

AD A 016 971

RIA-75-U1275

A016971



AD

TECHNICAL
LIBRARY

AMMRC CTR 75-18

MACHINE CASTING OF FERROUS ALLOYS

SEPTEMBER 1975

G. D. CHANDLEY AND GARY SCHOLL
HITCHINER MANUFACTURING CO., INC.
ELM STREET
MILFORD, N.H. 03055

Interim Report

Contract Number DAAG46-73-C-0112

Sponsored by: Defense Advanced Research Projects Agency ARPA Order No. 2267

Program Code No. 4D10

Effective Date of Contract: February 1, 1975

Contract Expiration Date: February 27, 1976

Amount of Contract: \$466,661.00

Contract Period Covered by Report: 1 February 1975 - 30 June 1975

Prepared for

ARMY MATERIALS AND MECHANICS RESEARCH CENTER
Watertown, Massachusetts 02172

The view and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the Defense Advanced Research Projects Agency of the U. S. Government.

Mention of any trade names or manufacturers in this report shall not be construed as advertising nor as an official indorsement or approval of such products or companies by the United States Government.

DISPOSITION INSTRUCTIONS

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

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AMMRC-CTR 75-18	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Machine Casting of Ferrous Alloys		5. TYPE OF REPORT & PERIOD COVERED Interim Report Feb. 1975 - June 1975
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) G. D. Chandley Gary Scholl		8. CONTRACT OR GRANT NUMBER(s) DAAG46-73-C-0112
9. PERFORMING ORGANIZATION NAME AND ADDRESS Hitchiner Mfg. Co., Inc. Milford, N.H. 03055		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS D/A Project: Order 2267 AMCMS Code: 691000.21.66024 Agency Accession:
11. CONTROLLING OFFICE NAME AND ADDRESS Army Materials and Mechanics Research Center Watertown, Massachusetts 02172		12. REPORT DATE September 1975
		13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. 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) Solidification Die Casting		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Due to the lack of economic permanent die materials for use in Hipocasting ferrous alloys, three innovative approaches for creating a mold cavity for use in machine casting of ferrous alloys were explored. They were: use of liquid metal cooling of a thin walled die, use of a porous die, vacuum coated with dry ceramic and use of a membrane to vacuum from a disposable		

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

mold. Vacuum forming a disposable mold appears to be the most promising method for machine casting of ferrous alloys.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

i-a

FOREWORD

This report covers work done in the period 1 February 1975 - 30 June 1975, under the general title "Machine Casting of Ferrous Alloys". The work is sponsored by the Defense Advanced Research Projects Agency under ARPA Order No. 2267, Program Code No. 4D10. The work was carried out at the Hitchiner Manufacturing Company, Inc., Elm Street, Milford, N.H. 03055, by the principal investigators, G. D. Chandley and Gary Scholl, (Tel: (603)673-1100). The work was accomplished under Contract No. DAAG46-73-C-0112 with Dr. E. Wright/ Mr. Frank Quigley at Army Materials and Mechanics Research Center as the program technical monitor.

TABLE OF CONTENTS

	<u>Page</u>
Foreword	ii
List of Figures	iv
List of Tables	v
I. INTRODUCTION	1
II. NEW DIE SYSTEMS	1
A. Aspi-cast system	1
B. Hypo-V Process	3
C. Augmented Hypo-V Process	4
III. CONCLUSIONS	8
IV. RECOMMENDATIONS FOR FUTURE WORK	9

LIST OF FIGURES

<u>Figure</u>		<u>Page</u>
1	Schematic of Hipocast Process	10
2	Schematic of Composite Die	11
3	Test Apparatus for Aspi-Cast System	12
4	Pressure function for transition of sand retention mode.....	13
5	Functional relationship of surface area coverage	14
6	Photographs of porous metal dies which failed in service	15
7	Sequence of mold preparation for Hypo-V process	16
8	Photographs of first Hypo-V casting	17
9	Sequence of mold preparation for augmented Hypo-V Process	18
10	Drawing of suspension Bomb Lug	19
11	Photo of first bomb lugs made by the augmented Hipocast Process	20

LIST OF TABLES

<u>TABLE</u>		<u>PAGE</u>
1	Physical Properties of Porous Metal Die Materials.....	21
2	Composition and Physical Properties of Slurry.....	22

I. INTRODUCTION AND BACKGROUND

During the past thirty months, Hitchiner Manufacturing Company, Inc. has been actively engaged in the development of an economically feasible process to machine cast ferrous alloys. Several creative methods have evolved with varying degrees of success. The Hipocast process, see Figure 1, developed specifically for this program, continues to be the most encouraging of all machine casting processes presented to date. The program had initially been directed primarily toward the optimization of the casting system, assuming that, when this had been accomplished, conventional approaches to economic die life would fulfill the overall objectives. In keeping with this approach, the use of permanent molds of all likely materials have been investigated; the concept of a composite die which incorporates a second metal in the liquid phase to facilitate heat transfer, has also been pursued (see Figure 2). That operating assumption is now seen to be erroneous. In the casting of ferrous alloys, economic feasibility must begin with an economic mold system. Recent efforts have therefore been solely devoted to the development of a mold system which will satisfy the following requirements:

- 1) Ability to withstand 3000°F.
- 2) Ability to react to dimensional changes of the casting.
- 3) Freedom from chemical reactions which may cause surface and gas defects.
- 4) The ability to maintain surface and dimensional integrity.
- 5) The contribution of the die system cost to each casting should not exceed 25 cents for an 8 oz. part.

II. NEW DIE SYSTEMS

A. Aspi-cast system

An aspirating die system has been conceived and implemented in several stages for investigation. Porous metal molds were

fabricated by a powdered metals process. These inserts (containing the casting cavity) were placed in specially designed fixtures which created a vacuum behind the porous mold. The pressure differential across the mold to atmosphere was then used to maintain a thin coating of refractory particles at the exposed surface of the porous insert. The system relies on the refractory particles to protect the die materials from intimate exposure to the casting environment and allows for easy expulsion of the coating and casting by pressurizing the mold.

Initial tests were setup to establish functional relationships which would later be used to predict and control the nature of surface coatings. Here, it became immediately evident that a material's "porosity", as rated by the manufacturer, was related to an industry standard "bubble test" and, although indicative of the material's filtering capabilities, did not necessarily reflect the size of the exposed pores. To avoid confusion, pore size, as used in our work and this report, refer to the average diameter of pores measured at the surface. Table 1 in the appendix summarizes the physical properties of the porous die materials tested. Using the apparatus depicted in Figure 3, preliminary data was gathered using the following procedures:

- 1) Refractory sands of a single sieve size were bulk loaded onto the mold surface.
- 2) The vacuum pressure behind the mold was increased to 30 inches of mercury and the mold was rotated 180° (upside down).

3) The vacuum pressure was then slowly decreased until only a thin layer of sand remained attached to the mold face. The transition between bulk and lamellar retention was dramatic at well defined pressures. That transition pressure was found to be strongly related to the ratio of particle size to pore size and the function appears in Figure 4. The sand particles retained after the lamellar transition were then weighed and an estimated surface coverage was computed from geometric considerations. The surface area coverage function is linearly proportional to the ratio of retained weight to particle size, and is influenced somewhat by a size factor. An illustration of the function appears in Figure 5.

Several casting cycles were accomplished using surface coverages of approximately 40 and 250%. Failure resulted in all tests after a small number of castings (i.e. less than 5). Tests using a porous bronze material failed when a substance (probably tin) melted, migrated and resolidified closing porous passages. A micrograph of this phenomenon appears in Figure 6. Porous inserts of 316 stainless steel failed when the surface pores became clogged with an oxide of unknown origin. An optical photograph of this failure mode also appears in Figure 6.

B. Hypo-V Process

Concurrent with the investigation of the Aspi-cast die system, the evaluation of possible advantages of a mold system which totally creates the cavity in unbonded sand using a light vacuum and a low permeability membrane was begun. The sequence of events can best be described by the schematic illustrations

in Figure 7. Essentially, the process begins by vacuum forming a thin membrane to a porous pattern board. This board and membrane is then placed against a hollow die, which is subsequently backfilled with sand. Finally the die is evacuated of remaining air and atmospheric pressure is returned to the pattern board. This effectively transfers the membrane, still retaining the pattern surface geometry, to the die.

Preliminary tests were accomplished using a polyethylene film stretched and vacuum formed over a pattern which was mounted to a porous metal plate. The first castings to be made using this mold system and the Hipocast machine appear in Figure 8. The surface texture which appears here was improved upon slightly by selecting finer sands for the mold and by decreasing the vacuum pressure in the mold to reduce penetration. It now appears, however, that to achieve the desired surface roughness (100-250 micro-inch) the dies must be altered to cause pressure molding of fine sand grains at the membrane surface.

C. Augmented Hypo-V Process

An improved system is currently being pursued which incorporates a porous ceramic coating between the membrane and the sand mold. The ceramic is spray deposited in an ethyl silicate and flour slurry which is rapidly gelled chemically. The advantages of such a mold system are numerous and excellent surface and geometric integrity can be achieved. Although several steps are required to complete the casting cycle, the system appears to lend itself to full automation and that the short casting

cycle times associated with "machine casting" will be achieved. The ceramic coating, although permeable, will support the mold face without the cavity forming membrane. This then gives rise to the possibility of a reuseable membrane. Further, with the membrane removed, we have essentially a low cost, permeable mold which is highly suitable for vacuum ingestion of high temperature liquid or semi liquid metals. The sequence of events for such a casting cycle are schematically represented in Figure 9.

The material selection for the low permeability membrane is considered an important aspect in the development of this process. Early tests were conducted using readily available polyethylene films marketed as food packaging wraps (e.g. Saran Wrap, Miracle Wrap, Glad Wrap, and others). Of these items Glad Wrap yielded superior results when formed over small parts which did not have complex shapes. These materials had an added advantage in that once transferred to the mold, they could be easily ignited and burned off while curing the ceramic coating. At this time in the program a decision was made, selecting a suspension type bomb lug (see Figure 10) for our standard machine casting part. This part is to be cast in 4340 low alloy steel and has a market potential of 5 million parts per year at a price of \$2 each. The part is presently being made as a machined forging and can not be priced at this level as an investment casting. The complex geometry of this part could not be transferred using the polyethylene films and an in depth materials search was initiated.

Although the overall elongation of the parting membrane for the bomb lug part was around 200%, the complex geometry of several selected areas requires elongation which may exceed 800%. This led to an investigation of elastomers. An important criteria for elastomers, in light of their high costs, was reuseability. This has come to mean

- 1) Alkali and Acid resistance
- 2) General resistance to chemical attack
- 3) Low porosity
- 4) Availability in thin sheet form
- 5) Heat resistance
- 6) High elasticity

Several natural and synthetic rubbers have been tested. The fluorocarbon compounds of Kel-F and Viton were not available in the thin sections required, the natural and silicone rubbers frequently did not satisfactorily resist chemical and mechanical attack by the ceramic. Reasonable success has been achieved using an ablative teflon mold release to protect the natural rubbers. Neoprene rubbers and a cast teflon film are still under investigation.

Additional plastic films have also been investigated. Here the low cost frequently makes the films economic on a non-reuseable basis. In many cases this means that the only necessary criteria is elongation. However, this one criteria has excluded all films to date. Although many of these films are thermoplastic, the controlled addition of heat creates other problem areas in the ultimate process automation and this

technique has not as yet produced satisfactory results.

Several other approaches to the release membrane problem are also under consideration. For example, casting of the pattern geometry in a flexible material (such as rubber) for evaluation.

The ceramic coating is applied by spraying a slurry onto the formed release membrane. The slurry consists of zircon flours suspended in a partially hydrolyzed ethylsilicate binder. These materials were readily available and are used daily in Hitchiner's shell building facilities in the production of investment casting shell molds. Several minor alterations of the slurries are necessary, however, to adjust the gelation time and the viscosity for compatibility with the process requirements and spray apparatus. The typical slurry formation and physical data appear in table 2 in the appendix. Numerous problem areas have arisen in conjunction with the application of the ceramic coating. The majority of these have been solved on a cut and try basis. At this time the best coating methods seem to incorporate the following criteria:

- 1) The spray device should have a gravity feed and the slurry must not be permitted to stand in the nozzle section.
- 2) Agitation of the slurry can not be discontinued for periods in excess of 1 minute.
- 3) The application of granular sands AFS No. 100 by sand blast, results in a superior coating with respect to uniformity and strength.

- 4) The optimum method for applying the coating appears to be by alternating between the gelling solution and the slurry as opposed to simultaneous sprays.

Prior to casting, the alcohol solvent in the ceramic coating is ignited by a low temperature flame. This also insures completion of the gelling reaction and drives off any remaining moisture. The remaining coating contains numerous microscopic cracks but these are not readily visible to the unaided eye nor are they visible on the casting.

Several bomb lug castings using this mold system and the hipocast machine have been made. The results are very encouraging and in some respects are superior to the quality achieved using metallic molds. A photograph of the first of these parts appears in Figure 11.

III. CONCLUSIONS

The necessity to control mold amortization costs in a machine casting process for ferrous alloys excludes the use of conventional metallic dies when casting with liquid metal. Several regenerating refractory mold systems have been examined; one of these methods may ultimately result in an economically feasible mold system.

The hypo-V process has the inherent advantage of its simplicity and accompanying low costs. The membrane requirements, however, have not yet been met for complex geometries. The augmented hypo-V process yields superior surface integrity and is easily adapted to vacuum filling. On the other hand, this process requires more sophisticated control and automation procedures, which along with

increased material costs, may exceed our amortization objectives. The Aspi-cast system has numerous cost advantages but the technical feasibility remains in question.

IV. RECOMMENDATIONS FOR FUTURE WORK

Vacuum mold systems are being actively tested. The coming months should produce conclusive results in at least one of these methods. The concept of vacuum injecting molten and semi-molten steel into these molds will become a reality in the coming weeks. It is hoped that this concept can be incorporated with any of these vacuum die systems and will alleviate some problem areas unique to the hipocast process.

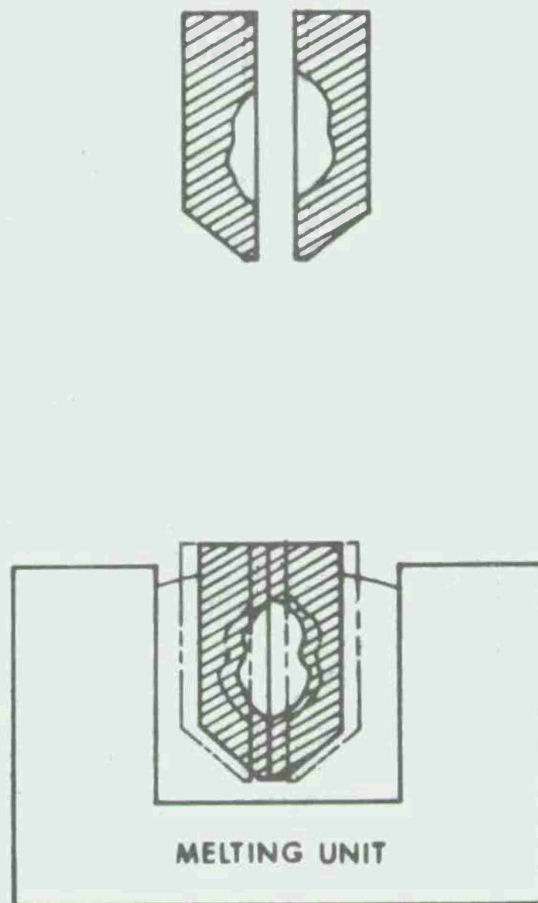


Figure 1. Schematic of Hipocast Process

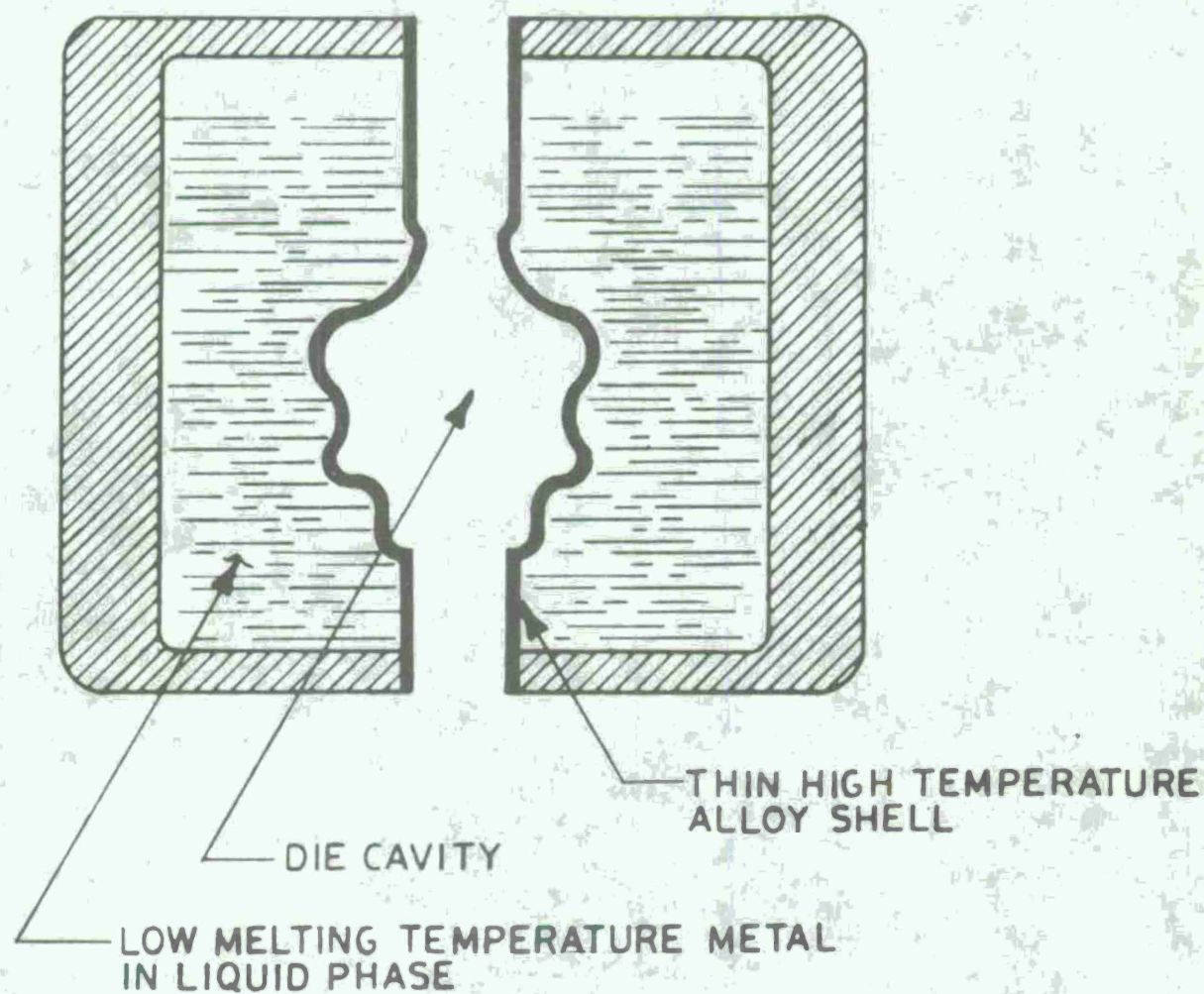


Figure 2. Schematic of Composite Die.

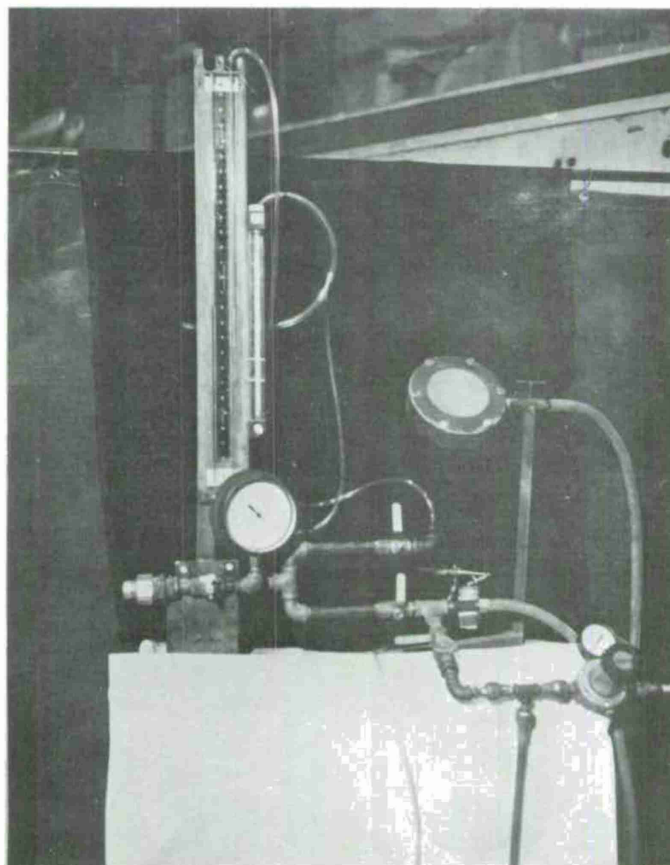


Figure 3. Test Apparatus for Aspi-Cast System.

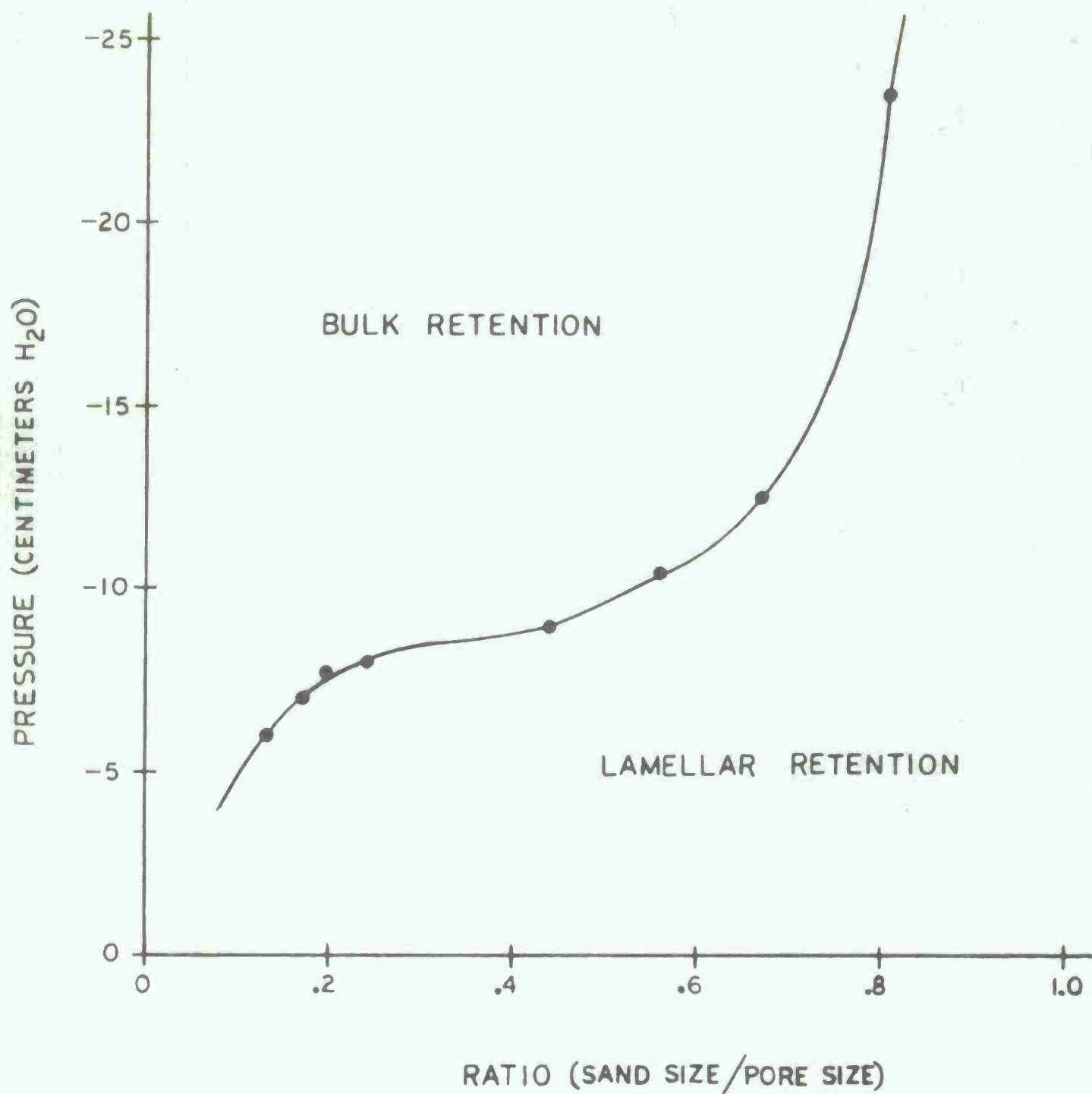


Figure 4. Pressure function for transition of sand retention mode.

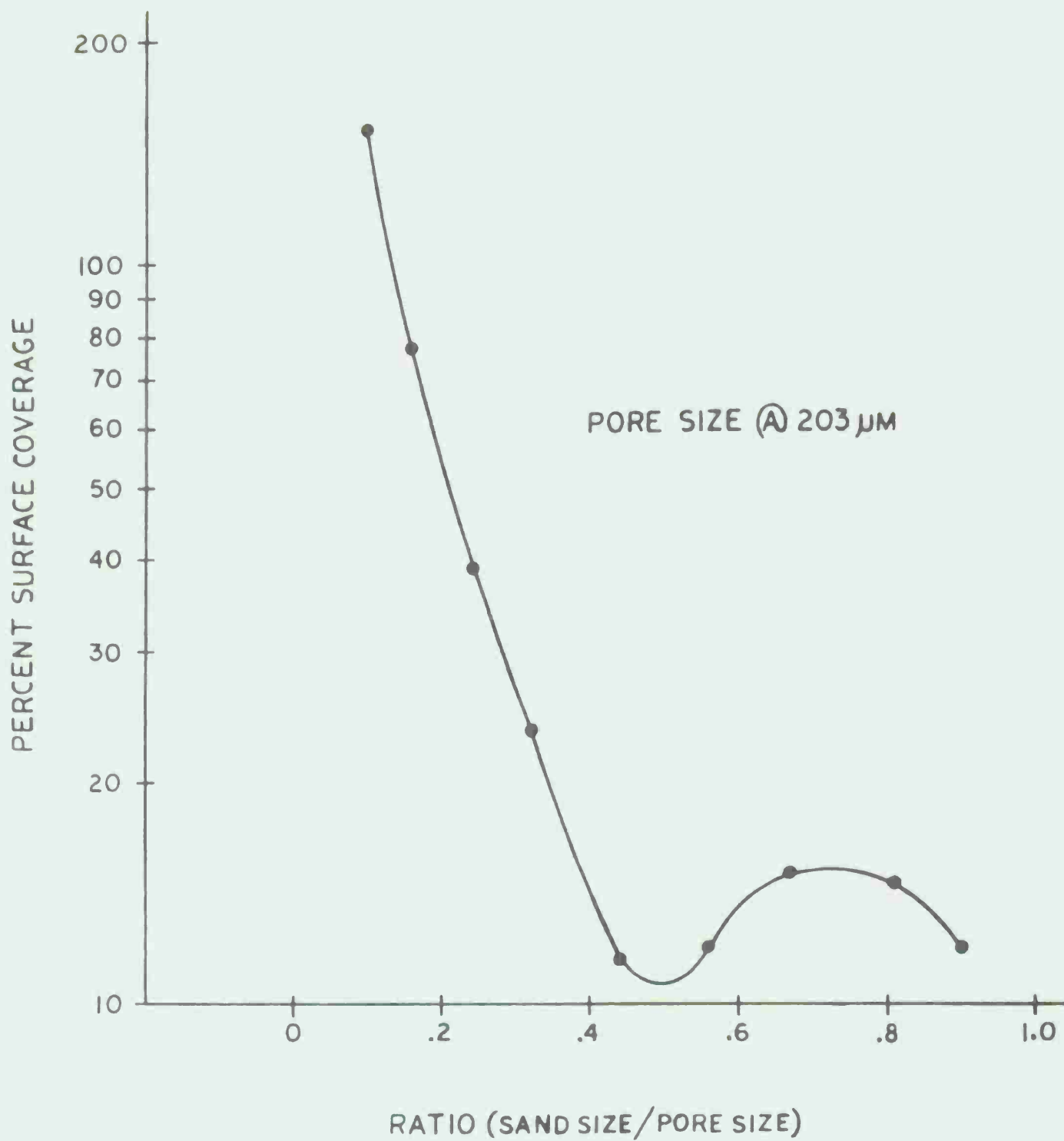
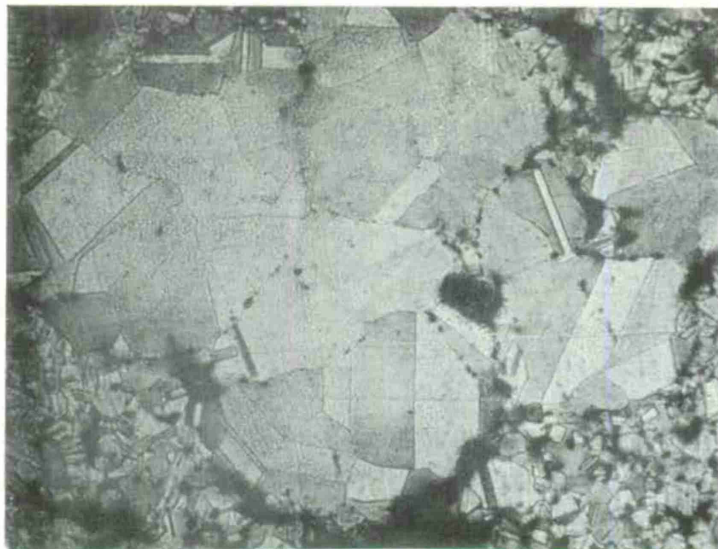
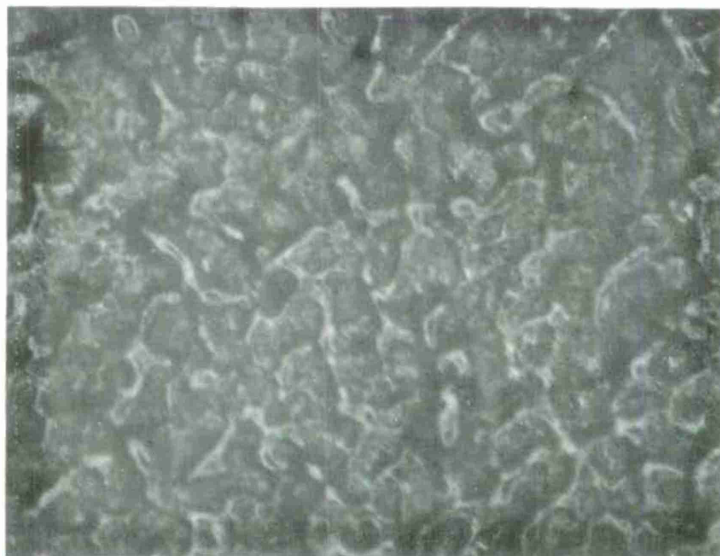


Figure 5. Functional relationship of surface area coverage.



(a) Interior section of bronze die (200x)



(b) Surface of 316 stainless steel die
after 5 castings (56x)

Figure 6. Photographs of porous metal dies which failed
in service.

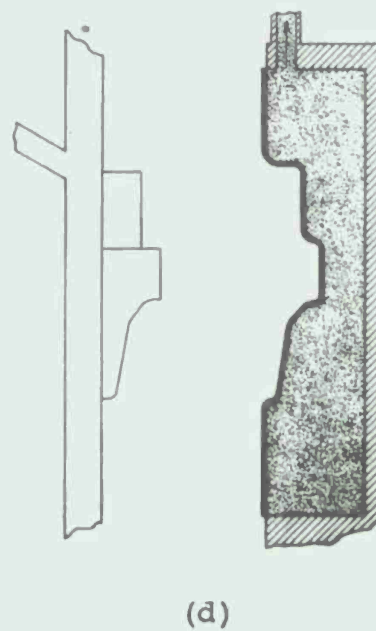
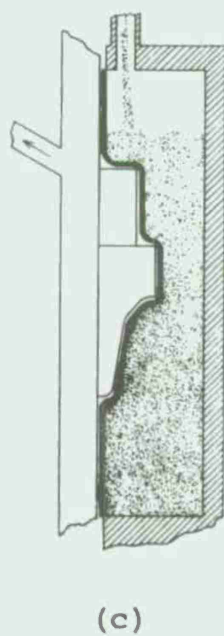
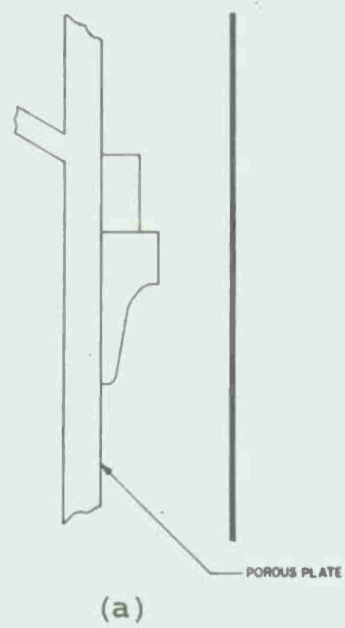


Figure 7. Sequence of mold preparation for Hypo-V Process.

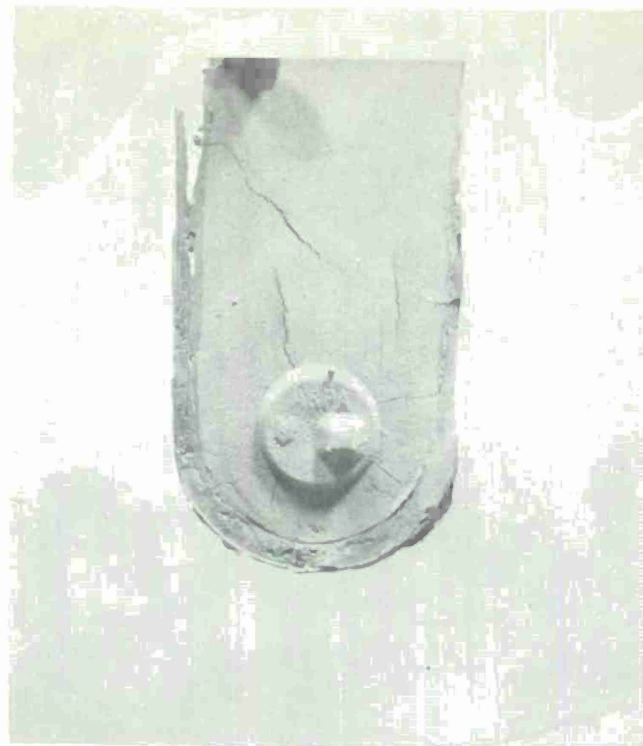


Figure 8. Photographs of first Hypo-V casting.

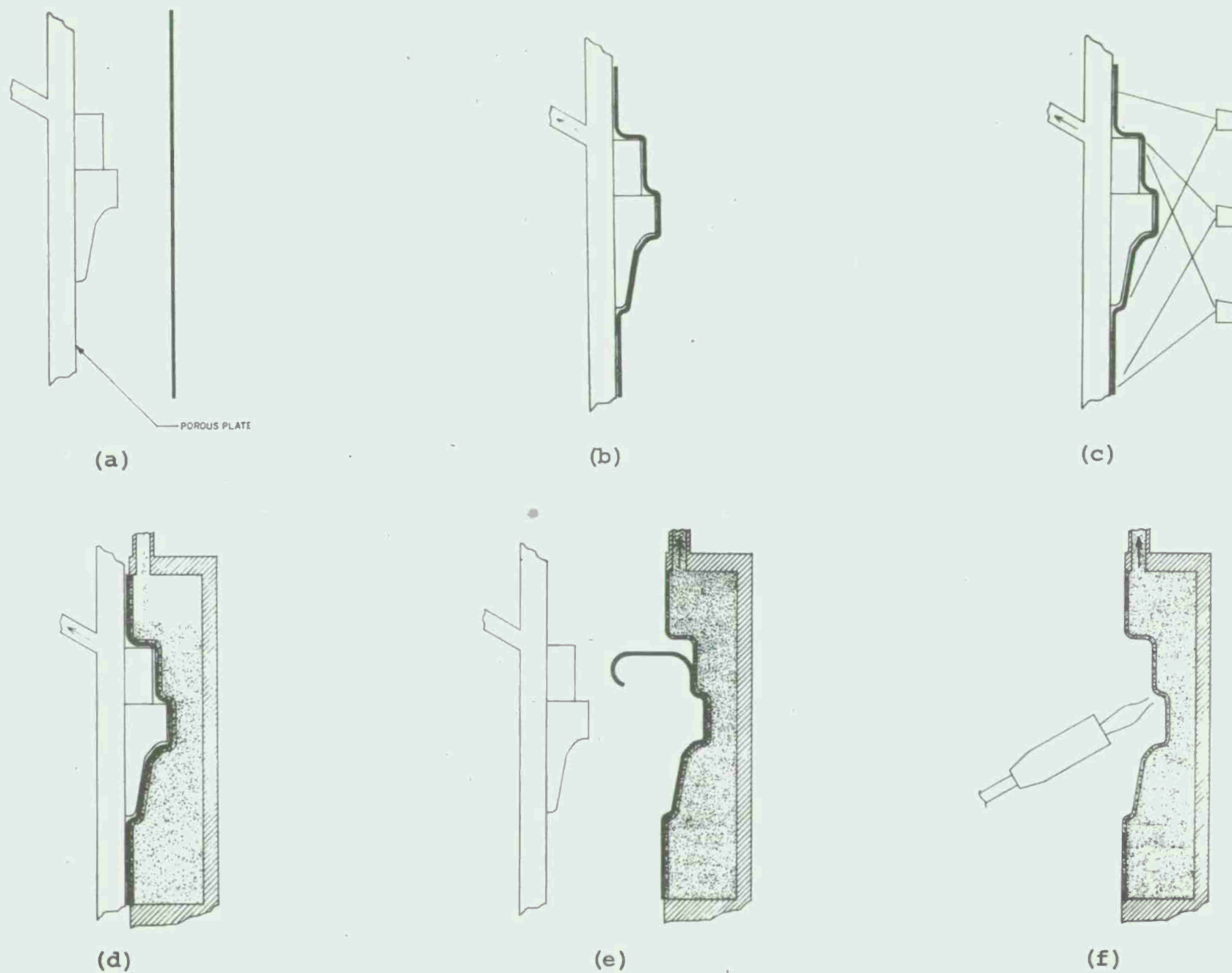
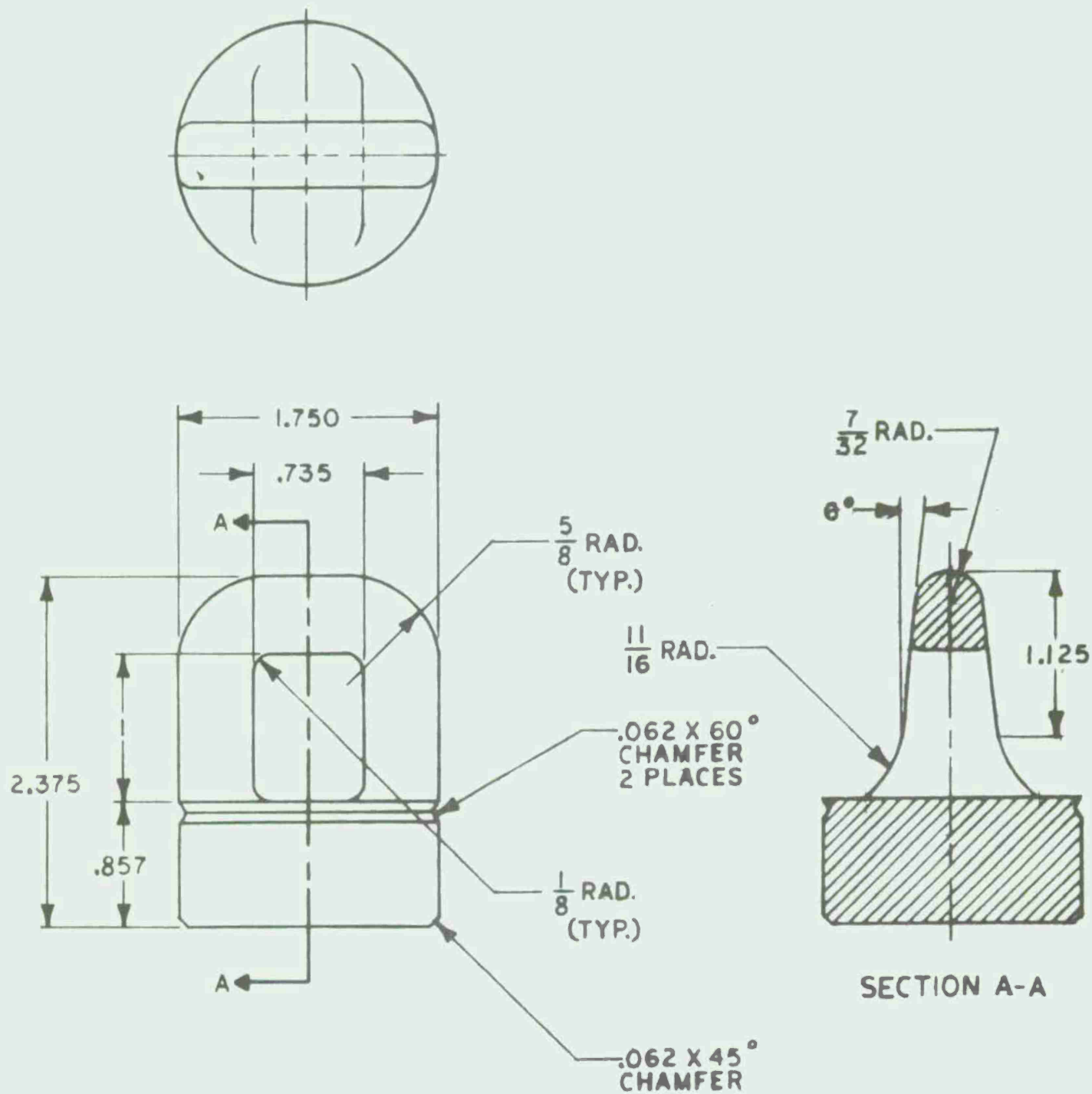


Figure 9. Sequence of mold preparation for augmented Hypo-V Process.



SCALE-FULL

Figure 10. Drawing of suspension Bomb Lug.

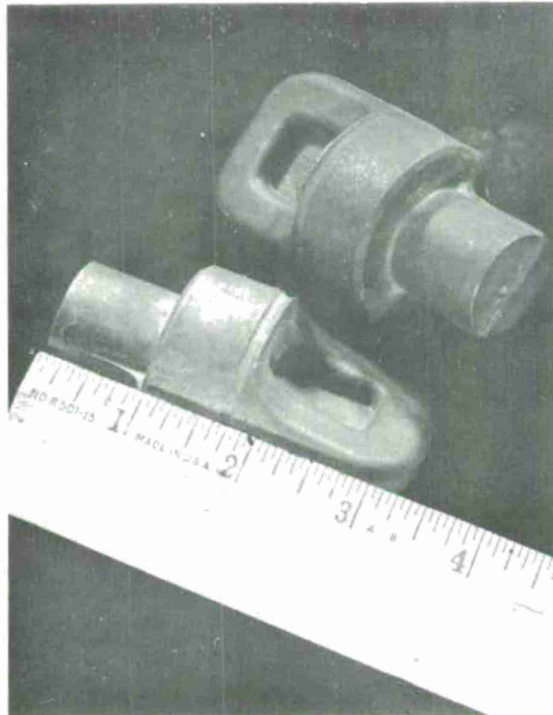


Figure 11. Photo of first bomb lugs made by the augmented Hipocast Process.

TABLE 1. Physical Properties of 316 Stainless Steel
Porous Metal Dies

<u>Porosity Micron</u>	<u>Particle Size Micron</u>	<u>Density %</u>	<u>Flow Conductance $\frac{\text{Scm}^3/\text{s}/\text{cm}^2}{\text{g}/\text{cm}^2}$</u>
5	165	50	.994
10	240	47	1.92
20	450	48	3.60
40	725	41	21.6

TABLE 2. Composition and Physical Properties
of Slurry

Composition by Weight

Ethyl Silicate 40	15%
Isopropyl Alcohol (Anhydrous)	6%
Refractory flours (2-6 micron dia.)	79%

Physical Properties

Specific Gravity	1.65
pH	2
Gel Time for 75cc Slurry with 6cc 2.5% $(\text{NH}_4)_2\text{CO}_3$ solution	100 sec
Viscosity	
Brookfield No. 3 spindle	
@ 100 RPM	115 cp

TECHNICAL REPORT DISTRIBUTION

No. of Copies	To
1	Office of the Director, Defense Research and Engineering, The Pentagon, Washington, D. C. 20301
12	Commander, Defense Documentation Center, Cameron Station, Building 5, 5010 Duke Street, Alexandria, Virginia 22314
1	Metals and Ceramics Information Center, Battelle Memorial Institute, 505 King Avenue, Columbus, Ohio 43201
	Chief of Research and Development, Department of the Army, Washington, D. C. 20310
2	ATTN: Physical and Engineering Sciences Division
	Commander, Army Research Office (Durham), Box CM, Duke Station, Durham, North Carolina 27706
1	ATTN: Information Processing Office
	Commander, U. S. Army Materiel Command, 5001 Eisenhower Ave., Alexandria, Virginia 22304
1	ATTN: AMCRD-TC
	Commander, Deseret Test Center, Fort Douglas, Utah 84113
1	ATTN: Technical Information Office
	Commander, U. S. Army Electronics Command, Fort Monmouth, New Jersey 07703
1	ATTN: AMSEL-GG-DD
1	AMSEL-GG-DM
	Commander, U. S. Army Missile Command, Redstone Arsenal, Alabama 35809
1	ATTN: Technical Library
1	AMSMI-RSM, Mr. E. J. Wheelahan
	Commander, U. S. Army Armament Command, Rock Island, Illinois 61201
1	ATTN: AMSAR-SC, Dr. C. M. Hudson
1	AMSAR-PPW-PB, Mr. Francis X. Walter
2	Technical Library
	Commander, U. S. Army Satellite Communications Agency, Fort Monmouth, New Jersey 07703
1	ATTN: Technical Document Center
	Commander, U. S. Army Tank-Automotive Command, Warren, Michigan 48090
2	ATTN: AMSTA-BSL, Research Library Branch
	Commander, White Sands Missile Range, New Mexico 88002
1	ATTN: STEWS-WS-VT

No. of
Copies

To

Commander, Aberdeen Proving Ground, Maryland 21005
1 ATTN: STEAP-TL, Bldg. 305

Commander, Frankford Arsenal, Philadelphia, Pennsylvania 19137
1 ATTN: Library, H1300, Bldg. 51-2

Commander, Picatinny Arsenal, Dover, New Jersey 07801
1 ATTN: SMUPA-RT-S

Commander, Redstone Scientific Information Center, U. S. Army Missile
Command, Redstone Arsenal, Alabama 35809
4 ATTN: AMSMI-RBLD, Document Section

Commander, Watervliet Arsenal, Watervliet, New York 12189
1 ATTN: SWEWV-RDT, Technical Information Services Office

Commander, U. S. Army Foreign Science and Technology Center,
220 7th Street, N. E., Charlottesville, Virginia 22901
1 ATTN: AMXST-SD3

Director, Eustis Directorate, U. S. Army Air Mobility Research and
Development Laboratory, Fort Eustis, Virginia 23604
1 ATTN: Mr. J. Robinson, SAVDL-EU-SS

Librarian, U. S. Army Aviation School Library, Fort Rucker, Alabama 36360
1 ATTN: Building 5907

Commander, USACDC Ordnance Agency, Aberdeen Proving Ground, Maryland 21005
2 ATTN: Library, Building 305

Naval Research Laboratory, Washington, D. C. 20375
1 ATTN: Dr. J. M. Krafft - Code 8430

Chief of Naval Research, Arlington, Virginia 22217
1 ATTN: Code 471

Air Force Materials Laboratory, Wright-Patterson Air Force Base, Ohio 45433
2 ATTN: AFML (LAE), E. Morrissey
1 AFML (LC)
1 AFML (LMD), D. M. Forney

National Aeronautics and Space Administration, Washington, D. C. 20546
1 ATTN: Mr. B. G. Achhammer
1 Mr. G. C. Deutsch - Code RR-1

National Aeronautics and Space Administration, Marshall Space Flight
Center, Huntsville, Alabama 35812
1 ATTN: R-P&VE-M, R. J. Schwinghamer
1 S&E-ME-MM, Mr. W. A. Wilson, Building 4720

No. of
Copies

To

- Wyman-Gordon Company, Worcester, Massachusetts 01601
1 ATTN: Technical Library
- Defense Research Projects Agency, 1400 Wilson Boulevard,
Arlington, Virginia 22209
5 ATTN: Dr. E. C. VanReuth
- National Science Foundation, 1800 G Street, Washington, D. C. 20550
1 ATTN: Dr Robert Reynik
- 1 Dr. Maurice Sinnott, University of Michigan, Assoc. Dir. of Engineering,
Ann Arbor, Michigan 48104
- General Electric Company, Corporate Research and Development,
Schenectady, New York 12301
5 ATTN: Mr. F. X. Gigliotti, Jr.
- Hitchiner Manufacturing Co., Inc., Elm Street, Milford, New Hampshire 03055
5 ATTN: Mr. G. D. Chandley
- Abex Corporation, Research Center, Mahwah, New Jersey 07430
5 ATTN: H. R. Larson
- Massachusetts Institute of Technology, Dept. of Metallurgy and Materials
Science, Cambridge, Massachusetts 02139
5 ATTN: Dr. Merton C. Fleming
- 1 Fred E. Ziter, Adirondack Steel Casting Co., Shaker Road,
Watervliet, New York 12189
- 1 Dr. Raymond J. Bratton, Westinghouse Electric Corporation Research
Laboratory, Pittsburgh, Pennsylvania 15235
- 1 Lt. Col. Edward E. Chick, Chief, Materials Branch, U. S. Army R&D Group
(Europe), Box 15, FPO New York 09510
- 1 TRW Equipment, TRW Inc., 23555 Euclid Avenue, Cleveland, Ohio 44117
1 ATTN: Elizabeth Barrett, T/M 3417
- 1 W. M. Spurgeon, Director, Mfg., Qual. Control & Home Systems,
Program Management Center, Bendix Research Laboratories, Bendix Center
Southfield, Michigan 48075
- 1 S. T. Wlodek, Director of Stellite R&D, Stellite Division, Cabot Corporation,
1020 West Park Avenue, Kokomo, Indiana 46901
- Deposite & Composites Inc., 1821 Michael Faraday Drive,
Reston, Virginia 22090
1 ATTN: Richard E. Engdahl, President

No. of
Copies

To

- 1 Mr. William A. Butler, Contract Administrator, Microwave Associates, Inc.,
Burlington, Massachusetts 01803
- 1 Mr. John A. Ulrich, Sr. Vice-President, Chamberlain Manufacturing Corp.,
Waterloo, Iowa 50705
- 1 A. V. Illyn, Technical Director, Babcock & Wilcox, Old Savannah Road,
Augusta, Georgia 30903
- 1 Mr. W. J. Welsch (Code 224), Naval Materials Industry Resources Office,
N.A.E.C., Building #537, Philadelphia, Pennsylvania 19112
- 1 Mr. R. E. Cross, Federal Die Casting Co., 2222 Elston Avenue,
Chicago, Illinois 60614
- 1 Captain Ebenezer F. Porter, 2618 S. Lynn Street, Arlington, Virginia 22202
- 1 Mr. Charles E. Bates, Head, Metallurgy Section, Southern Research Institute,
2000 Ninth Avenue, South, Birmingham, Alabama 35205
- Director, Army Materials and Mechanics Research Center,
Watertown, Massachusetts 02172
- 2 ATIN: AMXMR-PL
1 AMXMR-PR
1 AMXMR-CT
1 AMXMR-X
1 AMXMR-XC
1 AMXMR-ER
1 AMXMR-AP
- 1 Mr. R. F. Kirby, Chief, Materials Engineering Dept., Dept. 93-39M,
Aircraft Manufacturing Company of Arizona, 402 South 36th Street,
Phoenix, Arizona 85034
- 1 Dr. Wally Evans, Ford Motor Company, Casting Division, Rm 1350,
3001 Miller Road, Dearborn, Michigan 48121

Army Materials and Mechanics Research Center
Watertown, Massachusetts 02172
MACHINE CASTING OF FERROUS ALLOYS
G. D. Chandley
Gary Scholl
Hitchiner Manufacturing Co., Inc.
Milford, N.H. 03055

AD
Unclassified
Unlimited Distribution

Key Words

Solidification
Die Casting

Technical Note: AMMRC CTR 75-18, September 1975
Contract DAAG46-73-C-0112
AMCMS Code: 691000.21.66024
Interim Report, 1 February 1975 - 30 June 1975

Due to the lack of economic permanent die materials for use in Hipocasting ferrous alloys, three innovative approaches for creating a mold cavity for use in machine casting of ferrous alloys were explored. They were: use of liquid metal cooling of a thin walled die, use of a porous die, vacuum coated with dry ceramic and use of a membrane to vacuum from a disposable mold. Vacuum forming a disposable mold appears to be the most promising method of machine casting of ferrous alloys.

Army Materials and Mechanics Research Center
Watertown, Massachusetts 02172
MACHINE CASTING OF FERROUS ALLOYS
G. D. Chandley
Gary Scholl
Hitchiner Manufacturing Co., Inc.
Milford, N.H. 03055

AD
Unclassified
Unlimited Distribution

Key Words

Solidification
Die Casting

Technical Note: AMMRC CTR 75-18, September 1975
Contract DAAG46-73-C-0112
AMCMS Code: 691000.21.66024
Interim Report, 1 February 1975 - 30 June 1975

Due to the lack of economic permanent die materials for use in Hipocasting ferrous alloys, three innovative approaches for creating a mold cavity for use in machine casting of ferrous alloys were explored. They were: use of liquid metal cooling of a thin walled die, use of a porous die, vacuum coated with dry ceramic and use of a membrane to vacuum from a disposable mold. Vacuum forming a disposable mold appears to be the most promising method of machine casting of ferrous alloys.

Army Materials and Mechanics Research Center
Watertown, Massachusetts 02172
MACHINE CASTING OF FERROUS ALLOYS
G. D. Chandley
Gary Scholl
Hitchiner Manufacturing Co., Inc.
Milford, N.H. 03055

AD
Unclassified
Unlimited Distribution

Key Words

Solidification
Die Casting

Technical Note: AMMRC CTR 75-18, September 1975
Contract DAAG46-73-C-0112
AMCMS Code: 691000.21.66024
Interim Report, 1 February 1975 - 30 June 1975

Due to the lack of economic permanent die materials for use in Hipocasting ferrous alloys, three innovative approaches for creating a mold cavity for use in machine casting of ferrous alloys were explored. They were: use of liquid metal cooling of a thin walled die, use of a porous die, vacuum coated with dry ceramic and use of a membrane to vacuum from a disposable mold. Vacuum forming a disposable mold appears to be the most promising method of machine casting of ferrous alloys.

Army Materials and Mechanics Research Center
Watertown, Massachusetts 02172
MACHINE CASTING OF FERROUS ALLOYS
G. D. Chandley
Gary Scholl
Hitchiner Manufacturing Co., Inc.
Milford, N.H. 03055

AD
Unclassified
Unlimited Distribution

Key Words

Solidification
Die Casting

Technical Note: AMMRC CTR 75-18, September 1975
Contract DAAG46-73-C-0112
AMCMS Code: 691000.21.66024
Interim Report, 1 February 1975 - 30 June 1975

Due to the lack of economic permanent die materials for use in Hipocasting ferrous alloys, three innovative approaches for creating a mold cavity for use in machine casting of ferrous alloys were explored. They were: use of liquid metal cooling of a thin walled die, use of a porous die, vacuum coated with dry ceramic and use of a membrane to vacuum from a disposable mold. Vacuum forming a disposable mold appears to be the most promising method of machine casting of ferrous alloys.

