BANGLADESH
AGRICULTURAL DEVELOPMENT CORPORATION
SHALLOW TUBEWELL DIVISION

SMALL SCALE IRRIGATION PROJECT

TECHNICAL ASSISTANCE

FOUNDRY MANUAL
APRIL 1982

AGENCY FOR INTERNATIONAL DEVELOPMENT
LOAN 388-T-010

AMMANN & WHITNEY
CONSULTING ENGINEER
NEW YORK DACCA

FOUNDRY MANUAL

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FOUNDRY MANUAL

PREFACE

This manual is aimed at the working foundrymen, foundry foremen, and owners of Bangladesh iron foundries. Foundries in Bangladesh do not have ready access to facilities enjoyed by foundries in developed countries where most of the operations have been automated with precision control. Such mechanization is a response to demand for closely controlled quality products within a short production time, in an environment of sharply rising labour and raw material cost and Government acts, and stringent pollution controls. Technical information is available to the foundries in advanced countries through trade publications, seminars by organized professional organizations, and the foundries research and development division. In Bangladesh the foundry operations are at a low level which offers no comparison with that of advanced countries. In Bangladesh "Foundry Technical Assistance" means informing and assisting foundries with basic methods that will economize their operation while upgrading product quality. This manual is prepared accordingly, avoiding technical jargoons as much as possible and indicating areas especially in manufacturing of hand pumps where efficiency can be increased.

FOUNDRY LAYOUT

The foundry layout for production of hand pumps depends on the following basic steps adopted in making of castings.

1. Pattern making
2. Mould and core making
3. Melting and pouring
4. Cleaning the casting
5. Machining the casting

Pattern Making:

This is the first step in making the casting. The pattern is a model of the product to be manufactured in accordance with the specified drawing for hand pump. It is made either of wood, aluminum or cast iron.

Small foundries generally buy patterns from pattern makers experienced and skilled in the process. Larger foundries normally have their own pattern shop. In most cases 150 sq.ft. of area should be allocated for preparing of hand pump patterns.

Mould and Core Making:

The mould is the cavity which is formed with the help of the pattern in material suitable for maintaining the form. In Bangladesh foundries, the mould material is mixture of moulding sand, coal dust and clay with about 5-7% moisture. When a hole or recess is required in the casting, as in the barrel, head cover, handle and plunger assembly, it is achieved by placing a suitable 'core' of a shape corresponding to the shape of the hole or recess, in the mould. These cores, a mixture of sand and clay tempered with moisture, are baked in an oven at a temperature of about 600-800°F for about 3-5 hours, and then held in the oven with no firing for another 3 hours. Sometimes the patterns are made so that a separate 'core' in not required as in the case of base plate where the pattern itself provide means for the hole or recesses.

The floor area for moulding and core making including core oven for about 200 pumps per pouring day would be as shown below:

Sand preparating & mulling	-	150 sq.ft.
210 hand pump mould	-	5250 sq.ft.

(5% reject estimated) Core making space	-	150 sq.ft.
Core drying Oven (8' high) for about 1600 lb sand core	-	250 sq.ft.
		5800 sq.ft.
	Say	6000 sq.ft.

Melting and Pouring:

Once the mould is made it is ready to receive the molten metal from the furnace which in Bangladesh are mostly coke fired cupola furnaces. A 2 ton per hour cupola furnace with 28" internal diameter(diameter after refractory lining) is sufficient for an input of 16,800 lb (7.6 M.T.) of metal charge consisting of pig iron and scrap iron to yield sufficient molten metal for 200-210 complete hand pumps.

The space requirement for cupola furnace, with charging platform, pig iron, scrap, limestone is about 500 sq.ft.

Cleaning:

After the molten metal is poured in the mould, it is allowed to solidify at room temperature. When the process of solidification is completed the casting of hand pump components is taken out. Hand pump castings are allowed to cool for about 5-8 hours in the mould before cleaning.

The process of cleaning is done in 2 stages:

1. All extra parts like sprues, gates (path to pour molten metal) etc. are removed.

2. The surface of the casting is cleaned by removing the sand clinging to it.

3. If it is a casting with core (base plate, barrel, handle etc.) the core is removed.

In Bangladesh except in one foundry employing a mechanised tumbler, all private foundries (till 1982 March) clean manually. The space requirement for cleaning for 200-250 hand pumps is about 150 sq.ft.

Summary: Foundry Layout

For a monthly production of 1600-2000 hand pumps at the rate of 8-10 pouring days per month the following floor area requirement is suggested. If the pouring days are increased, then the production would be more. Because for each pouring day the floor space can be utilised for 200-210 nos. of complete hand pumps @ 16-20 pouring days/month, the same floor space would produce about 3500 hand pumps per month.

A) Foundry Shop

Pattern making	...	150 sq.ft.
Mould & Core making	...	6,000 sq.ft.
Melting & pouring	...	600 sq.ft.
Cleaning bed	...	150 sq.ft.
Storage & Office	...	500 sq.ft.
Open space	...	600 sq.ft.
Floor Space (A)	=	8,000 sq.ft.

B) The Machine Shop

The required machinery are:

Lathe Machine	...	2 Nos.-3 Nos.
Column drill Machine	...	3 "
Shaper	...	1 No.
Grinder (Smaller)	...	1 "
Grinder (Large)	...	3 Nos.
Floor Space (B)	=	2,000 sq.ft.

Total (A + B) Floor Space =10,000 sq.ft.

Appendix (A) suggests layout plan

PRODUCTION OF HAND PUMP

Raw Materials:

Pig Iron

Suggested chemical composition:

Carbon	...	3.00 - 4.10%
Silicon	...	2.50 - 3.50%
Manganese	...	0.60 - 0.90%
Sulpher	...	0.15% maximum
Phosphorous	...	0.45% maximum

Fuel:

Coke

Suggested chemical composition:

Fixed Carbon	...	85%
Volatile Matter	...	1½% maximum
Ash content	...	12% maximum
Sulpher content	...	1% "
Shatter index	...	85% maximum on 2" screen
Lump size	...	2½" - 5½" (63.5mm) (139.7mm)

Others:

Flux (Lime stone) and scrap iron of grade to produce hand pump casting of required mechanical strength.

Brinell Hardness No.BHN = 153-207

Specification of the Product (SSIP Hand Pump)

Weight:

The weight of complete Hand Pumps components are in the following weight range.

Barrel	...	29.5 - 31 lb
Head Cover	...	11.5 - 12 lb
Handle	...	11.5 - 12.5 lb
Base Plate	...	6 - 6.5 lb
Plunger	...	2 - 2.25 lb
Check Valve	...	0.25- 0.25 lb

64.75 - 64.5 pound

The weight of assembled pump with all components is within the range of 64.75 - 68.5 pound.

General specification of other part i.e. Barrel, Base Plate, Head Cover, Handle, Plunger assembly, Piston rod, Rod pin, Fulcrum pin, Jam nut, Hexagonal Head bolts and nuts, lock washer check valve, cotter pin, PVC bucket and flapper valve are as per updated drawings and specification issued time to time with tender documents.

PATTERN

Following are the materials which are common in pattern making for hand pumps:

Wood

Cast Iron

Aluminium

Wood - Wood though cheaper, easily available, easier to fabricate and lighter in weight is not used for large volume production work in making hand pump as it is easily affected by moisture of the moulding sand and warps and has less resistance to sand abrasion. It is mostly used to make the Master (production) pattern made of either Cast Iron or Aluminium or its alloys.

Cast Iron - Cast Iron does not have the disadvantages of wooden pattern, it has good corrosion resistance, and resistance to sand abrasion. However Cast Iron patterns are heavy and should be handled carefully to avoid any sudden impact as impact resistance of Cast Iron is poor.

Aluminium - Aluminium patterns are more popular because of their lightness, resistance to corrosion and abrasion by sand and long life, however they are the costliest of among the three.

Types of Pattern

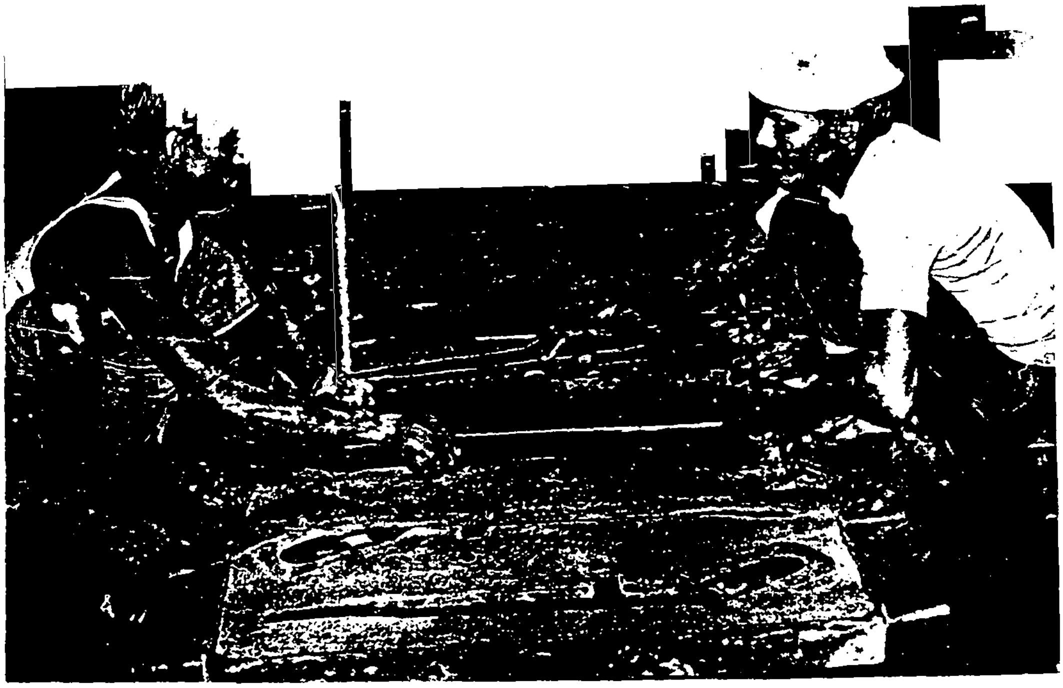
One piece or solid pattern: These patterns are made in one piece without joints, partings or loose pieces. Example; base plate, head cover, handle, plunger assembly.

Two pieces or split pattern: These patterns are made in two pieces which are joined at parting lines. Splitting at the parting line is done to facilitate the withdrawal of the pattern. Example; barrel pattern.

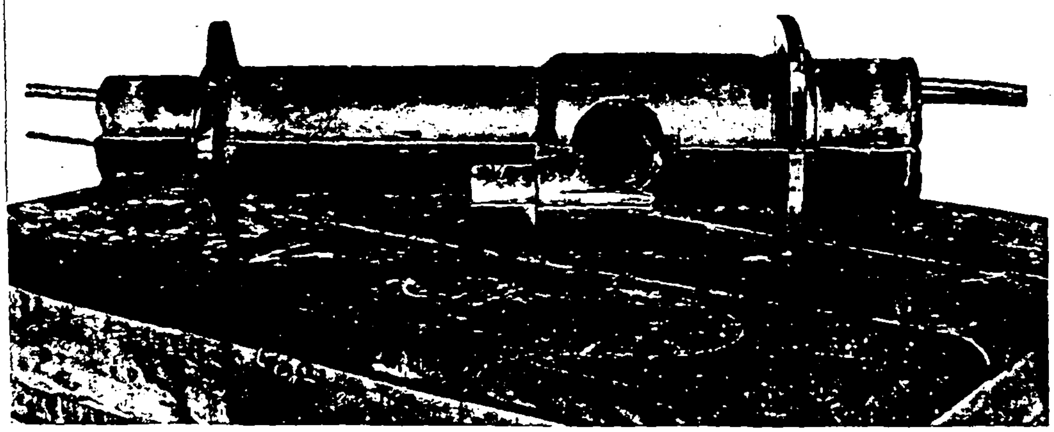
Steps in Pattern Making

The steps in pattern making are:

1. Study of the hand pump drawing.
2. Making a wooden pattern for casting the metal pattern.
3. Casting and machining the metal pattern per specified drawing, taking care that all draft (taper) to be ¼ inch/foot, pattern shrinkage allowance to be 1/8 inch/foot, machining allowance, smoothness and correctness.



Making mould for
handle



Pattern for
barrel

Making mould for
barrel, withdrawing
pattern from top
moulding box

TABLE-I(A) - MAN-HOUR REQUIREMENT FOR WOODEN PATTERN

Components	Required Machine	Operation	Operations Man-Hr/Comp.	Total Man-Hr. Per Comp.
1. Base Plate	-	A. Cutting and finishing to shape	8	
	Lathe	B. Turning	4	12
2. Barrel	-	A. Cutting and finishing to shape	24	
	Lathe	B. Turning	8	32
3. Head Cover	-	A. Cutting and finishing to shape	16	
	Lathe	B. Turning	4	20
4. Handle	-	A. Cutting and finishing to shape	16	16
5. Plunger	-	A. Cutting and finishing to shape	16	
	Lathe	B. Turning	8	24
6. Flapper Valve Wt.	-	A. Cutting and finishing to shape	8	8
			Total Man-Hours	112

TABLE-I(B) - METAL PATTERN MAN-HOUR REQUIREMENT

1. Base Plate	Lathe	A. Turning & Facing	16	
	-	B. Finishing to Dimension	16	32
2. Barrel	Lathe	A. Turning & Facing	32	
	-	B. Finishing to Dimension	24	56
3. Head Cover	Lathe	A. Turning & Facing	8	
	-	B. Finishing to Dimension	24	32

4. Handle	-	A. Finishing to Dimension	32	32
5. Plunger Assembly	Lathe	A. Turning & Facing	16	
		B. Finishing to Dimension	24	40
6. Flapper Valve Wt.	-	A. Finishing to Dimension	1	1
		Total Man-Hours		193

Man-hours required for one set of pattern:

1. Making wooden pattern - 112 Man-Hours
2. Moulding, melting, pouring and cleaning the metal pattern - 16 "
3. Making metal pattern and finishing (Table IB) - 193 "

321 Man-Hours

TABLE 2 - SERVICE LIFE OF PATTERNS

Pattern Component	Material of Pattern	Wt. of Pattern	Service life in terms of moulds made	Service life in terms of finished casting made (at 10% casting reject)
1. Base Plate	Aluminium	2 lb. 4 oz.	20,000	18,000
2. Barrel	"	32 lb. (solid pattern, inclusive core paint)	10,000	9,000
3. Head Cover	"	4 lb. 10 oz.	20,000	18,000
4. Handle	Cast Iron	16 lb.	12,000	10,800
5. Plunger Assembly	Aluminium	1 lb. 4 oz.	8,000	7,200
6. Flapper Valve Wt.	"	1.3 oz.	20,000	18,000

Required Number of Pattern for a Specified Production Volume

The number of patterns required is related to the production capacity of the foundry. The production capacity is controlled by the following factors:

i) Number of days metal poured a month (pouring days per month)

ii) Average casting rejection percentage

iii) Melting capacity of furnace

iv) Production rate of moulder

v) The floor area

Service Life

Refering to Table 2, the service life of a pattern with a monthly production volume of 2,000 hand pumps per month may be estimated as follows:

Table 3

Pattern	Estimated Service Life @ 2000 Hand Pump per Month
Base Plate	9 months
Barrel	5 "
Head Cover	9 "
Handle	5 "
Plunger	4 "
Flapper Valve	9 "

With care during use, the service life of patterns can be extended.

MOULDING PROCESS

Moulding process can be classified in a number of ways, but broadly they are classified either on the basis of the method used or on the basis of the materials used.

Classification Based on Method Used

1. Bench Moulding (Manual)
2. Floor Moulding (Manual)
3. Pit Moulding (Manual)
4. Machine Moulding

Classification Based on Material Used

Sand Moulding: Green sand mould
Dry sand mould
Skin dried mould
Chemically bonded sand mould

Metallic Moulding

Bench Moulding

This type of moulding is preferred for small jobs. The whole moulding operation is carried out on a bench of convenient height. In bench moulding a minimum of two moulding boxes are used. In Bangladesh private foundries have not adopted this moulding method. This method saves floor space and is suitable for small components such as plunger assembly or valve weight (of hand pump).

Floor Moulding

In this type of moulding, only the top moulding box is used, usually the bottom moulding box is replaced by the moulding floor itself. It is the most widely used moulding method to make cast iron hand pumps in Bangladesh private foundries.

Pit Moulding

Pit moulding as the name implies uses a 'pit' in the foundry floor. It is in fact, a type of 'floor moulding' but used for much larger castings like flywheels, lathe beds, etc. Hand pumps casting are not made by pit moulding process, as hand pump's weight and dimension do not necessitate a pit wall and bottom of which are generally made of thick strong brick work or in some cases of reinforced concrete. The moulding material remains same (sand carefully blended with clay, coaldust, moisture, etc.).

Machine Moulding

Bangladesh private foundries till date have not adopted machine moulding. The probable reasons are high investment risk, spare problem, dependency on electrical power, and sufficient machine loading requirements. Manual moulding (bench moulding/floor moulding/pit moulding) do not require dependency on the factors mentioned. Machine moulding gives a consistent product in a short time period.

Sand Moulding

Green Sand Mould - The word 'green' signifies that the moulding sand is in moist state at the time of pouring molten iron in it. The main constituent of green sand mould are sand, clay, coal dust, and moisture. Green sand moulding is a economical method of moulding. All private foundries in Bangladesh employ green sand moulding to make hand pump and its components. A common proportion of sand & coal dust for hand pump castings is:

New Sand	-	8 parts	Or	25%
Floor Sand (Existing)	-	20 parts		64%
Coal Dust (Fine)	-	3 parts		10%
	Total	31 parts		100%

The weight ratio of hand pump casting to sand required to mould is about 1:6, if the as-cast weight of hand pump barrel is 32 pound a total of 192 lbs. (Approx.) prepared sand would be required to make the mould.

The weight ratio of hand pump casting to sand required to make core varies. For the barrel it is 1:¼ i.e. if the weight of as-cast barrel is 32 pound, a total cf 8 lb. prepared sand would be required to make the core, whereas the weights of sand required to make respective core for head cover, handle and plunger assembly are much less, about 15% to 8% of the weight of as-cast casting. The term as-cast means casting with the sprue and gating system.

The moisture of the green sand mould should be closely controlled to avoid blow holes.

Dry Sand Mould

The word 'dry' sand signifies that at the time of pouring the molten metal, the mould is in dry state. The moulds (prepared with both bottom and top moulding box) are dried in an oven to drive off moisture. Dry sand moulds are used when the mould requires greater strength and hardness.

In Bangladesh, dry sand moulds are not used for production of hand pumps.

Skin Dried Moulds

These moulds are compromise between the green sand and dry sand moulds. In this case, only a surface layer about ½" - ¾" of the mould cavity is dried by a blow-lamp, or portable heaters fired by coke (drum-heaters). During monsoon period, when the weather is humid, most of Bangladesh foundries use skin-dried, hand pump moulds.

Chemically Bonded Sand Moulds

In these process, proprietory chemicals are mixed with clean and graded sands, and the mould harden in room temperatures.

Mould for barrel

Placing core in barrel mould

A very smooth finish is obtained. However, use of this system in Bangladesh foundries for making hand pump moulds is remote because (1) it calls for the presence of a qualified chemist to determine the ratio of chemicals under changing humidity level; (2) chemicals are to be imported; (3) requirement of careful storage; and, (4) relatively high cost.

Metallic Moulding

As the name implies, the mould is made of metal. Same mould can be used over and over, ejecting the casting from it. Because of its much longer life these moulds are known as permanent moulds. Bangladesh private foundries do not use metallic moulding for hand pumps, for the reason that enhanced cooling would make the pump parts difficult to machine.

CORE MAKING

Core making basically consists of the following four steps:

1. Core Sand Preparation
2. Core Making
3. Core Baking
4. Core Finishing

Core Sand Preparation

As the core has to withstand the severe action of hot metal which completely surrounds it, the following needs considerations:

1. The pores in the core should be such as to allow easy escape of hot gases.
2. The core sand should be highly refractory in nature.
3. The core sand should be of such nature that it does not obstruct the free shrinkage of the metal at the time of cooling.

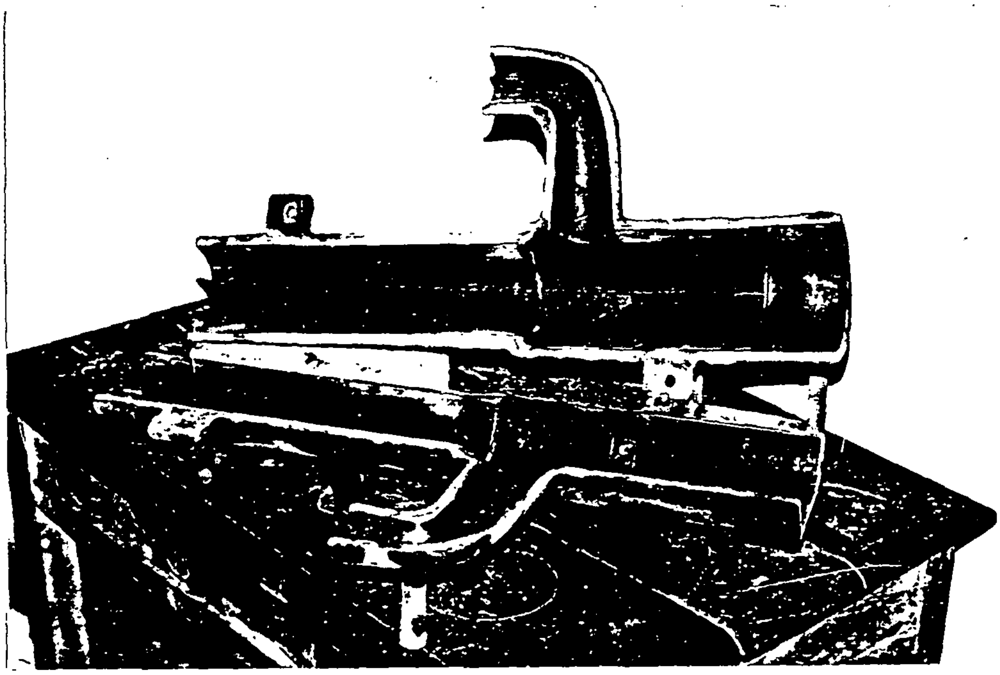
Most of the Bangladesh foundries use manual methods to prepare core sand mixture, blending sand and clay for core for barrel, and blending sand and molasses for core for head cover and handle. A mechanical mixer is preferred to obtain homogenous and satisfactory mixing.

Core Making

In Bangladesh foundries core for hand pumps are made manually in core boxes. Advanced countries use machines to make cores. A cast iron bar (weighing about 6 lbs) is

Withdrawing pattern from bottom portion of mould

Barrel core in mould



Core box for
barrel core

Dried barrel core

used to reinforce the core for barrel and also to counteract the buoyancy effect produced by molten metal.

Core Baking

After the cores are prepared, they are baked in a baking oven. The main purpose of baking is to drive away the moisture and harden the core.

The hand pump cores should be heated slowly. The temperature of core oven should be around 700°F, the hand pump core should be held at this temperature for 3-4 hours, and then held in the oven for another 2-3 hours, with the fuel shut off. The core should be carefully carried to the core room and properly placed in the shelves to avoid distortion and sagging.

The cores should be cooled to room temperature before placing it in the mould.

Core Finishing

After baking, the cores are given finishing operation to remove fins, bumps, or other sand projection from the surface of the core by rubbing or filing. After checking the dimensional accuracy, the cores are placed in the mould.

MELTING

Furnace: Cupola

Cupola furnace is used in Bangladesh by private foundries for mass production of cast iron hand pump. This furnace has the following advantages:

1. It is suitable for the production of all grades of grey cast iron.

2. The furnace and its centrifugal blower can be constructed locally. Fire brick and fire clay required for the furnace with welding rods and electric motors are available within the country.

3. Once the operational principles are understood by furnace operator and his assistants, they can conduct melting operations satisfactorily. Cupola melting techniques are common among most of the foundries and furnace operators with knowledge of cupola operation are available within the country. However, the level of their knowledge is not often adequate to obtain optimum result.

Charging of metal, coke
and lime stone into cupola

Taking delivery of molten
metal from cupola furnace
into pouring ladle

4. Cupola furnace is flexible in operation. Its capacity in terms of delivering tons of molten metal per hour can be varied (increase or decrease) by changing:

   - Combustion air input
   - Internal diameter of cupola
   - Ratio of carbon of the coke to charge metal

5. Melting in cupola furnace is relatively fast and continuous. Depending on design and diameter of cupola (18" - 90") molten metal would be obtained continuously @ 1 ton to 30 ton per hour, so long charge metal, fuel and flux (limestone) are available in the furnace.

6. Of the following types of melting furnaces only cupola provides molten iron continuously from the spout.

   - Crucible (oil/gas/coke fired)
   - Rotary (oil/gas/coke fired)
   - Air furnace (oil/gas/coke fired)
   - Electric direct arc
   - Electric induction

   Furnances other than cupola, are batch melters i.e. a certain tonnage of metal is charged to furnace and after a specified time (1½ - 2 hours) it is drained from the furnace after melting, again it is charged and the process repeated. Where as, in continuous cupola the metal is charged in to the furnace, and after the blower is on, molten metal starts flowing from the taphole within 15-20 minutes and this metal flow remain uninterrupted so long metal, fuel, flux and combustion air are put into the furnace in suitable proportion.

<u>CUPOLA TYPE</u>

- <u>Coke Cupola</u>, most common in Bangladesh
- <u>Gas Assisted Coke Cupola</u>, consuming 30-40% less charge of coke. Four such gas-assisted cupola are operating in 3 private foundries of Bangladesh. Any coke cupola can be converted to this type.
- <u>Gas Cupola</u> - With no coke, operates with gas. None operating in Bangladesh. Mostly used in USSR, few in U.K. and Iran.

- Conventional Tuyere Cupola (Coke Fired) - Combustion air is admitted through single row of tuyeres (4 to 6 nos. in a row), at a height of about 24" from the base place or double row of tuyere, the 2nd row of tuyeres being placed at a height of about 11½" from the 1st row. This type of cupola is most common in Bangladesh.

- Divided Blast Cupola (Coke Fired)

  Combustion air from the blower is equally divided, and fed through two rows of tuyeres in a controlled way. Compared to conventional cupola 8-10% charge coke may be saved, but the melting time should be more than 3-hours to make the melting economical as more bed coke is required for higher coke bed. No such cupola is operating in Bangladesh. However larger foundries who melt more than 3 hours may consider this design. Any conventional cupola may be converted to divided blast cupola.

- Secondary Air Cupola (Coke Fired)

  2/3rd of combustion air is fed through the lower row of tuyere and 1/3rd of it is fed through upper row of tuyere in a controlled way. About 5-8% of charge coke can be saved compared to conventional cupola. No extra bed coke is required. Any conventional coke cupola can be converted to secondary air cupola.

  Out of 3 such secondary air cupola in Bangladesh, two have been converted to gas-assisted cupola.

- Oxygen Enriched Cupola (Coke Fired) - Pure oxygen is fed into blast pipe or tuyere for better combustion (higher temperature).

- Hot Blast Cupola (Coke Fired/Gas Fired) - Combustion air is heated for better combustion (higher temperature).

Cupola Construction and Operation

Cupola is a vertical cylindrical furnace. The cylinder is made of mild steel plates 1/8" to ¼" thick. The inside of the cylinder is lined with refractory (fire clay) bricks. The lining thickness vary from 5" to 10". The cupola shell (cylinder) is generally mounted on a cast iron base plate 1½" to 2" thick supported by two steel I-beam resting on four steel joists. Depending on foundry's melt requirement the height of the joists are fixed at 3' to 6'. The higher height of the joist means a higher cupola spout to accommodate either a forehearth or a bigger ladle. Sometime the base plate is supported by concrete structure. The base plate has a circular opening equal to the internal diameter (after refractory lining) of the furnace. This opening is closed with two semicircular hinged door at the time of preparing the furnace for melting. The semicircular doors are supported by steel post.

At a height of about 2 feet from the base plate there are 4-6 openings (either square or round in cross section) for admitting conbustion air (received from a wind box) into the coke bed. These openings, called tuyeres, are connected to a "wind box" located at a suitable height (2' to 3') from the center of the tuyeres. The wind box is about 20" to 40" high (depending on combustion air demand) and 12" - 14" wide. The wind box receives combustion air from the centrifugal blower through blast pipe. The "charge door" through which metal is charged into the cupola should be at a minimum height of 4 times the internal diameter (after lining) of the cupola measured from the vertical center of the lowest row of the tuyere i.e. if the cupola's diameter is 2', the charge door should be located at a minimum height of 8' from the vertical centre of the tuyere. Except in 2 private foundries in Bangladesh charge metals are lifted manually to the charging platform.

Cupola Operation

Prior to melting operation, the following activities are to be completed:

1. Weigh pig iron and metallics to make metal charge. Size of each metal piece should not be more than 1/3rd of cupola diameter in length, or 3 feet, whichever is less, width of metal piece should be within 4" - 6", thickness not more than 4".

2. Weigh correct size of coke and lime stone. Size of coke and limestone has an important bearing on the combustion characteristics of cupola. Size of coke should not be less than 2½" x 3½" lump where as lime stone should not be more than 1" x 1" lump.

3. Check whether refractory lining of furnace is alright and furnace blower, motor, etc. are functioning properly.

4. If all items in 3. are OK, the bottom doors are closed and supported by a steel post securely held. A mixture of sand with very little clay content, is placed on top of the closed bottom door and rammed to a minimum thickness of six inches. This rammed sand layer is gently sloped towards the tap hole with a taper of 1" per foot. After preparing this sand layer, fire wood is carefully placed on it and carefully ignited with gradual addition of coke. All coke should not be added at a time. A layer should be added only when the previous layer of coke has been ignited. Coke is continuously added till a height of 3' - 4' from the vertical center of lowest row of tuyere is reached, dependent on the pressure at which combustion air is delivered by the cupola. When the height of

coke bed is settled, to the specified height, the bed should be held for a minimum 3 hours with all tuyeres open, to uniformly heat the refractory lining and to assist uniform ignition of the coke bed. The height of coke bed is very important, it may be estimated by the relation:

Example:

Cupola bed coke height calculation:

Capacity	Internal Diameter	Blower Pressure (Oz/Sq.In.)	Estimated Coke Bed Height
2 tons per hour	28"	9	10.5 (P½) + 6" = 10.5(3) + 6" = 37"

Height of bed coke measured from the vertical centre of the lowest row of tuyere = 10.5 (P½) + 6"

Where P = Pressure (in Ounce/Sq.in.) of combustion air delivered by the blower.

Melting Operation

The melting operation takes place in the following sequence:

1. Prepare bed coke and pre-heat for 3 hours.

2. After 3 hours charge one layer of coke (not ignited).

3. Charge one layer of lime stone (not more than 1" x 1" size) of suitable quantity.

4. Charge metal (a suitable blending of pig iron and scrap) of suitable weight, preferably not more than ¼th of hourly melting capacity, for a 28" inch internal diameter, 2 tons per hour capacity furnace. The weight of one metal charge would be around 1100 - 1200 lb.

5. Charge coke at 1/6th or 1/8th of the metal charge. For a metal charge of 1200 lb., coke charge would be 1/6 (1200) = 200 lb. with medium grade of coke (80-82% fixed carbon) and 1/8 (1200) = 150 lb. with good grade of coke (85% or above fixed carbon).

6. Charge limestone at about ¼th of the coke charge. If the coke charge is 200 lb, the limestone charge would be ¼(200) = 50 lb.

7. Repeat operation - 4, charging metal, and continue sequence i.e. charge coke then limestone and on top of it charge metal, till the furnace is full to the level of charge door.

8. Close the tuyere cover, check voltage and current reading, start blower. No person at this time should stand close to the furnace door, danger of carbon monoxide poisoning through inhaling exists.

9. If the coke bed heigt is proper, molten iron would start flowing within 15-20 minutes at the cupola spout after the start of blower.

10. Molten metal is collected in ladle, and poured in the mould.

11. Charging operation continues as required.

12. On completion of melting, all molten metal is drained off the furnace.

13. Blower is stopped, cupola bottom doors are opened, all materials that remained in cupola are dropped and cooled with water jet.

14. The furnace is allowed to cool.

15. On cooling the furnace lining is cleaned, slag clinging to furnace lining removed, lining eroded during melting repaired and the internal diameter of the cupola brought back to standard dimension.

15. On completion of step 15, the furnace is again ready for operation.

POURING MOLTEN METAL

Pouring molten metal into moulds is done by the use of hand ladles in all Bangladesh private foundries except one which uses an overhead crane. The molten metal is sometimes poured into large transfer ladles and transported to various locations (in the foundry) where it is poured into the hand ladles. Pouring rate of molten metal is important to produce good casting. Fast pouring rates (lbs/sec) will result in boiling of the metal in a mould with core causing gas holes, sand wall erosion, and upward pressure on core (example barrel of hand pump) resulting in core float. While a slower pouring rate will cause other types of casting defects i.e. misrun, cold shuts and low fluidity through heat loss caused by delayed pouring time. For cast iron hand pumps a pouring rate of 4-5 lb/sec have been found to be satisfactory.

The pouring time can be estimated from the following formula applicable to grey iron casting.

$$T\ (\text{Sec}) = \left(A + \frac{t}{B}\right) W^{1/2}$$

Whereas T = Time in second, for pouring 'W' lb of molten grey iron in the mould

A = 0.95 (a constant)

B = 0.853 (a constant)

t = Average thickness (inch) of the casting

W = Estimated weight (lb) of the casting plus sprue and runner (cavity through which molten metal enter the mould)

<u>Example</u>: Barrel of No.6 cast iron hand pump head

- Estimated weight W = 33 lb
- Average thickness t = 5/16" (0.3125")
- $A = 0.95$; $B = 0.853$

$$\therefore T\ (\text{Sec}) = \left(0.95 + \frac{0.3125}{0.853}\right) 33^{1/2}$$

$$= (0.95 + 0.366)\ 5.744$$

$$= 7.55$$

i.e. 33 lb of molten metal for barrel should be poured within 7.55 seconds pouring rate

$$\frac{33\ \text{lb}}{7.55\ \text{Sec.}} = 4.37\ \text{lb/sec.}$$

The sprue should be gently tapered toward the bottom and the pouring ladle should not be positioned too high above the sprue at the time of pouring.

CLEANING THE CASTING

After the hand pump castings have been solidified and cooled, they are removed from the moulding boxes for cleaning in the following sequence:

1. Knocking out sand cores
2. Removal of sprues and gates

3. Cleaning the sand from the surface of casting

4. Removal of fins and unwanted projections at places where sprues/runners have been removed.

The sand core (from barrel, plunger, etc.) is removed by rapping(knocking) the casting with an iron bar or hammer. The cast iron core rod used in the barrel core is removed by breaking it at the thinest section.

Sprues and gates are removed by knocking those with hammer. However care should be taken not to damage the main body of the casting.

Except in one private foundry, the surface sand is cleaned manually with steel wire brush. If the moulding sand is properly sieved, and has correct proportionate mixture of coal dust, it can be cleaned without much difficulty.

The unwanted metal fins and projections are removed from the surface of hand pump casting by chipping with hand tool and grinding with floor mounted grinders.

After cleaning the components are sent to the machine shop.

MACHINING

The following machining operations are performed in the machine shop.

Operation	Machine	Hand Pump Component
Drilling	Drill press	Barrel (8 holes) Handle (3 holes) Head cover (2 holes) Valve weight (1 hole)
Internal threading	Drill press (Threading tap attached to drill chuck)	Plunger cage (Portion to receive piston rod)
Internal threading	Lathe Machine	Plunger cage (Portion to receive plunger follower) Base plate (Portion to receive pipe)
External threading	Lathe Machine	Plunger follower (Portion to fit plunger cage)

Grinding handle

Drilling barrel holes - jigs used to locate holes correctly

Facing	Lathe Machine	Base plate (Portion to fit leather seat valve)
		Barrel bottom (Portion to fit base plate)
		Plunger follower (Portion to fit plunger valve)
		Plunger weight (Portion to fit plunger follow on)
Turning	Lathe Machine	Barrel (internal) Bore 3½" dia x 12¼"

Grey cast iron does not require any cutting fluid during any of the machining operation, drilling threading facing, turning and shaping. However, depending on the cutting tool material the cutting speed (Feet Per Min) should be varied. The cutting speed with normal high speed steel tools is 50 fpm; with cemented carbide tool it is 100 fpm and with carbon steel tool the speed is 25 frm.

Example:

At what rpm (revolution per minute) should 5/8" (0.625") fulcrum hole be drilled head cover.

- Tool material = High speed steel
- Recommended speed = 50 feet/min (for high speed steel)

The following equation may be set up:

$$50 \text{ fpm} = 3.14 \times \frac{0.625"}{12} \times \text{rpm}$$

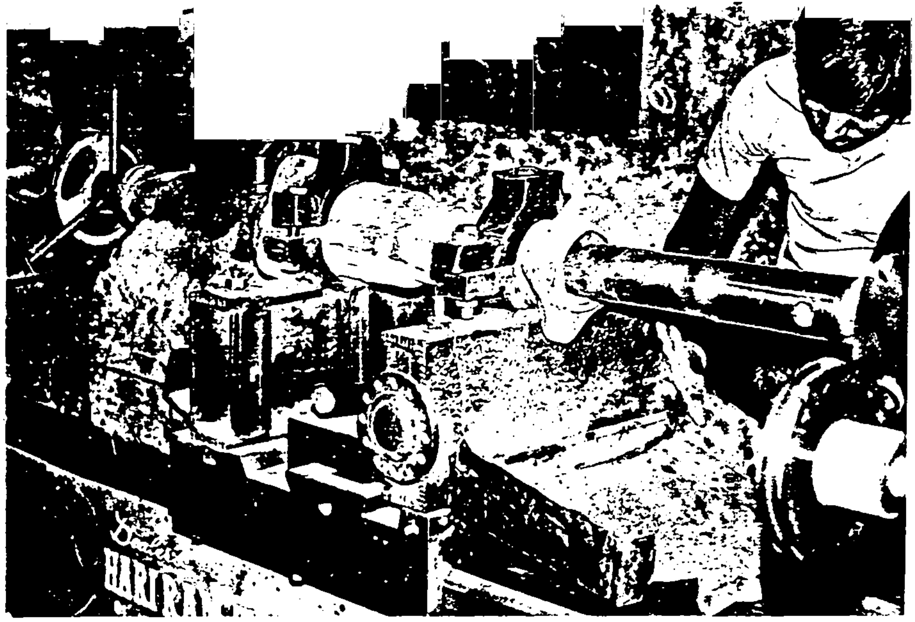
$$= 3.14 \times 0.0520 \times \text{rpm}$$

$$\text{or rpm} = \frac{50}{3.14 \times 0.0520} = 312$$

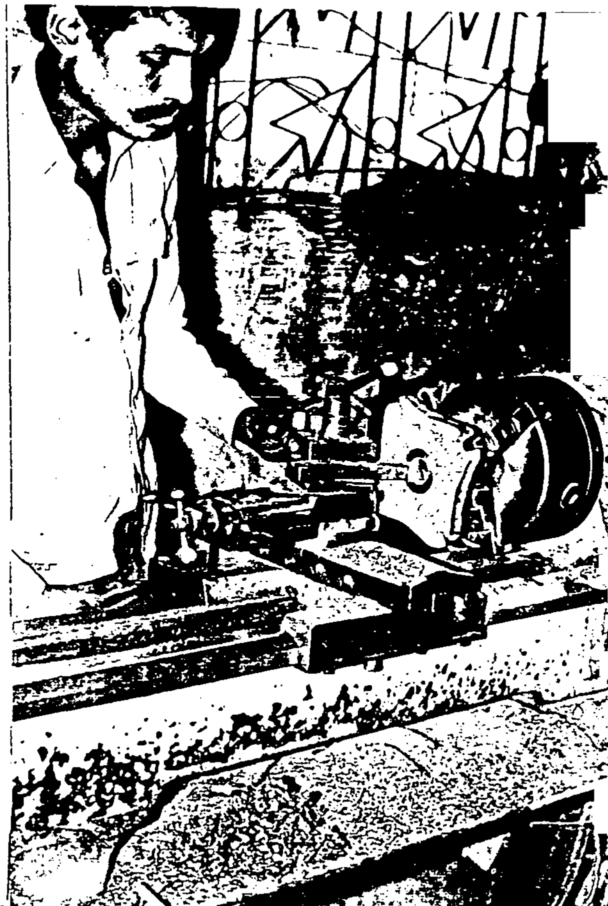
The drill press rpm should be 300.

The drilling time required can be calculated as follows:

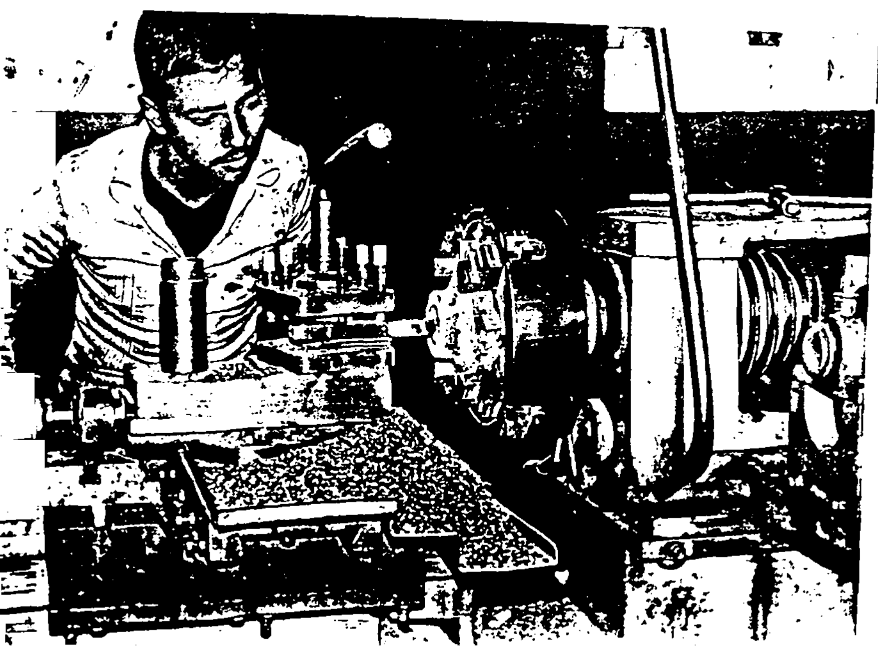
The suggested feed for cast iron at 50 fpm is 0.015 inch per revolution i.e. the drill will penetrate the cast iron at this rate. The 3/4 inch head cover hole would require 10 seconds.



Turning internal bore of barrel



Facing base plate



Threading base plate

The iron hand pump has a Brinnel hardness value ranging from 153-207. At this range about 0.8 hp is required per cubic inch per minute of material removed. The motor hp required for drilling holes in the head cover can be found as follows:

Hole dia	=	5/8" (0.625")
Hole length	=	3/4" (0.75")
Feed	=	0.015 ipr (inch per revolution)
Speed	=	50 fpm
rpm	=	300
hp/cu.in/min	=	0.8

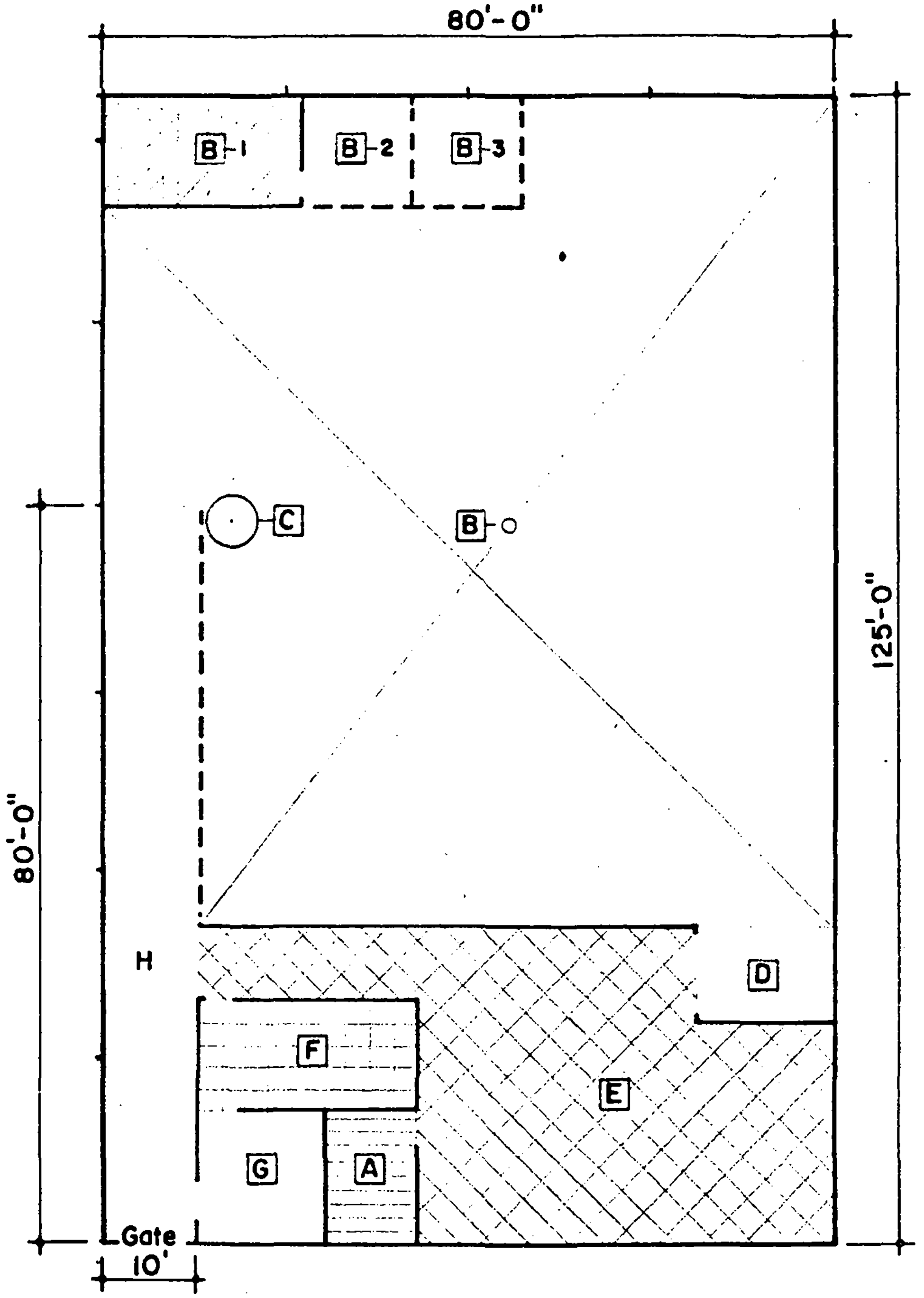
$$\text{hp to drill} = (0.625)^2 \times \frac{\pi}{4} \times 0.015 \times 300 \times 0.8 = 1.10$$

$$\text{Considering 80\% efficiency} = \frac{1.10}{0.8} = 1.37 \text{ hp.}$$

Select 2 hp motor for safety.

The simple formulas mentioned above can be used to select proper machine tools, the formula are also applicable to turning, shaping, and shaper cutting (cast iron).

FOUNDRY LAYOUT (10,000 SFT)
-(2000-3000 HAND PUMP/MONTH)



LEGEND:

A - PATTERN SHOP - 150 SFT.
B -1 CORE ROOM. B-2 CORE MAKING,
B -3 SAND PREPARATION
B-0 MOULDING - TOTAL (B) - 6000 SFT.
C- MELTING & POURING- 600 SFT.
D- CLEANING BED - 150 SFT.
E-MACHINE SHOP — 2000 SFT.
F-GENERAL STORE, G-OFFICE, F & G-500 SFT
H-OPEN SPACE- 600 SFT.

APPENDIX-A

COMMON CASTING DEFECTS OF HAND PUMP

Blow Holes

Blow holes are cavities in a casting that are formed by entrapped air or steam arising out of excessive moisture in the moulding sand or in the core. The air may be entrapped due to a poor runner design and insufficient venting (mould is pierced with small holes) of the mould. If the core or the mould wall surrounding the cavity has free moisture, the entrance of the molten metal vaporizes the moisture. If the steam can not escape through the mould wall, it will escape through the metal causing a blow hole on the surface of the casting.

Remedy

1. The moulds should not contain more water than is necessary to impart binding strength to the moulding sand mixture.

2. Where possible, the moulds should be skin dried and coated with a film of graphite paste.

3. Shallow channels should be cut into the parting surface of the mould.

Cold Shut

Cold shuts usually appear as a lapped joint. It occurs when a stream of metal comes in contact with metal that has already solidified and the two do not bond together causing a joint or discontinuity.

Remedy

1. Avoid pouring cold metal.

2. Avoid slag entering the mould with the iron.

3. Decrease time to fill the mould.

Porosity

Porosity appears as pin holes on the surface of the casting after machining.

Remedy

1. Porosity may result out of microshrinkage caused by a reduction in the percentage of free carbon. Carbon content must be balanced.

2. Control moisture content in the mould.

APPENDIX B

3. The mould material must be properly rammed.

Shrinkage

Shrinkage usually occurs when the carbon equivalent (C.E.) falls below that specified for a particular grade or class of iron. Carbon equivalent being the ratio between the percentage of carbon and that of silicon plus phosphorus.

Remedy

1. Avoid materials in the furnace charge that are known to deplete carbon and/or silicon from the melt.

2. Conduct wedge test throughout the casting day and use metal not meeting wedge test specifications for heavy sections or parts not to be machined.

Misrun

A misrun occurs when the mould is not completely filled with metal.

Remedy

1. Avoid interruptions in filling the mould. Maintain a steady stream of metal.

2. Decrease time to fill the mould.

3. Prevent slag from entering the mould with the iron.

4. Avoid use of cold iron.

Core Shift

A core shift can occur if the core is not adequately supported during the drying operation and does not retain its shape or if the core moves out of its placed position during the filling of the mould.

Remedy

1. Provide proper support for cores in the core oven.

2. Accurately position cores in the mould so they can not move.

Mismatch

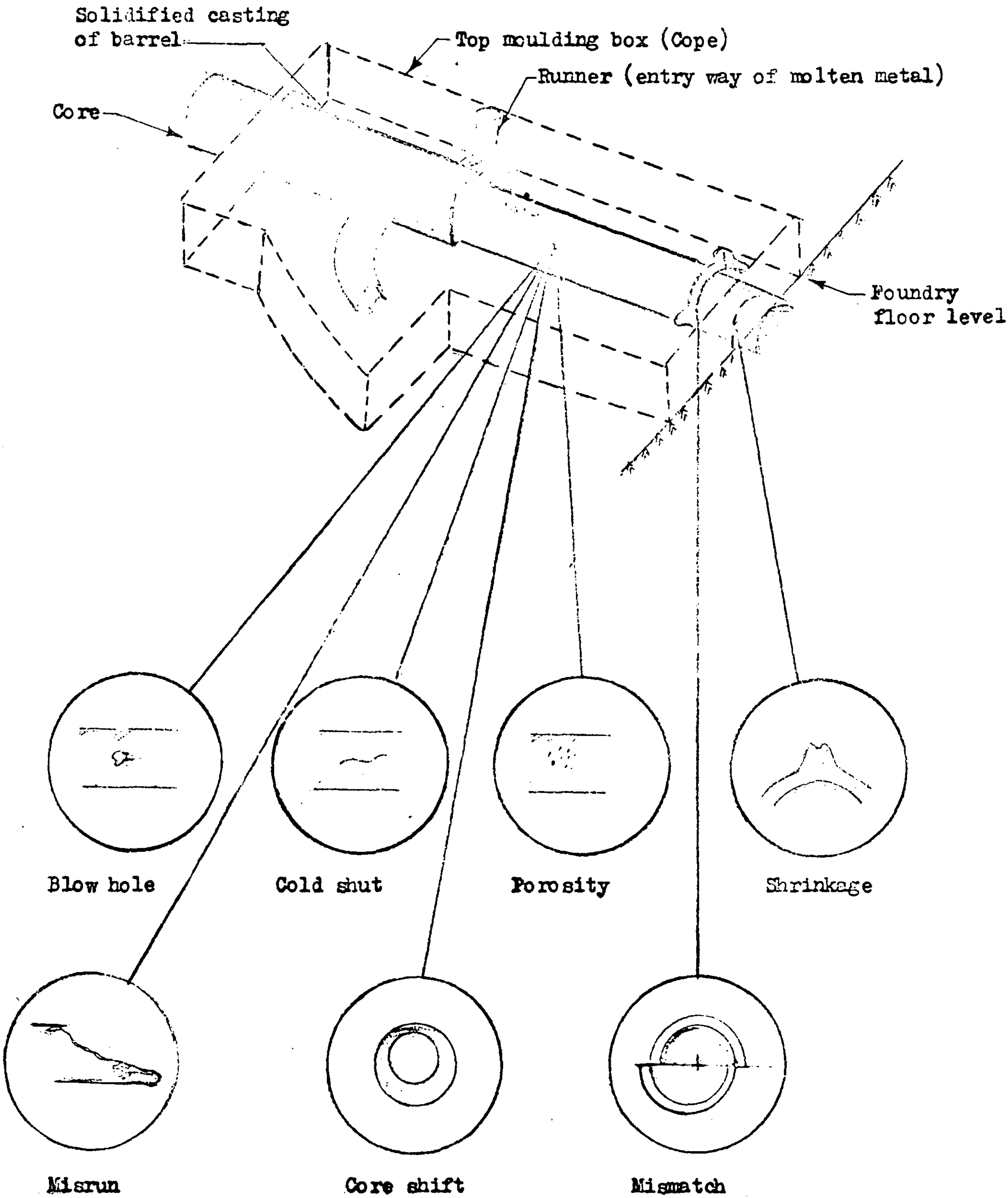
A mismatch occurs when the cavity in the cope (top) section of the moulding box is not placed directly on the cavity in the drag (bottom) section of the moulding box.

Remedy

1. Use well placed guide pins that can be firmly pushed into the perimeter (outer edge) of the drag section of the mould so that the cope section can be accurately positioned.

2. Exercise care when placing the two halves of the mould together.

COMMON CASTING DEFECTS IN HAND PUMPS



APPENDIX B