST:8:2);
    WRITELN;
    WRITELN('This is the purchase price for a DME Support
Package');
    WRITELN('consisting of:');
    WRITELN('          2 1118-57 Mold Plates');
    WRITELN('          10 6144 Support Pillars');

    WRITELN('          1 SR50125 Sprue Reamer');
    WRITELN('          1 Sr50125H Sprue Reamer');
    WRITELN('          6 EX17M14 Ejector Pins');
    WRITELN('          20 EX19M10 Ejector Pins');
    WRITELN('          14 EX-27 M6 Ejector Pins');
    WRITELN('          30 3/4 x 1/2 Tubular Dowls');
    WRITELN('          8 5410GL Leader Pins');

```

```

WRITELN('          4 HTIS24362 Insulator
Sheets');
WRITELN;
WRITELN('DO YOU WANT TO CHANGE THE SUPPORT PACKAGE COST?
Y OR N.');
```

```

READ(ANSWER);
CHECKANSWER;
```

```

IF (ANSWER = 'N') OR (ANSWER = 'n') THEN
  SUPCOST:=GIVENSUPCOST
```

```

ELSE BEGIN
  WRITELN;
  WRITELN ('ENTER NEW SUPPORT PACKAGE COST');
  READ (NEWSUPCOST);
  WHILE (NEWSUPCOST < 0) OR (NEWSUPCOST/10 > 10000) DO
```

```

BEGIN
```

```

  WRITELN;
  WRITELN('THE COST OF THE SUPPORT PACKAGE MUST BE
A NUMBER BETWEEN 0 AND 100000');
  WRITELN ('ENTER THE COST OF THE SUPPORT PACKAGE.');
```

```

  READ (NEWSUPCOST)
END; (WHILE)
```

```

  SUPCOST:=NEWSUPCOST
END (ELSE)
```

```

END; (PROCEDURE GETSUPPORTCOST)
```

```

(*****
****)
```

```

PROCEDURE GETHOTCOST (VAR HOTCOST:REAL);
```

```

  CONST
    GIVENHOTCOST=5672.00;
```

```

  VAR
    NEWHOTCOST:REAL;
```

```

  BEGIN
```

```

    WRITELN;
    WRITELN('This is the purchase price for a DME Hot Runner
Package');
```

```

    WRITELN('consisting of:');
    WRITELN('          1          Manifold ');
    WRITELN('          6 EHT0001          Nozzle
Assemblies');
```

```

    WRITELN('          6 EHT0013          Sprue Gate Tip
Sub-Assembly');
```

```

    WRITELN('          8 ECH0118          Cartridge
Heaters');
```

```

    WRITELN('          4 ECH0103          Cartridge
Heaters');
```

```

    WRITELN('          3 ETC0251          Thermocouple');
```

```

WRITELN('          1  EHLO253   Locating Ring');
WRITELN('          1  EHN0002   Nozzle Seat  ');
WRITELN('          1  ECBO162   Center Support');
WRITELN('          4  ERPO163   Riser Pad');
WRITELN('          2  ERPO165   Riser Pad');
WRITELN('         12  ESRO158   Spacer Rings');
WRITELN('          2  EHRO155   Seal Rings');
WRITELN;
WRITELN('DO YOU WANT TO CHANGE THE HOT RUNNER PACKAGE
COST?  Y OR N.');
```

```

READ(ANSWER);
CHECKANSWER;

IF (ANSWER = 'N') OR (ANSWER = 'n') THEN
    HOTCOST:=GIVENHOTCOST
ELSE BEGIN
    WRITELN;
    WRITELN ('ENTER NEW HOT RUNNER PACKAGE COST');
    READ (NEWHOTCOST);
    WHILE (NEWHOTCOST < 0) OR (NEWHOTCOST/10 > 10000) DO
BEGIN
    WRITELN;
    WRITELN('THE COST OF THE HOT RUNNER PACKAGE MUST
BE A NUMBER BETWEEN 0 AND 100000');
    WRITELN ('ENTER THE COST OF THE HOT RUNNER
PACKAGE.');
```

```

    READ (NEWHOTCOST)
    END; (WHILE)

    HOTCOST:=NEWHOTCOST
    END (ELSE)
    END;(PROCEDURE GETHOTRUNNERCOST)

{*****
**}

PROCEDURE GETCYCLETIME (VAR CYCLETIME:REAL);

CONST
    GIVENCYCLETIME=02.00;

VAR
    NEWCYCLETIME:REAL;

BEGIN
    WRITELN;
    WRITELN('The cycle time is the time in minutes, from the
instant');
```

```

    WRITELN('the polymer enters the mold, until it is
ejected.');
```

```

    WRITELN('Cycle time has a significant impact on
production cost');
```

```

WRITELN('as the number of units increases. Enter');
WRITELN('the part's cycle time in minutes. A default
cycle ');
WRITELN('time of 2 minutes is the current model value');
WRITELN;
WRITELN('THE CYCLE TIME FOR THE PART
IS',GIVENCYCLETIME:6:2);
WRITELN('DO YOU WANT TO CHANGE THE CYCLE TIME? Y OR N');

READ(ANSWER);
CHECKANSWER;

IF (ANSWER = 'N') OR (ANSWER = 'n') THEN
    CYCLETIME:=GIVENCYCLETIME
ELSE BEGIN
    WRITELN;
    WRITELN ('ENTER NEW CYCLE TIME');
    READ (NEWCYCLETIME);
    WHILE (NEWCYCLETIME < 0) OR (NEWCYCLETIME > 100) DO
BEGIN
        WRITELN;
        WRITELN('THE CYCLE TIME MUST BE A NUMBER BETWEEN
0 AND 100');
        WRITELN ('ENTER NEW CYCLE TIME');
        READ (NEWCYCLETIME)
        END; (WHILE)
        CYCLETIME:=NEWCYCLETIME
    END (ELSE)

END;(PROCEDURE GETCYCLETIME)

```

{*****}

```

PROCEDURE GETIFLH (VAR IFLH:REAL);

CONST
    GIVENIFLH=05.00;

VAR
    NEWIFLH:REAL;

BEGIN
    WRITELN;
    WRITELN('The time to inspect and finish the part is the
time');
    WRITELN('in minutes to insure proper size, shape, and');
    WRITELN('quality for 100 parts after ejection from the
mold. Most');
    WRITELN('parts require no trimming or alteration.
However, more');
    WRITELN('complex parts may require some post-molding
procedures. ');

```

```

WRITELN('A default time of 5 minutes is the current model
value');
WRITELN('This time is for a lot of 1-100 units, and will
include');
WRITELN('all Quality Control operations. ');
WRITELN;
WRITELN('THE INSPECTION AND FINISHING TIME FOR 100 PARTS
IS',GIVENIFLH:8:2);
WRITELN('DO YOU WANT TO CHANGE THE INSPECION AND
FINISHING TIME? Y OR N');

```

```

READ(ANSWER);
CHECKANSWER;

```

```

IF (ANSWER = 'N') OR (ANSWER = 'n') THEN
  IFLH:=GIVENIFLH
ELSE BEGIN
  WRITELN;
  WRITELN ('ENTER NEW INSPECTION AND FINISHING TIME');
  READ (NEWIFLH);
  WHILE (NEWIFLH < 0) OR (NEWIFLH > 100) DO BEGIN
    WRITELN;
    WRITELN('THE IFLH MUST BE A NUMBER BETWEEN 0 AND
100');
    WRITELN ('ENTER NEW IFLH');
    READ (NEWIFLH)
  END; (WHILE)
  IFLH:=NEWIFLH
END (ELSE)

```

```

END; (PROCEDURE GETIFLH)

```

```

(*****)

```

```

PROCEDURE SETCOMPLEXITYLEVEL (VAR MPLH,COMP:REAL);
BEGIN
  WRITELN;
  WRITELN('A crucial factor in determining the cost of
the');
  WRITELN('finished part is it's complexity. The
complexity');
  WRITELN('of the part will factor heavily in the time
and');
  WRITELN('cost required to produce the original mold and
to');
  WRITELN('inspect and trim the molded part. JOWP
divides');
  WRITELN('parts into five levels of complexity. Examine
the');
  WRITELN('descriptions below and enter the level which
best');
  WRITELN('describes the part whose cost you wish to

```

```

estimate. ');
  WRITELN;
  WRITELN('Press RETURN to continue. ');

  READ(ANSWER);

  IF ANSWER <> '' THEN
    BEGIN
      WRITELN;
      WRITELN;
      WRITELN(' Complexity          Description');
      WRITELN;
      WRITELN('5 - Very High: Large size or multiple cavities.
20 or more walls. ');
      WRITELN(' 600 Hours 20 or more holes or depressions.
Projections ');
      WRITELN('          perpendicular to the opening of
the mold. ');
      WRITELN('          Loaded inserts. Geometries
which will make ');
      WRITELN('          ejecting the part from the mold
difficult. ');
      WRITELN;
      WRITELN('4 - High: 10 to 20 walls. Large size or
multiple cavities. 10 to 20 ');
      WRITELN(' 400 Hours holes or depressions. Narrow,
deep walls or grooves. ');
      WRITELN('          Geometries which will make
ejecting the part difficult. ');
      WRITELN;
      WRITELN('3 - Moderate: 5 to 10 walls. Moderate size.
One or two ');
      WRITELN(' 120 Hours holes or depressions. No
geometries which ');
      WRITELN('          will make the part difficult to
eject. ');
      WRITELN;
      WRITELN('2 - Low: 1 to 4 walls. Few holes or
depressions. ');
      WRITELN(' 70 Hours No non-circular holes. No
projections. ');
      WRITELN;
      WRITELN('1 - Very Low: Continuous, uniform wall in the
direction ');
      WRITELN(' 30 Hours of the injection. No holes,
depressions. ');
      WRITELN('          grooves, inserts, or
projections. ');
      WRITELN;
      WRITELN('Enter the number of the part's complexity
level')
    END;

```

```

READ(COMP);

    WHILE (COMP < 0) OR (COMP > 5) DO BEGIN
        WRITELN;
        WRITELN('The part's complexity level must be a
number between 1 and 5. ');
        WRITELN ('Enter the complexity level of the
part. ');
        READ (COMP)
    END; (WHILE)

    IF COMP=1 THEN BEGIN
        MPLH:=20;
    END
    ELSE IF COMP=2 THEN BEGIN
        MPLH:=70;
    END
    ELSE IF COMP=3 THEN BEGIN
        MPLH:=120;
    END
    ELSE IF COMP=4 THEN BEGIN
        MPLH:=400;
    END
    ELSE IF COMP=5 THEN BEGIN
        MPLH:=600;
    END
END; (PROCEDURE SETCOMPLEXITYLEVEL)

(*****
***)
PROCEDURE GETPRODNUM;

BEGIN
    WRITELN;
    WRITELN('Do you wish to estimate production costs for more
than');
    WRITELN('one unit? Y OR N. ');

    READ(ANSWER);
    CHECKANSWER;

    IF (ANSWER = 'N') OR (ANSWER = 'n') THEN
        PRODNUM:=1
    ELSE BEGIN
        WRITELN;
        WRITELN ('How many units do you wish to produce? ');
        READ (PRODNUM);
    END (ELSE)
END;

(*****
***)

```



```

WRITELN(' Cost of Raw Material                               $
',MATCOST:8:2,' per pound');
WRITELN;
WRITELN(' Cost of Mold Base Package                           $
',MBCOST:8:2);
WRITELN;
WRITELN(' Cost of Control Package                               $
',CONCOST:8:2);
WRITELN;
WRITELN(' Cost of Hot Runner Package                           $
',CONCOST:8:2);
WRITELN;
WRITELN(' Cost of Support Package                               $
',SUPCOST:8:2);
WRITELN;
WRITELN(' Complexity                                           ',COMP:8:2);

WRITELN;
WRITELN(' Minutes to Prepare Material
',PREPTIME:8:2);
WRITELN;
WRITELN(' Number of Units to be Produced
',PRODNUM:8:2);

WRITELN('Press RETURN to continue.');
```

READ(ANSWER);

```

IF ANSWER <> '~' THEN
  BEGIN
    WRITELN(' Manufacturing Costs');
    WRITELN;
    WRITELN(' First Unit Costs');
    WRITELN;
    WRITELN(' Raw Material           $ ',RAWMATCOST:8:2);
    WRITELN(' Mold Cost                 $ ',MOLDCOST:8:2);
    WRITELN(' Control Package           $ ',CONCOST:8:2);
    WRITELN(' Hot Runner Package        $ ',HOTCOST:8:2);
    WRITELN(' Support Package           $ ',SUPCOST:8:2);
    WRITELN;
    WRITELN(' Cost of First Unit       $ ',FUCOST:8:2);
    WRITELN;
    WRITELN(' Cost of ',PRODNUM:8:2,' Units');
```

```

WRITELN;
WRITELN(' Raw Material           $ ',PRODMAT:8:2);
WRITELN;
WRITELN(' Material Preparation     $ ',PREPCOST:8:2);
WRITELN;
WRITELN(' Cost of Labor            $ ',FABLABCOST:8:2);
WRITELN;
WRITELN(' Inspection and Finishing $ ',INSFINCOST:8:2);
WRITELN;

```

```
WRITELN('Per unit cost of',PRODNUM:8:0,' units is
',PRODCOST:8:2);
WRITELN;
WRITELN('The cost of producing ',PRODNUM:8:0,' units is $
',TOTCOST:8:2);
END;
{*****
*****}
END.~Z
```

Bibliography

Allen, Carl P. and Moriarity, Shane. Cost Accounting. New York: John Wiley & Sons, 1991.

Baer, Eric. Engineering Design For Plastics. New York: Reinhold Publishing Corporation, 1964.

Baird, Major John. Advanced Polymer Component Air-to-Air Missile Case Design Exercise. United States Astronautics Laboratory (AFSC), Edwards AFB CA, 1990.

Chew, James S. B. Program Manager, United States Air Force Astronautics Laboratory (AFSC). Personal Interview. Air Force Institute of Technology, Wright-Patterson AFB OH, 13 June 1991.

Chew, James S. B. and John Rusek. Solid Rocket Propulsion Applications For Advanced Polymers. United States Astronautics Laboratory (AFSC), Edwards AFB CA, 1989.

"Company to Expand Plant Making plastic Compounds," The Wall Street Journal, Jan 12, 1990, C15J.

Cooper, Doug and Clancy, Michael. Oh! Pascal. New York: W. W. Norton & Company, 1982.

DuPont & Company. Price List for DuPont Liquid Crystal Polymers. Wilmington DE, 1991.

Fabryky, Wolter J. and Blanchard, Benjamin S. Engineering Systems Analysis. Englewood Cliffs NJ: Prentice-Hill, Inc. 1981.

Firefly, Rufus T. Yes, But Can The Steam Engine Do This? Millbrook NY: Bench Press, Inc. 1981.

Foley, Michael "Computer-based Manufacturing Cost Analysis for the Fabrication of Thermoplastic Composite Structures," Society of Manufacturing Engineers Technical Paper, 1990.

Frank, Christopher L. Injection Mold Design. Air Force Advanced Composites Program Office, 1990 (SM-ALC-00096).

Frank, Christopher L. Air Force Advanced Composites Program Office, Personal Interview. Wright-Patterson AFB OH, August 1991.

Garrison, Ray. Managerial Accounting, Business Publications, Inc., 1979.

George, Rudolph. Chief Machinist, Acutech Corporation.
Personal Interview. Huber Heights OH, July 1991.

Kirkham, Steven L. "Injection Molding Thermoplastics,"
Modern Plastics, 286-288 (Oct 1990).

Leopold, Phillip M. "Injection Molding Thermosets", Modern
Plastics, 288-290 (Oct 1990).

Livermore, Robert. Equipment Price Quotations. DME
Company. Monterey Park CA, June 1991.

Millbank, Dana. "Use of Plane Plastics May Ground
Aluminum," The Wall Street Journal, Nov 23, 1990, A2B.

Rusek, John. Program Manager, United States Air Force
Astronautics Laboratory (AFSC). Personal Interview. Air
Force Institute of Technology, Wright-Patterson AFB OH, 13
June 1991.

Stoddard, William. Chief Executive Officer, Accutech
Corporation. Personal Interview. Huber Heights OH, July
1991.

"Toray Industries Says Boeing Co. Approved Plastic Fiber
For Jets," The Wall Street Journal, April 16, 1990, B6G.

VITA

K. Frederick Byard was born on November 1, 1959 in Suffern, New York. He graduated from high school in Millbrook, New York, in 1977. After receiving a degree in Behavioral Science from the United States Air Force Academy in 1981, he was commissioned an officer in the USAF. Capt Byard has served as Operations Officer for the 321 Security Police Squadron in Grand Forks, North Dakota, and as Cost and Program Analyst for numerous Electronics Systems Division Programs while stationed at Hanscom AFB, Massachusetts. In 1987, he was the ESD Team Chief during the first on-site inspection of a Soviet ballistic missile production facility in Votkinsk, USSR. He earned a Bachelor of Science in Physics from the University of North Dakota, and a Master of Business Administration from Western New England College, Springfield, Massachusetts, prior to entering the Government Cost Analyst and Engineering Physics programs at the Air Force Institute of Technology in May, 1990.

He is married with three children.

Permanent address: 4347 Newberry Ct
Beavercreek, Ohio 45432

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.				
1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE September 1991	3. REPORT TYPE AND DATES COVERED Master's Thesis		
4. TITLE AND SUBTITLE A MICROCOMPUTER PROGRAM FOR ESTIMATING PRODUCTION COSTS OF INJECTION MOLDED PLASTIC STRUCTURES			5. FUNDING NUMBERS	
6. AUTHOR(S) Kyle Frederick Byard, Capt, USAF				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)			8. PERFORMING ORGANIZATION REPORT NUMBER AFIT/GCA/ENS/91S-1	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)			10. SPONSORING / MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution unlimited			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) The job of estimating the production costs of injection molded thermoplastic structures requires designers and analysts to produce detailed preliminary drawings and consult machinists with expertise in mold production. Interviews with injection molding experts produced a scale of part complexity and associated range of labor hours for mold production. This scale is incorporated into a cost estimating methodology which allows the analyst to estimate the cost of the structure without the aid of technicians. The resulting cost model is then programmed into an interactive Pascal computer program for ease of use and documentation.				
14. SUBJECT TERMS Plastics, Thermoplastics, Injection Molding, Cost Estimating			15. NUMBER OF PAGES 55	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UL	

AFIT RESEARCH ASSESSMENT

The purpose of this questionnaire is to determine the potential for current and future applications of AFIT thesis research. Please return completed questionnaires to: AFIT/LSC, Wright-Patterson AFB OH 45433-6583.

1. Did this research contribute to a current research project?

- a. Yes b. No

2. Do you believe this research topic is significant enough that it would have been researched (or contracted) by your organization or another agency if AFIT had not researched it?

- a. Yes b. No

3. The benefits of AFIT research can often be expressed by the equivalent value that your agency received by virtue of AFIT performing the research. Please estimate what this research would have cost in terms of manpower and/or dollars if it had been accomplished under contract or if it had been done in-house.

Man Years _____ \$ _____

4. Often it is not possible to attach equivalent dollar values to research, although the results of the research may, in fact, be important. Whether or not you were able to establish an equivalent value for this research (3 above), what is your estimate of its significance?

- a. Highly Significant b. Significant c. Slightly Significant d. Of No Significance

5. Comments

Name and Grade

Organization

Position or Title

Address

**END
FILMED**

DATE:

1-92

DTIC