NEAR EAST UNIVERSITY

Faculty of Engineering

Department of Mechanical Engineering

DESIGN OF FOUNDRY FOR CASTING OF COVERINGS FOR TELECOMMUNICATION SYSTEM

Graduation Project ME - 400

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Preface

In the year 1982, the United Nations wanted to develop the communication system in Cyprus. So, they asked the governments of each of the two part of Cyprus to make a number of coverings *(062cm Manhole Covers)* that support the telephone cables from natural factors.

A foundry in Haspolat in Lefkosia suburbs was given that project; and after one year, around 2000 units was submitted. As ıı"fourth year mechanical engineering student at our great NEAR EAST UNIVERSITY, I toÔk the same project and I was lucky because Mr. Metin Bilin the engineer who designed the project in 1982 was my supervisor for the this project.

Abstract

Explain what you have done chapter by chapter.

- Installation
- (j)vvdıvck-~- fy;; manufactured
- Material

Introduction:

Dedicated to my family and to all my teachers, and sure for
Mr. TAYSEER ALSHANABLI and MRS. FiLiZ ALSHANABLI

Who have brought a new level of love, patience, and understanding into our lives.

References:

Metals handbook by American society for metals
Material and processes in manufacturing forE.PAUL DE.GARMO
Note of manufacturing in the NEAR EAST UNNERSITY by MR. METIN BILIN

CH.1 THE·FOUNDRY

1.lintroduction

When to product something, it is very important to make the proper plan for the process, the proper selection for the way of production, the proper cost analysis and of course the proper production schedule.

The product.

Name: 062-cm manhole covers

Number of unit: 2000

Time for production: 1

Properties of the product:

1. Two parts :a *cover* anda *chamber*
2. M.aterial:gray cast iron
3. Weight:
   a. 80 kg for the cover
   b. 120 kg for the chamber
4. Manufacturing process: Casting

1.2 The foundry:

The main important parts of the foundry are:

1. the area
2. the equipment
3. the labor
4. Raw material

1.2;1 Area

Since we are going to work on a schedule and there is a dead line for finishing all the parts, the area should be sufficient to be able to finish the parts on time.
The foundry area is 360 m squa((i

1.2.2 The Equipment:

a- A sand separator and binder.
b- A Muller.
c- A cupola.
d- A crane. (3 ton capacity)
e- 65 flask.
f., 2 shank type ladle.(see appendix 17)
g- Automatic squeezing machine. (2)

1.2.3 Labor

We need 6 labors. (4 for mold making, 1 for core making, and 1 furnace keeper).

1.2.4 material

1.. 5 tons of sand
2. raw cast iron ((5% of 230kg)%2000piece=23 tons; take 25 tons)
3. Scraps ((95% of 230 kg)%2000piece=437tons; take 440 tons); engine parts, car bodies, ete.
4. flasks (65 (cope and drag) made of iron sheet metal)
5. Coke we need 1 kg (coke) for each 7kg (charging), where charging is about /A40+25=465 tons, so we need 465/7=66.5 tons
6. limestone: 35%of coke; we need 0.35%66.5tons =23.5 tons

1.2.5 Schedule

Weeks	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Sun.
1 st	Casting process	Cleaning and mold making	Mold making	Preparing the molds and cleaning the.cupola	Casting process	Cleaning and mold making	holiday
2 nd.	Preparing the molds and cleaning the cupola	Casting process	cleaning	Möld making	Preparing the molds and cleaning the cupola	holiday	holiday

It is seen that there will be casting three times every 14 days.

in order to be able to reach the dead line for work submission, 30 sets should be cast every casting day, which mean that 90 sets are to be cast every 14 days.

So we tıeed 44.44 week to complete our 2000 units, in other words 311 day, so we are 54 days before our dead line, which represents a factor of safety if sorne production problerns happen.

1.3 Summary

Since all of these steps are properly found, one can probably get satisfactory results.

CH 2 THE PATTERN

2.1 introduction

Casting processes can be divided into two basic categories; those for which a new mold must be created for each casting (the expandable mold processes) and those that use a permanent reusable mold. Almost all of the expandable- mold processes begin with permanent, reusable pattern a duplicate of the part to be cast modified to reflect the casting process and the material beirıg cast.

in the pattern making we should take care of the shrinkage that occurs while,~Ôlidification of the pattern.

The pattern also should have very dimensional accurate in order to have betler production results. Also the type of material of the pattem depend on the number of the casting being cast. For example if the number of casting is no more than 20 or 50 parts it is better to use a wood pattern since it is less expensive and the properties of the pattern .won't get lose before the end of the castings, but in the case of about 1000 pieces or more a metal pattern should be used because the dirnensions won't get lose easily.

2.2 Materials for patterns

The materials of which pattern are usually made differ greatly in their characteristic and therefore in th~ applications to which they are suited.

The decision to what material to use fora specific pattern depend on:

1. Expecting production quantity.
2. Dimensional accuracy require?.
3. Molding process to be used in the foundry, including type and size of molding machine if one is used.
4. Size and shape of casting.

Appendix 10 presents a cortıparison of the important characteristic of four commonly used pattern materials - wood, aluminum, steel and plastic.

(The pattern for our project will be made of aluminum.)

Metal pattems are normally rnade from an aluminum alloy, gray iron, steel ora magnesium or copper alloy. The property on which metal selection is based includes resistance to wear, dimension stability machine ability and the ability to provide a smooth suıface fınish after machining. After metal patterns are cast, gating and flash must be removed, and the suıfaces must be made smooth and free of impeıfections.

Metal pattems afford better dimensional tolerances than wood patterns, longer pattem life, grater resistance to abrasion in molding, and for greater stability under changing humidity.

2.2.1 Type of patterns

The type of pattern used in a specific production application is determined by the number of castings required, the stage of development of the design of the casting the complexity of the design of the casting, arld the molding process used in the foundry.

2.3 Selection of pattern type

The number of casting to be produced and the accuracy required are pritnary coıısideration of the choice of an appropriate type of pattem. Patterns, which are ıha.de of metal, will retain accuracy longer. The number of casting to be produced also determines the molding equipment that will be used and the equipment available also affects pattem choice.

After the design and quality of the casting have been approved, a permanent pattern is selected, based on annual production requirements.

Seeappendix 11,12,13,and 14.

2.4 Allowance

The modifications that are incorporated into a pattem are called allowances, and the most important of these is the shrinkage allowance. Following the solidification, the casting continues to contract as it cools, the amount of contraction being as much as 2%. Thus the pattern must be made slightly larger than the desired casting as a mean of compensation. The exact allowance depends on the metal that is to be cast. Allowances typical of some engineering metals are:

Cast iron	0.8%-1.0%
Steel	1.5%-2.0%
Aluminum	1.0%-1.3%
Magnesium	1.0%":.1..3%
Brass	1.5%

The wood pattern is made 5% greater than the part to be cast, in order to let the shrinkage of the aluminum'pattern and the machining after the casting of the pattern then we can use this pattern for casting:

2.5 Conclusion

Choosing the patterrı type and material is the most important part of the casting since it determines whether casting may be good or not. And also the cost of the casting products can be less by the proper selection of the pattern type and material.

CH.3 THE CASTING PROCESS

3.1 Introduction

Sand casting represents one ofthe wellknown and famous casting because of it is relatively cheap method of casting and furthermore because of its relatively good quality.

3.2 Sand nıolding

Sand combined with a suitable binder, can be packed rigidity about a pattern, so that when the pattern is removed, a cavity correspondence to the shape of the pattern remains. Molten metal poured into this cavity and solidified develops a cast replica of the pattern.
The sand that forms is friable after the metal is cast, and can be readily be broken away for removal of the casting.
The ingredients that the sand (silica 90%) is mixes with:
Clay (3%), and water(7%).

,3.2.1 T)'peş of molds

Molds for sand casting are broadly classified as:

(a) Green sand molds

(b) Skin-dived molds

(c) Dry sand molds

(d) Dry sand core-molds

(e) Other types of sand molds.

Green sand molds are the most widely used of all sand molds. They are made of sand, clay, water, and other conditioning. Both ferrous and non-ferrous castings are produced in these molds. The molds are prepared, metal is poured, and castings are shaken out in rapid production cycles.

3.2.3 Advantages of green sand molds

1. Green sand molding is the least expensive method of producing a mold.
2. There is less distortion than in dry sand molds, because no braking is required.
3. Flasks are ready for reuse in minimum time.
4. Dimensional accuracy is good across the parting line.
5. There is less danger of hot tearing of casting than in other types of molds.

3.2.4 Disadvantages of green sand molds

1. Sand control is more critical than in dry sand mold.
2. Erosion in the mold is more common in the production of large castings.
3. Surface finish deteriorates s the weight of the casting increases.

3.2.5 Condltioning of molding sands.

Conditioning of molding sands may consist of one or more steps, includingSimple mixing of the sand with other ingredients, mulling of the ingredients, coôling of the sand from shakeout, and removal of the foreign material from the sand. S ee a:ppehdix 21 and 22.

3.2.5.1 The importance of sand treating

Refractoriness: the ability to withstand high temperature (basic nature of sand).

Cohesiveness: the ability to retain a given shape when packed into a mold.

Permeability: the ability to permit gases to escape.

Collapsibility: the ability to permit the metal to shrink after it solidifies and to ultimately free the casting through disintegration of the mold.

3.2.6 Allowance for metal shrmkage

In mold construction it 'is necessary to compensate for the following, to obtain accurate casting dimensions:

1. Mold-wall movement caused by thermal effect and static pressure of the molten metals.
2. Solidification shrinkage. This is i'metal feeding problem.
3. Thermal contraction of solidified castings. (See appendix 21 for shrinkage.)

Gray cast iron 1/1 0

3.2.7 Risers

A riser is a reservoir of molten attached to the casting, to provide.it with ınetal required because of shrinkage before and after solidification.

The metal poured into the casting cavity should begin to solidify at an extreme distance from the risers. Freezing should then advance toward the metal feeding elements iri such a manner that the solidification shrinkage is progressively föoved frôıiı the body of the casting and is contained entirely in the feeding system.

During the solidification ofa casting , a thin.skin offrozeı1ıneta.ls forms like a shell is ,in effect, a mold for the remainder of the casting, and tlıe v6lt1111e lost by the shrinkage of the 111t:ıı.aı~ as it solidifies within this shell must be replaced , frorn some feeding source, to avoid shrinkage porosity.

The function ofa pad or a riser is to supply liquid metal to the mass continuously until it is frozen solid without porosity. The thickened section provides feed patlı not to freeze until the isolated section.has solidifies.

See appendixl 8 for the riser design.

3.3 Cleaning the castings

The cleaning of castings usually refers to the operntionsipvoly)1 inth~ rernoval of sand and scale, gates and risers, and fines, chaplets or other metal not a pa.ıt ofthe casting.

3.3.1 Removal of gates and risers:

Usually is the first operation of cleaning. The gating system may be brokeııμy.impact as the casting are dumped out of the flasks and vibrated and taken off. Those gates and riser not broken during the shakeout cari be removed by being struck with a haınıner . When the molds are set on the cleaning floor and dumped by hand, the gating systemcan knocked off with a hammer. When the gating system can not be safely removed by iınpact, shearing can cut it off

3.4 Sand cores and core making

Cores are separate shapes of sand that are placed in the mold to provide castings with contours, cavities and passages that are not otherwise practically or physically obtained by the mold. Cores are composed mainly of sand but also contain one or more binder materials most of the principles that are applied for making a sand mold are applied for making a sand core. After the core box being make, sand is pressurized .into the core to get the required shape, after that the box is opened and the core is taken to the oven in order to dry and get the final strong shape, Appendix 15 represents the core box.

3.4.1 Core requirement:

During its preparation, a core must be hard enough to retain its shape without deforming. After baking or drying, it must be strong enough to withstand handling and to resist erosion ind deformation by metal during the filling of the mold. To make a true form for the casting, it must be stable with a minimum of contraction and expansion. The core must be sufficiently low in residual gas-forming material to prevent excess gas from entering the metal.

Provision must be made for venting any gases that are produced by the core.

Furthermore, the core must collapse after the molten metal solidifies, to minimize strains from the casting during shakeout.

3.4.2 Core boxes.

The most common method of forming cores is to use a core box, made of metal or wood, that contains a cavity the shape o:rtfie desired core.

This cavity is rammed full of sand to form the core, which is mounted ona support plate for backing.

3.4.3 Core mixture,

The composition of the mixtures depends onthe metal being cast and thestrength.required for the core.

3.4.3 OII sand.

Oil sand mixtures are those most widely used for cores in sand molds.

Their cost is low and by varying their composition they can be used for almost any sand application. The following is a typical formulation that contains cereal and a small amount of clay; this mixture has proved satisfactory for the casting of gra.yiron and several other metals.

Sand (by weight)	95.8%
Cereal flour	1.01%
Core oil.	1.1 7%
Water ....•.	1.86%
Betonite	0.16%

These materials are mixed in a Muller as follows:

1. Combined sand, flour and betonite, and mull dry for 1 min.
2. .Add water and mull for 1 min.
3; Add oil and mull for 4 min.

See appendix 15 for the core box.

The core is placed in the fnold cavity by tidying it to the mold by the mean of a thin wire in order not to fall down du,ting pouring the metal.

3.5 Preparing the molds.

3.5.1 For the cover

After the send is being prepared the following steps are followed:

1. The pattem is maintained in the drag part of the flask (the bottom of the flask should be covered with a thin wood plate).
2. We' add the sand to the flask everywhere and pack it well until it totally covers the pattern of the half part of the flask, then the sand should be packed well by squeezing it using squeezing equipment)
3. The flask is turned over, the wood part is taken away and cope is placed over the drag.
4. The riser and the sprue are hold in the flask and then sand is added until the cope is totally filled with sand, then the sand is squeezed well and after that some small holes are made in the sand with the aid ofa 4 or 5mm in diameter nail in order to let the gases and theairhold in the hollow to escape,

5, The flask is then opened.(cope and drag are seperated)
6. The pattem, riser and the sprue are take away.
7. Then the two green sand cores are maintained in their places in order to be able to produce the two keyholes existing in the pattern.
8. A runner is opened between the sprue, riser and the hollow of the pattem.
9. The flask is locked again before getting ready for casting.

3.5.2 For the chamber

After the sand is being prepared the following steps are followed:

1. The pattem is maintained in the drag part of the flask.
2. The sheet metal is inserted in the hollow of the chamber after being locked.
"3. The sand i~ added orily in the part between the exterior circumference of the sheet metal and the interior part of the flux, then the sand should be squeezed well by squeezing machine.
4. The flask is turned over and the wood part is taken away and the cope is placed on the drag.
5. The riser and the sprue are hold in the flask and then sand is added üntil the flask is totally filled with sand, then the sand is squeezed well and after that some small holes are made in the sand with the aid ofa 4 or Sının in diameter nail ihördeftoletthe gases and the air hold in the hollow to escape.
6. The two parts of the mold are separated.
7. The sprue and the riser are taken away then the sheet metal is unlocked and reınoved so that the pattern could be removed.
8. The mold is packed again and ready for casting:

See appendix 19.

3.6 Casting process

In the early morning the scraps and the coke are inserted in the charging door and let them to melt; after being melt, the molten metals are poured into a shank-type ladle (see appendixl 7) that is hold and then taken away by the mean ofa crane to the molds area where an experienced labor should pour the molten metals into the mold.

3.6.1 The points that the responsible worker of the poufiııg should take care of:

The flow rate of the nıolten metals.
He should stop when he sees the riser full of molten metal withoutforgettingto keep an eye on the sprues.

Note: 90% scraps of cast iron and 10% scraps of steel.

3.6.2 Flasks:

The flasks should be squared iron boxes that are opened at the top and bottôriı.iıı order to let the feeding ofthe sand .the figure shows the shape and the dimensions of theflasks.
See appendix20..

3.7 summary

In order to have a good quantity production, the experience is need.eclinthis field since most of the steps being stated are not theoretical, so one should not e xpect to have good production at the beginnirıg without having experience.

CH 4 MELTING CAST IRON

4.1 Introductiôn

One of the most iriıpôrtant steps in casting is to determine the type of the furnace and the temperature of the ın,ôlteıı metals, If the temperature of the molten metal was not higher enough, there will be lıiiprôper solidification appears in the body of the casting which leads to a had product or eveti a wroıg one.

On the other hand, had results will appear on the product if the molten temperature was Iiigher than necessary.

The nıanufactures use Cupolas for melting the cast iron.

4.2 Cupolas

The primary funetion of a cupola is to melt iron to a specified tapping temperature and chemical composition using as little coke as possible. A cupola is a vertical steel shaft into which coke, flux andmetal are in altemating layers.

Cupolas (such as those shown in appendixl) are prepared for operation of by closing the bottonı door, supporting them by a prop, then placing at thenı a bed of rammed sand 6 to 10 in. thick.

The taphole for iron is at the edge of the sand surface, the rows of tuyeres for entry for air is 12 to 36 in. above the sand, depending on the cupola size and whether tapping is internıittent or continuous. A bed of coke is placed on the sand bottom and ignited, and then made up to a height of 50 to 60 in. above the tuyeres. The shaft is filled through the charging door with alternate layers of coke and nıetallic charge.

Air supply or blast is then introduced through tuyeres and intense heat of combustion is thereby develops in the bed coke. The metal at the suıface of the, bed melts and trickles down through the hot coke to collect on the sand bottom in the well bellow the tuyeres.

The column of the charge materials descends to replace the metals melted, and afreshJayer of coke replenishes the coke burned in the bed to melt one charge. This process continues as long as air supply is continued and coke and metallic charges are added. Molten slag which is coke aslı and nonmetallic in the charges is also formed and floats on the surface of the molten iron in the well.

lf the cupola is continuously tapped, as most medium size and large cupolas are, the iron 'and the slag flows continuously through the same tapehole and are separated in a small basin in the spout, the slag floating and being discarded. For intermittent tapping, there is botharı iron tapehole in the front of the cupola and a slag taphole at the rear some 12 to 24 in. higher.

'Ilie iron taphole is closed with a fierclay plug, so that iron and slag are accumulated in the well, as the level rises, the molten slag floating on the iron reaches the slag hole and flows out. When the iron level is near or at that slag hole the iron tapehole is opened by removing the fierclay plug and most of the iron is drained out ata rate much higher than the melting rate.

Then the iron tapehole is .redosed and the cycle is repeated.

Çonventional cupolas have refractory linings from the sand bottom up to thecharging door, At the top gray iron blocks are used for lining because they are less susceptible to damage from the charge materials then are refractory linings and the ternperature here is not high. The stack portion of the cupola is li.ned with refractory but because temperatures are relatively low in the stack the type ofrefractory used is less critical.

Size of cupola may vary from one that melts no more than one ton per.hourto.one that melts nearly 50 tons per hour. Cupolas are usually rated in capacity by their inside diameter, it is possible to operate a specific cupola within amoderaterange ofmelting rates by varying the air blast and the percentage of coke in the charge. (See appendix 2 for the size of cupola).

4.2.1 Air blast.

The forced air required for combustion of coke in the cupola can be supplied by positive - displacement, centrifugal, or fan blower. The .pressure required depends on the type of charge, height of the charging door above the.tuyeres, and air volume blown, but usually it is about 1 oz per sq. in per foot charge height. A 32-0z blower is ordinary sufficient. It is important to measure and control air volume or weight since approximately one ton of air is consumed in melting one ton of iron. if the blast is 'to be heated, as in a hgİr-blast cupola the air is passed thröugh a gas fired or oil fired heatel"ifu.meôiafely before entering into the cupola.

The air for combustion is supplied to a wind box that encircles l:he cupôla. From the wind box, the air is admitted to the cupola through tuyeres, positioned tnifötnly about the circumference öf the cupola. Tuyeres are usually located on one leV~l, irtd hıöÔeı:ri pfactice _is to use relatively small tuyeres to give an air velocity , 50 feet .per second at normal \temperature and pressure for good penetration, except in vefy smallC\l.polas.

Combustion of the cupola takes place in the coke bed. The zône.ôfrri.aximutn temperature extends from about 5 to 20 in above tuyellevel, and it coincides with the zone of maximum refractory erosion in a lined cupola. Melting of charge material takes place ata somewhat higher level, depending on the melting point of the particular ifon, ancl itis in this bed of hot coke that melted iron a truckling down picks up its super heat.

If coke is added in the charge in less proportion than required tharithea.irstipplythe top of the bed is not replenished fully and it slowly burns to a lower level. This shörtehs the super - heating zone, and the iron becomes colder at the taphole. Conversely, excess coke makes too hot iron so s balance must be struck for uniform operation. In principle there are fixed relations among melting rate, iron temperature, percentage of coke charge ıı.üd air blast rate, and varies charts J.;ıas been published to simplify prediction. However,Jhe .relations also depend on coke quality, on the air distributi on' in a given cupola, and ön height from tuyers to top of charge column, so they become rules of thumb. The simplest rule is that a cupola normally will bum coke at a fairly constant rate of 1.1 to 1.2 lb. of coke per square inch of cross-section per hour, taking about 11 0 cu ft of air per pound 91 % fixed carbon coke.

4.2.3 Slag disposal.

The slag formed in the cupola is removed continuously; if the volume of the slag is small, it may be run dut on a dry sand bed and carried out with the bottom drop. Large volumes of slag are into suitable slag pots and cooled, and then taken to a slag dump after the metal buttons that from at the bottom of the pots are removed.

4.2.4 Disposal of the cupola drops.

When the required amount of iron is melted in jobbingshop,. or i11ternal repair becomes necessary in a continuously operated cupola, the cupola must be emptied. This is accomplished by dropping the bottomf doors after all molten füet.a.ıa11q slag have been tapped from the cupola.

The remaining material, which makes up the drop, is a mixture of sand coke, iron'and slag. The drop may be cooled in a place by water hose and removed or preferably (to permit the cupola to cool and to make a the work easier), the drop is pulled from under the cupola and cooled; then the drop is sorted; some unburned coke and partly melted iron are recoverable and the remainder is discarded.

4.2.5 Metal Tapping.

Metal is usually tapped from the cupola to transfer ladle or to tilting forehearth, called a mixing ladle, either of which is located in front of the cupola. Both of these containers must be heated before receiving the molten metal, in order to maintain iron temperature. The forhearth may have an auxiliary system for continuos heating.

4.2.6 Advantages of Cupola Melting.

They include flexibility in using a variety of low-cost materials to produce ğray iron, high melting rates, low fixed cost per unit of output, continuos (for a week.or more), and minimum down time.

4.2.7 Cupola l,İıtings

A cupola is divided irıto four zones:

1. The well or hearth;

2. The melting zone (the area immediately above the tuyeres, which varies in height depending on the initial height f the coke bed, the blast velocity and the degree of blast penetration);

3. The preheating zone

4. The stag above the charging door.

Temperatures and other conditions vary considerably among these four zones; thus, the requirements for refractory linings also vary.

Temperatures in the cupola well are several hundred degrees lower than in the melıing zone. However refractors in the well are exposed to molten iron and slag and must resist attack from these materials.

Maximum attack on the refractory lining occurs in the melting zone, where maximum temperature is generated (usually, about 3250 F). The high temperature accelerates the erosion oxidation of the lining materials by the hot gases, slag, flux, and iron oxide.

Temperature of the preheated zone decreases rapidly from the melting zone upward, as the result of absorption of heat by the descending charge, and linings are not in contact with molten iron and slag. However, linings in the preheating zone are subjected to sever abrasion from the dovvnward movetnent of the materials of the charge and the impact of the charge as it is dutı:iped irıtö the cupola.

in the cupola stack above .the charging doôr, côiıditiôrıs are 'not sever;>heı-e)thelining is required to withstand only the ternperature of gases.

4.2.8 Refractory Iinings

They are built up inside the cupola shell to form a uniform circular shape of predetermined size and thickness. ,

The original lining is installed most economically by using fire clay refractors manufactured in standard shapes.

Cupola blocks or shapes can be used for construction of the entire lining. The stack above the charging door is normally limned with brick that is bounded with a mortar of air setting high temperature cement. Because service requirements in this area are not severe, the brickwork usually lasts for a long time with little or no maintenance. Cast iron blocks are often installed at the area near the charging door where abrasion from impact of charge materials can cause rapid failure of refractory material.

The melting zone, where most refractory is consumed, is lined with brick ramming mix or, to minor extent silica stone slabs.

4.2.8.1 Thiclmess of lining.

Depends on the size of the cupola, the location of the cupola, and the length of the usual operating period. Typical lining thickness for cupolas of various sizes are given in appendix4

In a refractory-lined cupola, the maximum consumption of refractory is in the melting zone, and erosion to a depth of 8 in. in a band 12 to 15 in. high is common. Most of this erosion occurs in the first one to three hrs of operation, and the rate then decreases as the thinner lining is cooled by convection from the shell. Abnormally high consumption of lining material may be caused by excessive blast volume, excessive fluxing , a high proportion of steel serap in the charge , the use of an undersize cupola, or an uneven charging practice.

4.2.9 Cupola Bottofü

Cupolas have hinged metal doors at the bottoms that are dropped at the end of each heat or when repair is required. This type of bottoms requires a layer of refractory that is strong enough to support the molten metal, but is still weak enough to fall out when.the bottom doors are opened. Foundry sand mixed with a little fireclay or bentonite and water is the most commonly used refractory.

Bottom doors must be prov. ided with vent holes 1/4 to 1/2 in. in diameter to.permit gas and steam from the bottom sand to escape. If vents are not providedandkept opened entrapped steam is likely to blow up section of the sand 'bottom, causing run outs of molten iron.

Before the bottom doors are closed, the joints are daubed with refractory materials to ensure a good fit. Often arrow of firebrick is placed around the edges, especially in large cupolas.

The doors are held in place by props that are wedged upward from a firm foundation. The number of props used depends on the size of cupola, but it is good practice to make certain that the bottom is firefly propped, because a premature drop can be disastrous.

For cupolas that are to be operated fora few hours each day and the bottom then dropped for repair, the sand for the bottom is not critical; screened modeling sand, well ramped to a depth 4 to 6 in., is sufficient.

The sand is dumped into the cupola through the charging door and spread evenly over the bottom. It is then rammed with the peen end of the rammer into a large fillet against the lining of the wall. Two or three ramming are generally used.

The level of the bottom is slanted towards the taphole with a slope of about 1-in. per foot.(see appendix3).

4.2.10 Cupola Charges.

A cupola charge id composed of metal, fuel (coke), in the flux. Because of the changes in composition that take place during melting, the makeup of the charge is based largely on experıence.

4.2.11 Cupola Operatfo~

Cupolas may be designed for eitheritıtermittetıtor continuos tapping.

4.2.12 Intermittent 1'apping.

For intermittenttapping the operator manually removes the disposal sand Ôr day plug from the cupola taphole, with draws the needed amount of molten iron arid then plugs the taphole. This process is repeated with the rate of withdrawal and' ınelting rate per hour being balanced. The maximum amount that can be tapped at one time is determined by the diameter of the cupola and the height of the tuyeres above the bottorn sand. Intermittent ltapping requires a skilled cupola operator.

Intermittent tapping is generally restricted to jobbing foundries w here the demand for iron is intermittent and small and where conventional cupolas are used. For such operation a relatively large tap is necessary to prevent freeze-ups, because the tapholes and slagholes must be heated by the metal in the well. For intermittent tapping, as regular a pattern as possible should be possible, since iron held in the well picks up carbon froın the cock. This must also be correlated with slag withdrawal at the rate of the cupola, so the reasonably consist slag layer is maintained an intermittently tap cupola may be used with of without forhealth.

Any cupola can be operated in a flexible manner but the degree of control of result increase and costs decrease, as uniforrnity of operation increases.

A small cupola for melting 5 to 50 tons of iron per day may be simple and inexpensive. A cupola of this type usually has acid linings, uses cold blasts, is quipped for manual of mechanical charging, .and as minimum control measure has aif~weightcöritrol.The size of the heat is limited only by the deterioration of the refractory lining. Two ör three classes of iron are commonly pröduced during one heat.. The operation of a srna.Uicupola is sufficiently simple that öperators can become efficient after a moderate training period.control of the operation, however, is limited. The metal temperature of the pouring spout, which is a critical variable, is controlled by the initial and continuing bed height, the size of the coke, and the blast volume. These variables must be carefully adjusted and,. corıtrolled for maintenance of proper metal temperature, (See appendix 5).

4.2.13 Cupola Temperature

The temperature in the cupola stack is lowest at the top and ta.pidlY iricreaseSdôwtl the stack, becoming highest just above the level of the tyueres .. Below. the tytieres the temperature drops gradually, but remains above the melting points of the slag and iron. The temperature in the cupola stack and the shape of the zone of maximum ternperature depend on several variables including blast temperature and tuyre Iocation .• For cold blast operation, the lowest part of the zone of maximum temperatiıre in the cupola is about 5 in above the tuyere level (appendix 6a). As also seen in appendix 6 a, the height temperature zone is relatively narrow but extends upward to approximately 23 in above the tuyeres. When a hot blast is used (appendix 6b), the high temperature zone is not only lower and slightly shorter but also broader. The major causes of variations in iron temperature are variation in air blast volume, coke bed height and metal to coke ratio.

4.2.13.1 Hot Blast in the Cup ola

Hot blast applied to the cupola increases iron temperature, decreasescoke consumption per ton of iron melted, increases melting tate, and provides secondary benefits iri'the form of lower melting losses, less sulfur pick up, and increased ability to use lower carbon low material. The importance of hot blast are shown in the appendices 7, 8 and 9.

4.2.13.2 Iron 'I'emperature.

When the temperature of the air supplied to a cupola is increased, with no change in the amount of coke as a percentage of charge weight, the temperature of the iron at the spout increases. The increase in iron temperature is proportional to the increase in air temperature, approximately 15 F for every 100 F increase in air temperature as shown in appendix 7.

4.2.14 Coke required,

The use of hot blasted, by increasing iron temperature, makes possible a decrease of the " amount of coke charğed to the cupola. Fora given tapping temperature, each 100F increase in air temperatute rriakes pôssfble a decrease of 0.4 % of chatged weight in the amount of coke used (appendix 8). So ifwe take the point where the air temperature is about 100 F, a 2251bof coke are required per ton of iron.

4.2.15 Melting rate

Operating results ofa large number of cupolas have shown that the melting rate is linearly related to the coke rate (percentage of coke in the charge) over wide ranges of operating conditions and types of coke.

If the buming rate of the coke in lb per hour is constant, and if the amount of coke 'necessary to melt the iron is decreased by hot blast, melting rate in tons per hr increases in proportion to the blast air temperature. With no change in the air temperature, a decrease in the tapping temperature would result from a decrease of the coke rate; but with a suitable increase in air temperature, the decrease in iron temperature can be eliminated, yielding an increase melting rate with no decrease in tapping temperature. Thus, the use of hot blast will increase the melting rate ofa cupola ata given iron tapping temperature (appendix 9). Air volume must be maintained, since the coke-buming rate is unchanged. If the increase iron flow cannot be used, air volume must be decrease and the cupola must be operated bellow its normal capacity.

4.2.16 Air supply.

When the amount of coke necessary to melt a ton of iron is decreased by the use of hot blast, there is a corresponding decrease in the amount of combustion air necessary per ton of iron. this means that if hot blast is applied to a coke cupola without increasing the melting rate, the melting of the sir heater(in a cubic feet per min.) will be less than the requirement of the same cupola when it is operated in the same blast.

There is a small decrease in the amount of air necessary per pound of coke bumed with the hot blast, anda small decrease in carbon dioxide content of top gases, but neither with these effects is large enough to be of engineering importance.

4.3 Summary

As seen, the temperature is very important in the cupola and also the atnount of the used coke. Since every thing is a matter of money, it is better to reduce the amount of the use of coke but at the same time we should use the suitable pressure in the air blast.

CH 5 COST ANALYSIS

5.1 Introduction

In most of the application of working places in the world, finance is the most important factor since it determines the production ability.
So a factory must determine the least cost with respect to the customers needs.

5.2 Cost analysis.

5.2.1 the production requested elements

Each unit of covering needs should weight 200 kg (120 kg for the chamber + 80 kg for the chamber). But when production we should take the weight of the looses into account;
These looses are due to:

1. Weight of the solidified metal in the sprues, riser, runner and that of loses due to the machining if necessary.
2. The slag and the stuck metal in the cupola.
3. Other loses like some drops on the ground.

Due to these factors, more amount of the raw material should be used so that we can take a 15% more weight of the molten iron; so after easy calculation we can get the weight of the molten metal of one unit production to be 230 kg.

material	Price in $/kg	Amount(kg)	Cost ($)
Raw gray cast iron	1	25,000	25,000
scraps	0.3	437,000	131,100
Coke	0.'5	66,500	33,250
Limestone	0.0134	23,500	3,149
sand	0.3	5,000	1,500

Other costs:

Labors: 6% $500 %12 months = $36,000

Others: alcohol, graphite ete.

Cost = $230,164

The cost per piece = $230164/2000=$115.082

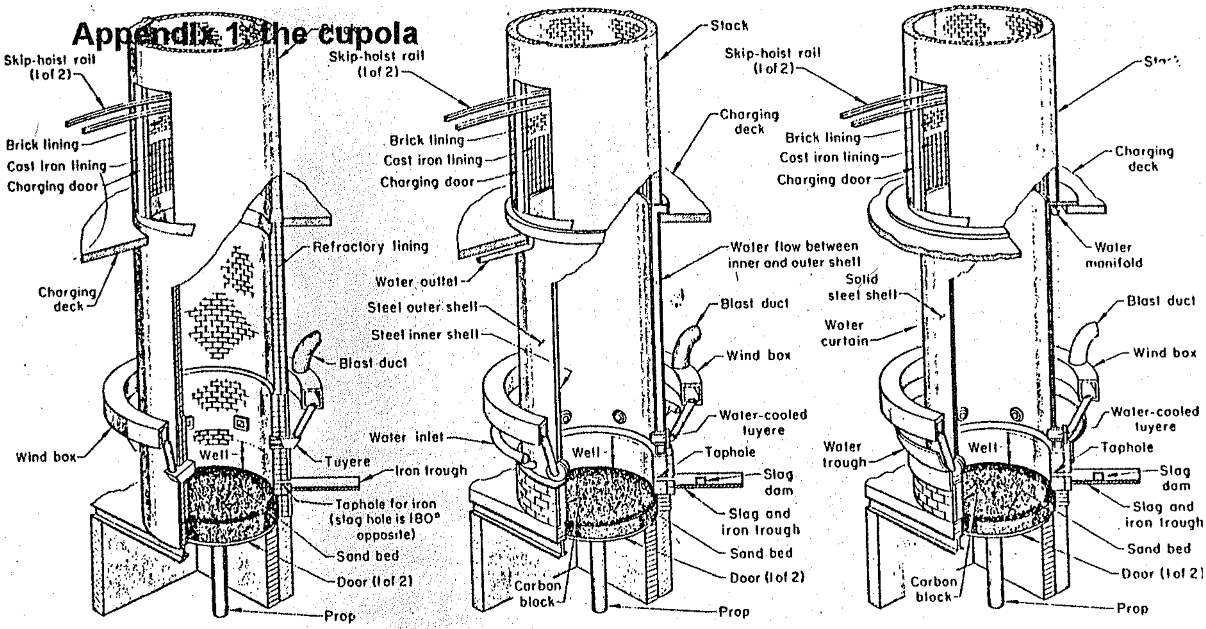
5.2.2 Percentage amount of the part

5.2.3 The cost of one unit

5.3 Summary

Everything that affect the cost of the production should be taken into account especially if one wants to have the best quality that could be afforded in the cheapest price that could be cost because the life is a matter of safety and saving money.

Appendix 1: the cupola



Conventional cupola   Water-cooled cupola (water wall)   Water-cooled cupola (flood cooled)

Fig. 2. Sectional views of conventional and water-cooled cupolas

Appendix 2: size of cupolas

our cupola

Table 3. Components, Operation Ratings, and Costs of Cupola Installations

Item	Inside diameter of cupola: 48 in., Refractory lined		48 in., Water cooled		72 in., Refractory lined		72 in., Water cooled		84 in., Refractory lined		108 in., Water cooled	
Number of cupolas	1	2	1	1	1	2	1	1	1	2	[illegible]	1
Diameter of shell, in.	66	66	48	48	90	90	72	72	108	108	[illegible]	108
Tuyeres (B, box; WC, water cooled)	B	WC	WC	WC	B	WC	WC	WC	B	WC	[illegible]	[illegible]
Skip charger (St, stationary; Sw, swivel)	St	Sw	St	St	St	Sw	St	St	St	Sw	[illegible]	[illegible]
Charge-weighing hopper and scale	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	[illegible]	Yes
Charge-weighing platform scale	Yes	No	Yes	No	No	No	No	No	No	No	[illegible]	No
Coke and stone bins	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	[illegible]	Yes
Coke and stone feeders	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	[illegible]	Yes
Coke-and-stone-weighing hopper and scale	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Blast preheater	No	1000 F	1000 F	1000 F	No	1000 F	1000 F	1000 F	No	1000 F	1000 F	1200 F
Charging crane	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
High-efficiency cleaning system	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Blower, 1000 cu ft per min	5	5	5	5	11.2	11.2	11.2	11.2	15.2	15.2	25.2	25.2
Forehearth capacity, tons	3	3	3	3	6	6	6	6	10	10	20	20
Melting rate, tons per hour	8	9	8 to 9	8 to 9	16	18	18	18	22	25	50	50
Operating hours per day	8 to 10	16	24	24	8 to 10	16	24	24	8 to 10	16	24	24
Cost, installed (approx), thousands of dollars	$108	$1200	$420	$1200	$390	$1500	$600	$2000	$540	$1800	$1200	$3000

NOTE: Above listing of equipment components is based on a minimum of 16-hr daily operation; thus, two cupolas are indicated for 16-hr operation when they are refractory lined (conventional); see text at bottom of column 2, page 337.

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Appendix 3: cross-section of cupola bottom door

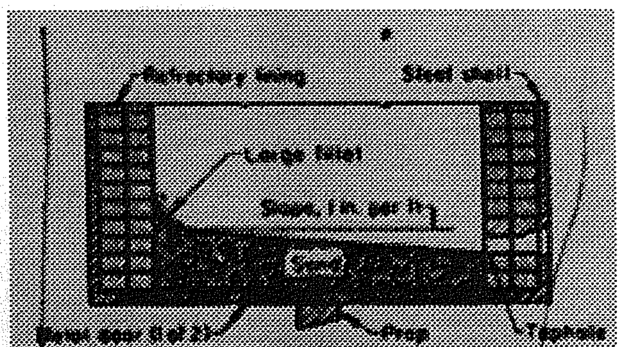


Fig. 4. Cross section of a cupola bottom with doors closed and sand in place. See text for discussion.

Appendix 4: typical thickness of cupola lining

Table 5. Typical Thicknesses of Cupola Linings(a)

Cupola ID, in.	Lining thickness, in.: Melting zone	Lining thickness, in.: Upper zones
27 to 38	6 to 9	2½
41 to 54	9	4½
63 to 99	9 to 12	6
102 to 106	12	6

(a) Lining thickness must be increased above the values shown for extremely long heats.

Appendix 5: advantages and disadvantages of cupola melting in a small foundry

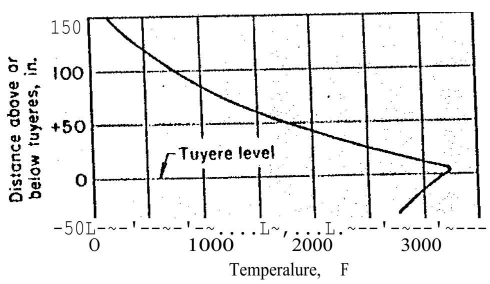
Table 11. Advantages and Disadvantages of Cupola Melting in a Small Foundry

1 Moderate capital costs and low fixed costs
2 Flexibility of size of heat
3 Flexibility of metal composition during heat
4 High melting rates
5 Moderate fuel costs
6 Moderate refractory costs
7 Moderate general maintenance
8 Relatively simple cupola operation.

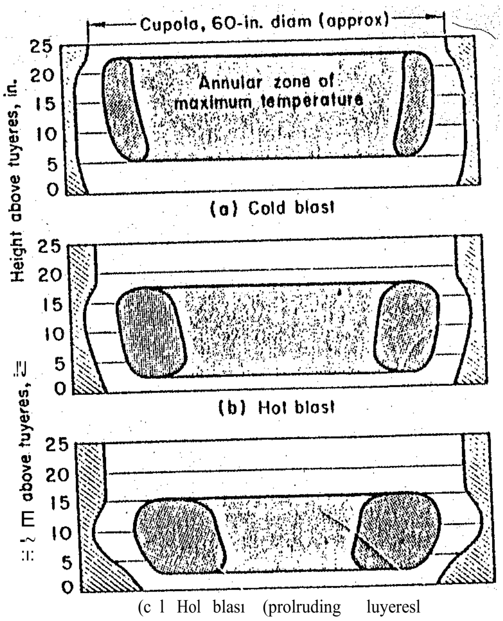
Disadvantages

1 Limited control of temperature
2 Limited control of metal composition
3 Metal charges are costly because of preparation and quality required
4 Charge requires extensive preparation and weighing
5 High sulfur pickup during melting
6 Metal and alloy losses are relatively high.

Appendix 6: temperature distribution in the cupola



Ffr,. 6. Rıılatloıı of teıııperature to tuı,ere locatl~ı in a cold blast cupola



Flflr6. Lacatlons aııd s!ıa1)CS of tıa:ı;lmıwı.. temperatııre zaııes fn relo.tıan to tııyer.eJevel, far cald blast and hat blast cupalas

Appendix 7: effect of blast air temperature on melting temperature of iron

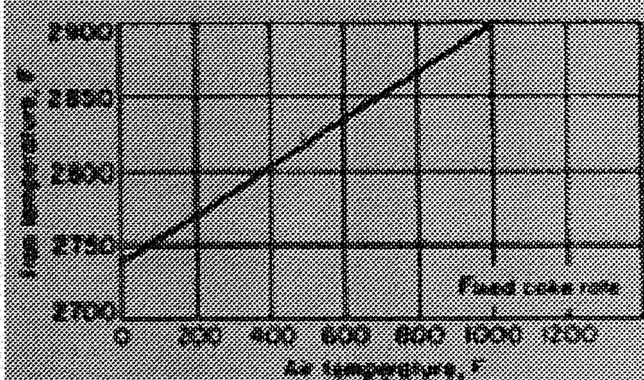
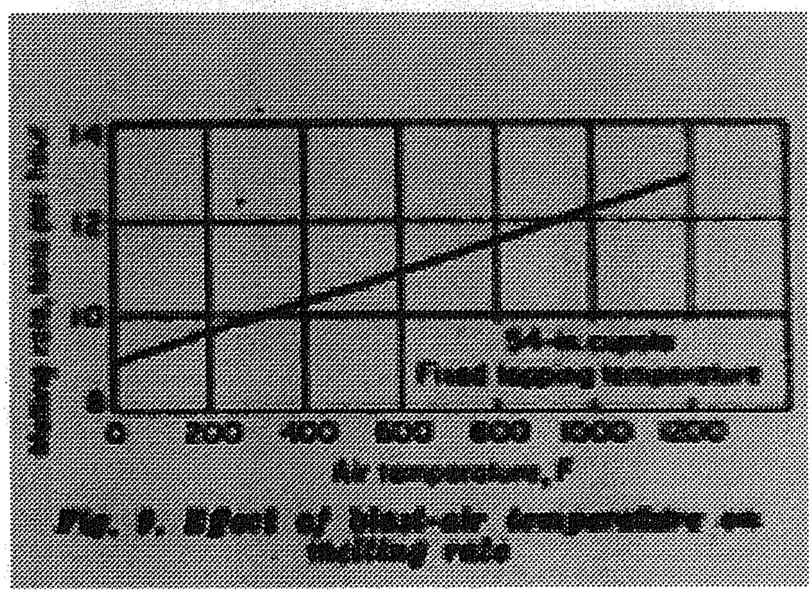


Fig. 7. Effect of blast-air temperature on tapping temperature of iron

Appendix 8: effect of blast air temperature on melting rate



Apperıdix 9: effect of blast air temperature on coke charge requirement

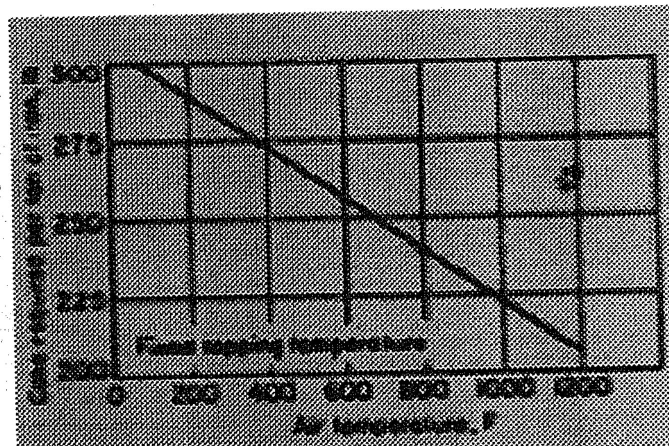


Fig. 2. Effect of blast-air temperature on coke charge requirement

Appendix 10: .comparison of characteristics of pattern materials

"

Table 1. Comparison of Characteristics of Pattern Materials

(E: Excellent; G: Good; F: Fair; P: Poor)

Characteristic	Pattern material — Wood	Aluminum	Steel	Plastic
Machinability	E	G	F	G
Wear resistance ...	P	G	E	F
Strength	F	G	E	G
Weight (a)	E	G	P	G
Repairability	E	P	G	F
Resistance to:				
Corrosion (b) ...	E	E	P	E
Swelling (b)	P	E	E	E

SOURCE: D. C. Ekey and W. P. Winter, "Introduction to Foundry Technology", McGraw-Hill Book Co., New York, 1958, p 46

(a) As a factor in operator fatigue. (b) By water.

appendix 10

Appendix 11: effect of moisture contents in wood

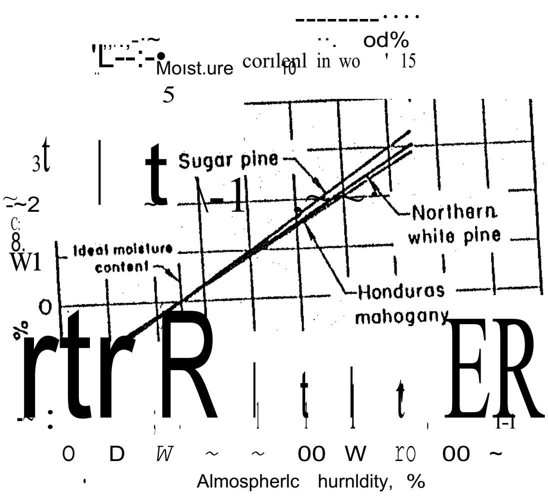
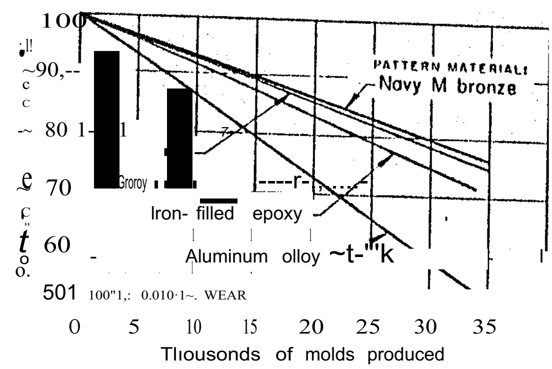


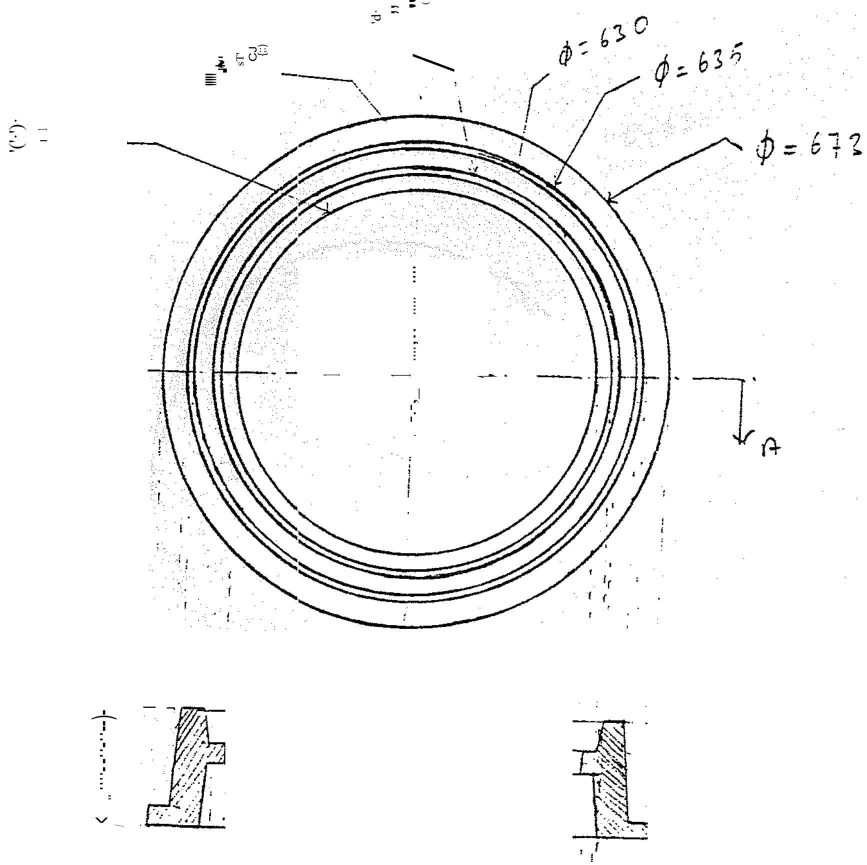
Fig. 1. Effects of moisture content in wood and of atmospheric humidity on expansion and shrinkage of three pattern woods

Appendix 12: life of pattern

150

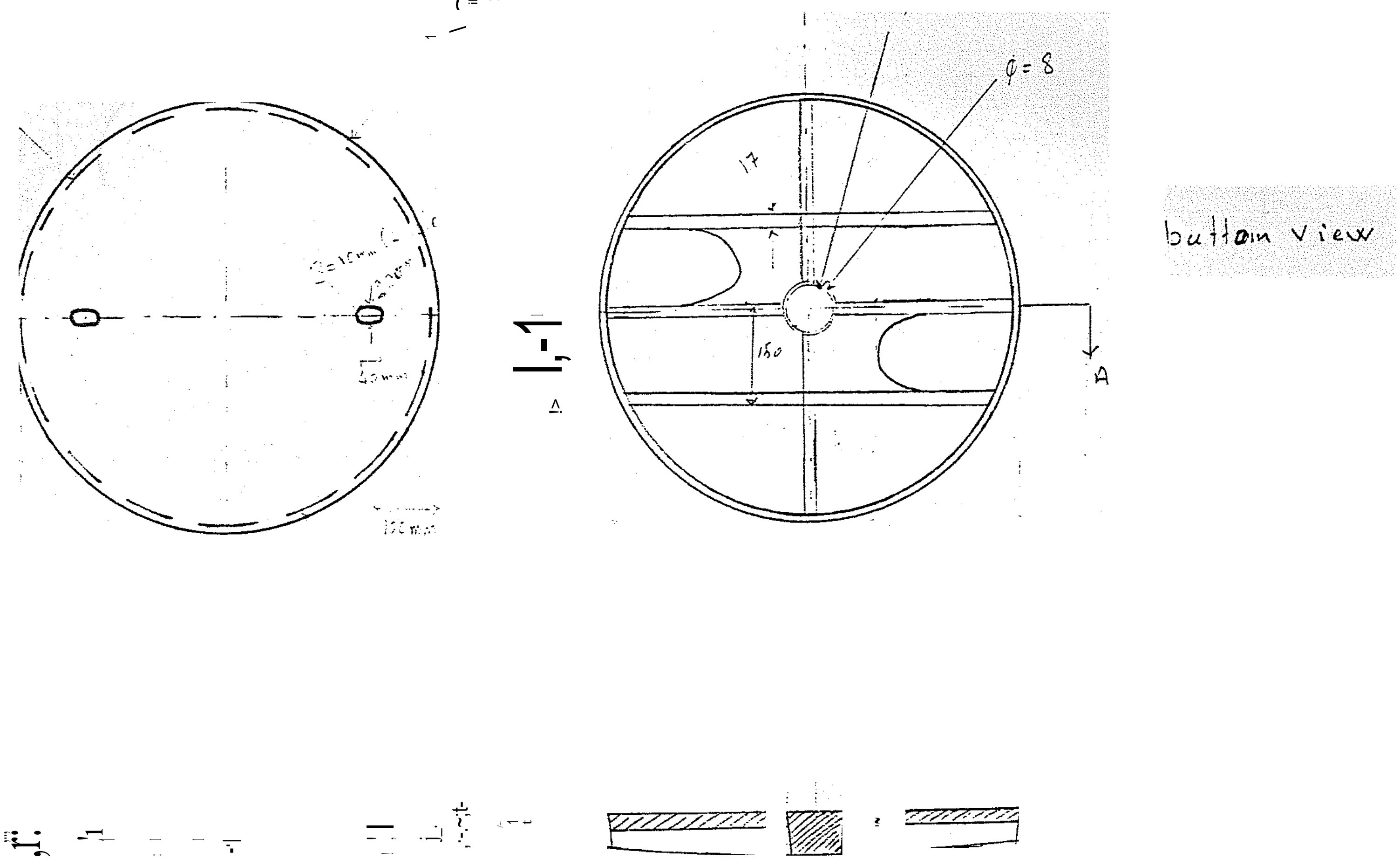


Flg, 2. Life o/ *pattern.~madc* o/ *lour dlOer-ent materials* (Example 148)



section A-A

dimensions are



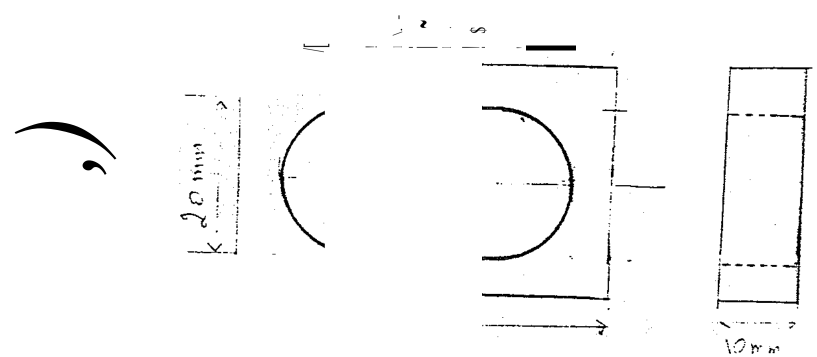
Part Name: COVER

Material : Gray cast iron

weight : 8 kg

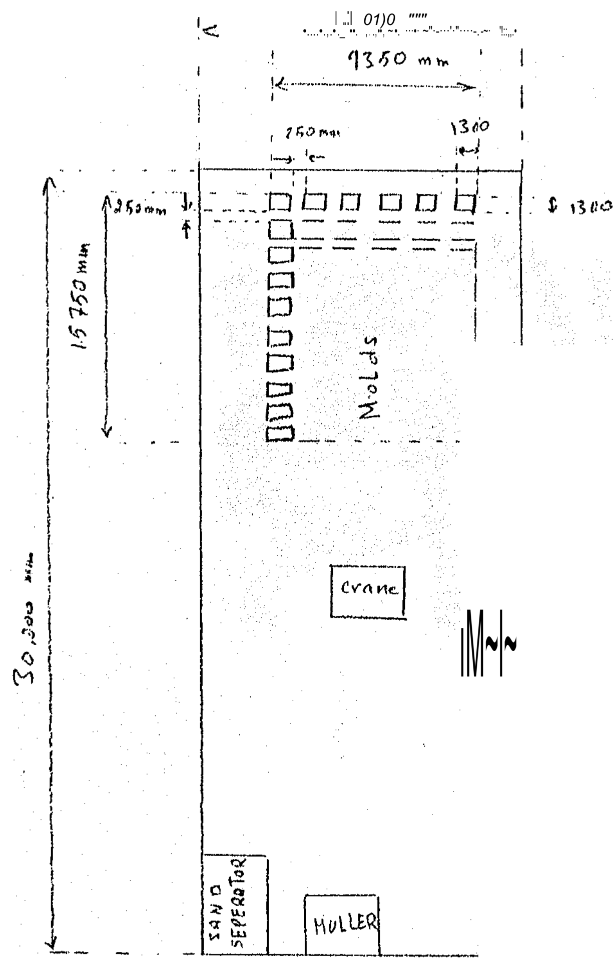
2000 Units

dimensions are in mm



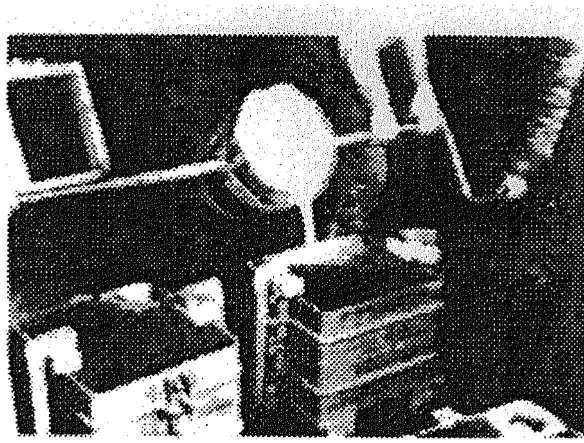
CORE BOX

Appendix 16: the foundry outlook view



A 12x30 m foundary

Appendix 17: the shank type ladle



[illegible]

Appendix 18: the riser design

Dr riser diameter

Vr: volume of the riser

Ar: Area of the riser

V c : volume of the cover casting part

V eh: Volume of the chamber casting part

Ach: Area ofthe chamber casting part

(TST)r: Total solidification time for riser

(T_2ST)ch: Total solidification time for chamber casting part

(TST)c: Total solidification time for cover casting part

Cm: mold constant

Using *Chvorinov's* rule: TST= Cm $(V/A)_2$

$$(TST)_{casting} < (TST)_{Riser} \Rightarrow \left[C_m \left(\frac{V}{A}\right)^2\right]_{casting} < \left[C_m \left(\frac{V}{A}\right)^2\right]_{Riser}$$

$$\Rightarrow \left(\frac{V}{A}\right)_{casting} < \left(\frac{V}{A}\right)_{riser}$$; assume $h = \frac{3}{5} D$

$$V_R = \frac{\pi D^2}{4} \times h = \frac{\pi D^2}{4} \times \frac{3}{5} D = \frac{3\pi D^3}{20}$$

$$A_R = \pi . D . H + \frac{2\pi D^2}{4} = \frac{11\pi . D^2}{10}$$

$$\Rightarrow \frac{V_R}{A_R} = \frac{3D}{22}$$

[illegible]

$$V_c = \frac{M_c}{\rho} = \frac{80,000\ kg}{7.5\ g/cm^3} = 10666.67\ cm^3$$

$$V_{ch} = \frac{M_{ch}}{\rho} = \frac{120,000\ kg}{7.5\ g/cm^3} = 16000\ cm^3$$

for the cover

$$A_c = \pi . 65 \times 620 + \frac{\pi \times (620)^2}{4} = 13082.0 \times \pi = \text{[illegible]}$$

[illegible]

Appendix 19: the mold preparfng steps

328 Casling Processes

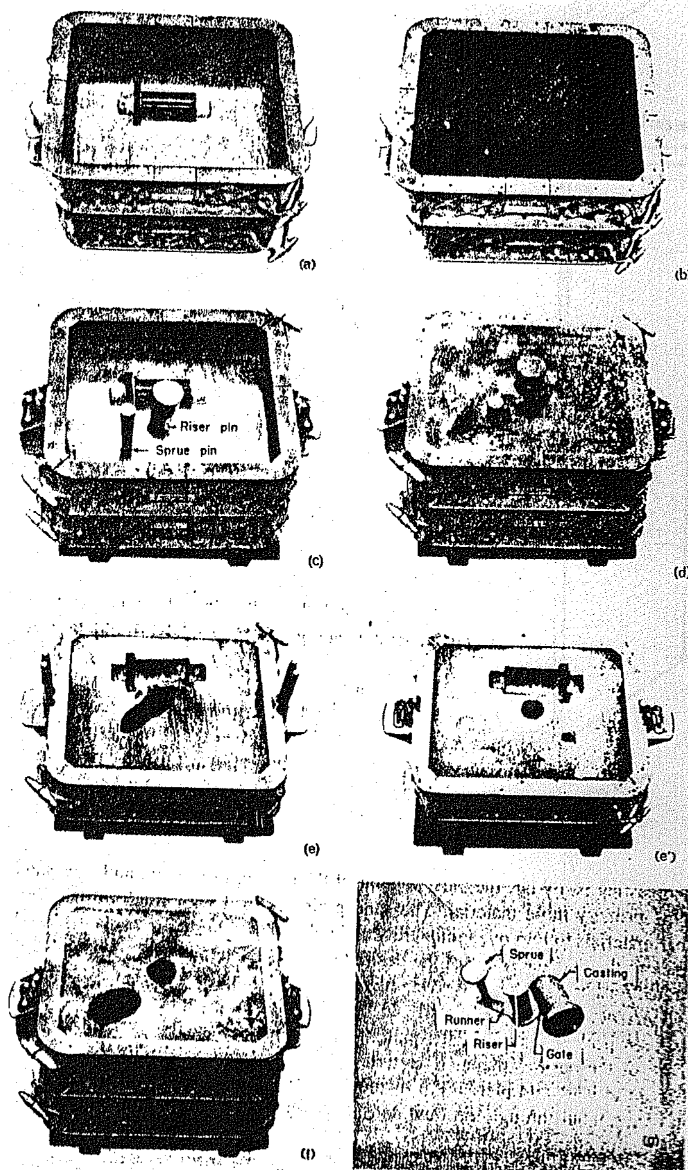
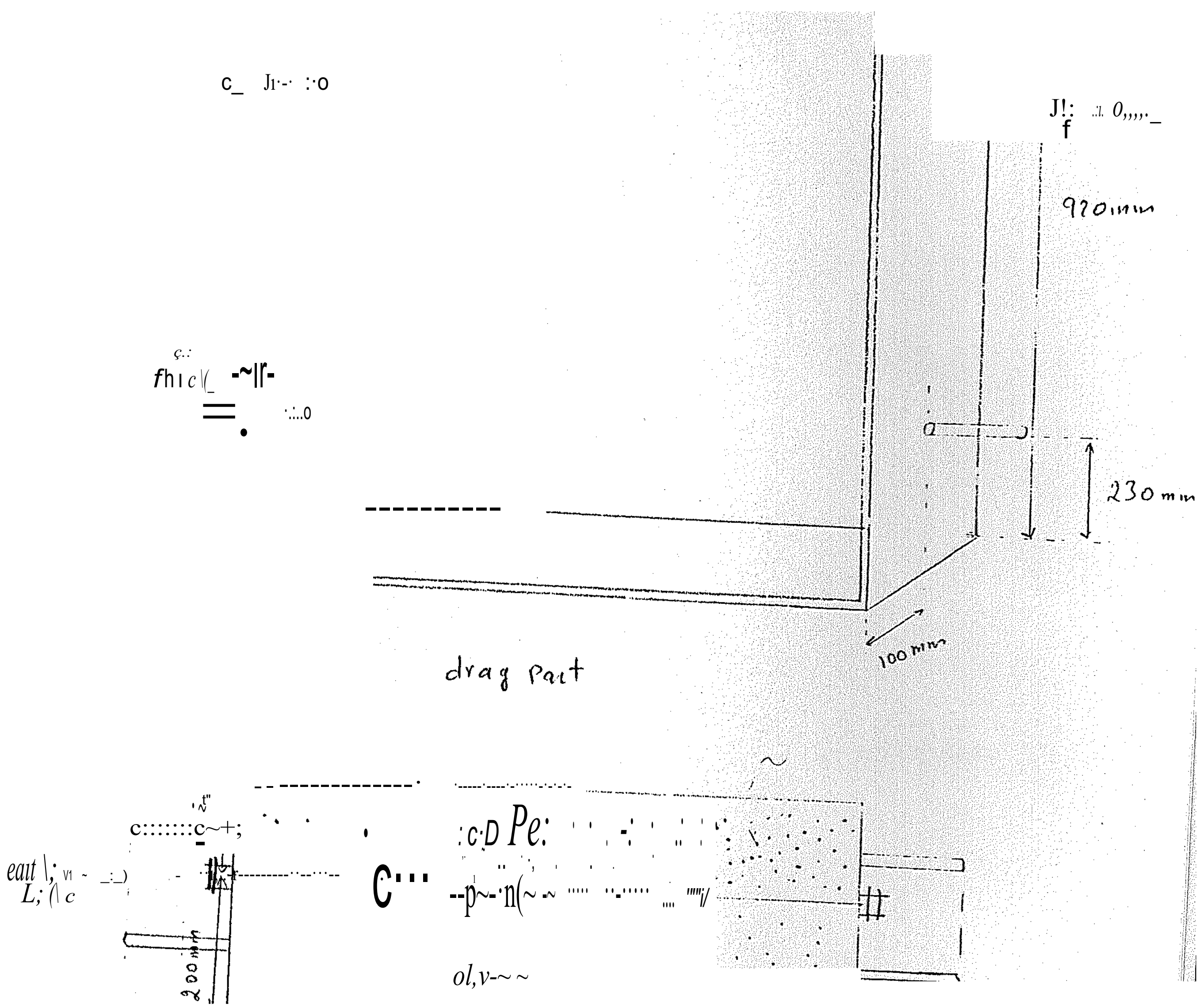


FIGURE 14-1 Essentiaf stepsin sand casting. !al Bottom CdragJ hafi of pattern in pface on mofd board be- tween hafves of flask ready lö receive sand. Cbl Drag hafi of mofd com- pfeted, ready lor turning over. !el Top (cope) hafi of pattern with sprue and riser pins in place. !dl Cope hafi of mofd packed with sand. (el Mold opened, showing parting surface of drag hafi with pattern drawn Cre- moved) and runner and gate cul. (e'l Parting surface of cope halt of !he mold wlth pattern and pins removed. CfJ Mold ciosed, ready tor pouring of the metal. CgJ Casting removed from the rnofd.

Appendix 20: the flask



PART [illegible]: FLASK ([illegible]

35 pieces

Material: sheet metal 5mm thick

Appendix 21: the sand s10paratot

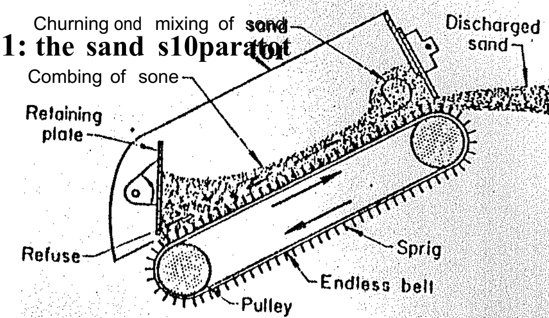


Fig. 9. Sand separator and blender

Appendix 22 : the MuUer

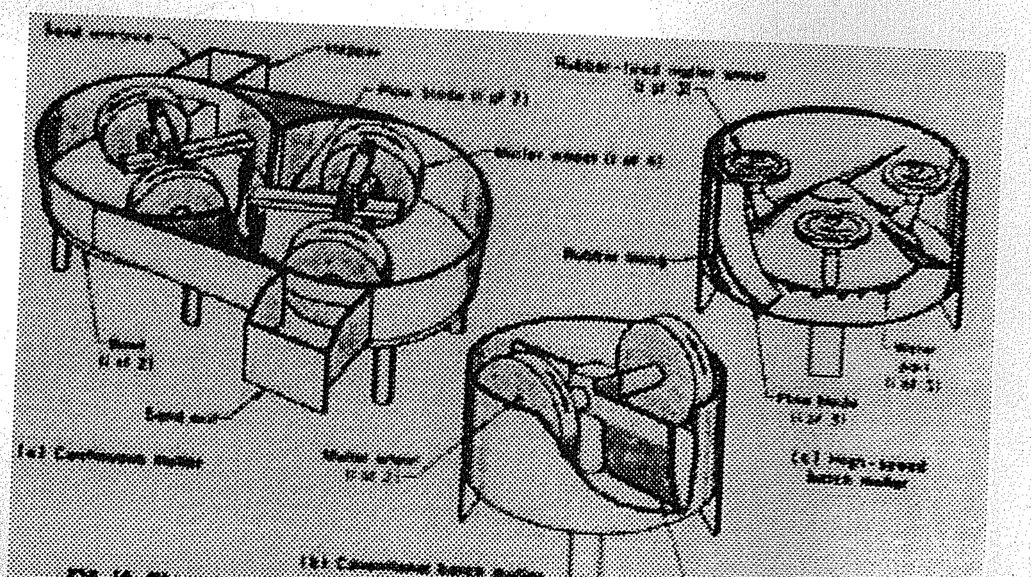
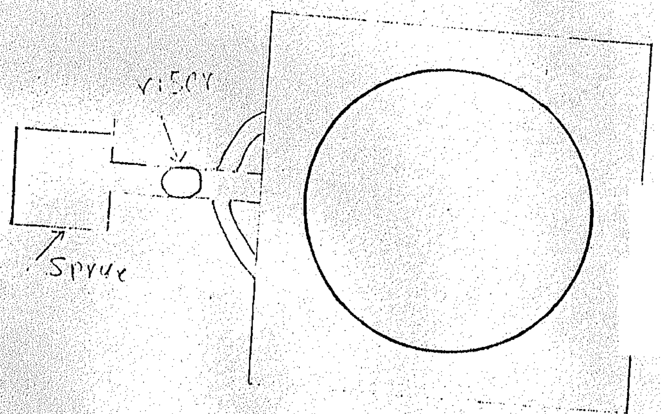
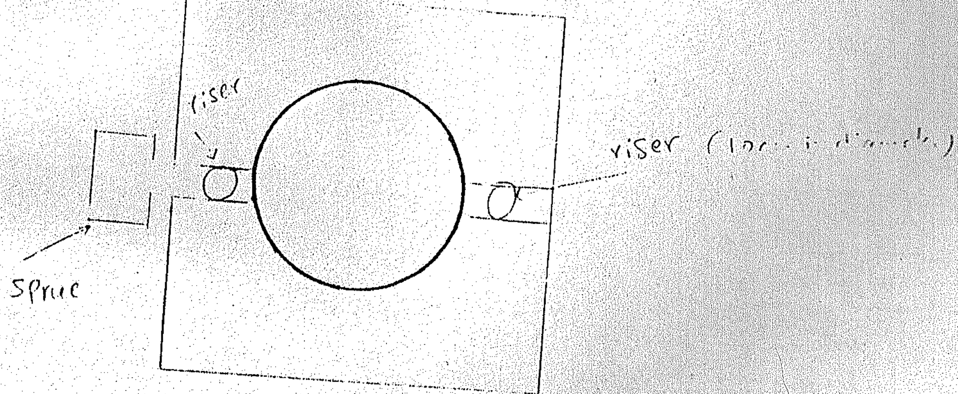


Fig. 16. Three types of mulling machines used for the conditioning of molding sand

APPENDIX 23: How the molds looks like



for the chamber



for the cover