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FABRICATION OF STEERING MOUNTING BRACKETS (CASTING)

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ABSTRACT

This is the Industrial based project contains the deep optimizations of manufacturing of the Steering Mountings Bracket (Castings) contains four modules. Each one deals with the introduction in which we have introduce the basic concepts of the Steering Mounting Bracket and its way of productions, presented mathematical methods required for the analysis of the project, put forth a succinct account of the survey of the literature and also mentioned the outlines of the thesis.

A Steering Column Mounting Bracket is provided with break - away bars integrally formed therewith to allow for a consistent break - away force and reduce noise in the cabin of an automobile. The break - away bars will allow for axial compression of the steering shaft during an accident involving a collision of an automobile.

Keywords *Steering mountins . brackets , Casting*

I. INTRODUCTION

It is desirable to have a steering column of a vehicle that is securely attached to the frame of the automobile so as to ensure safe operation thereof for the life of the automobile. Generally, this is accomplished by bolting the steering column to the instrument panel which is further secured to the frame of the automobile. However, it is further desirous to allow for the steering column to disengage from the instrument panel upon the application of a force during an accident.

It is known in the art to attempt to solve these contradictory goals by using polymer capsules to support the mounting bracket (such as disclosed in commonly assigned herein incorporated by reference) and the steering column that are designed in such a way as to break away under a given force. Thus, the steering column is allowed to break away from the instrument panel upon the application of a force in the event on an accident.

Further, the polymer capsules may fall out during installation and may change in shape which can cause the capsules to weaken or "creep." This creep can cause buzz/squeak/rattle (BSR) problems which are unwanted during the operation of the vehicle. Furthermore, the polymer capsules are relatively fragile and can become damaged prior to installation thus requiring the disposal of the part.

The present summary provides a break-away bar that will overcome the disadvantages of the prior art polymer capsules. It is an object of this invention to form these break-away bars from the same material as the remainder of the steering column mounting bracket. The magnesium or other metallic material of which the steering column mounting bracket is made is rigid and is not susceptible to being misshapen and is much more predictable than a polymeric material. Thus, the break-away bar will have a consistent break-away load, not be susceptible to BSR, and not break unintentionally during installation

II. OVER VIEW OF LITERATURE SURVEY

2.1 Sand casting

Sand casting, also known as sand molded casting, is a metal casting process characterized by using sand as the mold material. It is relatively cheap and sufficiently refractory even for steel foundry use. A suitable bonding agent (usually clay) is mixed or occurs with the sand. The mixture is moistened with water to develop strength and plasticity of the clay and to make the aggregate suitable for molding. The term "sand casting" can also refer to an object produced via the sand casting process. Sand castings are produced in specialized factories called foundries.

There are six steps in this process:

- Place a pattern in sand to create a mold.
- Incorporate the pattern and sand in a gating system.
- Remove the pattern.
- Fill the mold cavity with molten metal.
- Allow the metal to cool.
- Break away the sand mold and remove the casting.

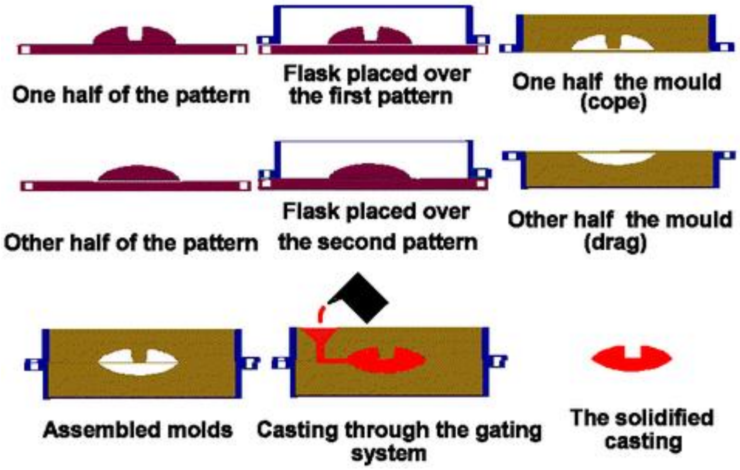

Fig. 1: Steps in sand casting

2.1.1 Patterns

In casting, a pattern is a replica of the object to be cast, used to prepare the cavity into which molten material will be poured during the casting process. Patterns used in sand casting may be made of wood, metal, plastics or other materials. Patterns are made to exacting standards of construction, so that they can last for a reasonable length of time, according to the quality grade of the pattern being built, and so that they will repeatable provide a dimensionally acceptable casting.

Patternmaking

The making of patterns, called patternmaking (sometimes styled pattern-making or pattern making), is a skilled trade that is related to the trades of tool and die making and moldmaking, but also often incorporates elements of fine woodworking. Patternmakers (sometimes styled pattern-makers or pattern makers) learn their skills through apprenticeships and trade schools over many years of experience. Although an engineer may help to design the pattern, it is usually a patternmaker who executes the design

Materials used

Typically, materials used for pattern making are wood, metal or plastics. Wax and Plaster of Paris are also used, but only for specialized applications. Mahogany is the most commonly used material for patterns, primarily because it is soft, light, and easy to work. The downside is that it wears out fast, and is prone to moisture attack. Metal patterns are more long lasting, and do not succumb to moisture, but they are heavier and difficult to repair once damaged. Wax patterns are used in a casting process called investment casting. The main advantage of wax patterns is that it can be reused multiple times. A combination of paraffin wax, bees wax and carnauba wax is used for this purpose. Plaster of paris is usually used in making master dies and molds, as it gains hardness quickly, with a lot of flexibility when in the setting stage.

Design

Sprues, gates, risers, cores, and chills

The patternmaker or foundry engineer decides where the *sprues*, *gating* systems, and *risers* are placed with respect to the pattern. Where a hole is desired in a casting, a *core* may be used which defines a volume or location in a casting where metal will not flow into. Sometimes *chills* may be located on a pattern surface, which are then formed into the sand mould. Chills are heat sinks which enable localized rapid cooling. The rapid cooling may be desired to refine the grain structure or determine the freezing sequence of the molten metal which is poured into the mould.

The design of the feeding and gating system is usually referred to as *methoding* or *methods design*. It be can be carried out manually, or interactively using general-purpose CAD software, or semi-automatically using special-purpose software

Allowances

To compensate for any dimensional and structural changes which will happen during the casting or patterning process, allowances are usually made in the pattern.

Contraction allowances / Shrinkage allowance

The pattern needs to incorporate suitable allowances for shrinkage; these are called *contraction allowances*, and their exact values depend on the alloy being cast and the exact sand casting method being used. Some alloys will have overall linear shrinkage of up to 2.5%, whereas other alloys may actually experience no shrinkage or a slight "positive" shrinkage or increase in size in the casting process (notably type metal and certain cast irons). The shrinkage amount is also dependent on the sand casting process employed, for example clay-bonded sand, chemical bonded sands, or other bonding materials used within the sand. This was traditionally accounted for using a shrink rule, which is an oversized rule.

Shrinkage can again be classified into *Liquid shrinkage* and *solid shrinkage*. Liquid shrinkage is the reduction in volume during the process of solidification, and Solid shrinkage is the reduction in volume during the cooling of the cast metal.

Generally during shrinkage, all dimensions are going to be altered uniformly, unless there is a restriction.

Draft allowance

When the pattern is to be removed from the sand mold, there is a possibility that any leading edges may break off, or get damaged in the process. To avoid this, a taper is provided on the pattern, so as to facilitate easy removal of the pattern from the mold, and hence reduce damage to edges. The taper angle provided is called the *Draft angle*. The value of the draft angle depends upon the complexity of the pattern, the type of molding (hand molding or machine molding), height of the surface, etc.Draft provided on the casting 1 to 3 degrees on external surface (5 to 8 internal castings)

Finishing or Machining allowance

The surface finish obtained in sand castings is generally poor (dimensionally inaccurate), and hence in many cases, the cast product is subjected to machining processes like turning or grinding in order to improve the surface finish. During machining processes, some metal is removed from the piece. To compensate for this, a machining allowance should be given in the casting.

Shake allowance

Usually during removal of the pattern from the mold cavity, the pattern is rapped all around the faces, in order to facilitate easy removal. In this process, the final cavity is enlarged. To compensate for this, the pattern dimensions need to be reduced. There are no standard values for this allowance, as it is heavily dependent on the personnel. This allowance is a negative allowance, and a common way of going around this allowance is to increase the draft allowance.

Distortion allowance

During cooling of the mold, stresses developed in the solid metal may induce distortions in the cast. This is more evident when the mold is thinner in width as compared to its length. This can be eliminated by initially distorting the pattern in the opposite direction

2.1.2 Molding box and materials

A multi-part molding box (known as a casting flask, the top and bottom halves of which are known respectively as the cope and drag) is prepared to receive the pattern. Molding boxes are made in segments that may be latched to each other and to end closures. For a simple object—flat on one side—the lower portion of the box, closed at the bottom, will be filled with a molding sand. The sand is packed in through a vibratory process called ramming and, in this case, periodically screeded level. The surface of the sand may then be stabilized with a sizing compound. The pattern is placed on the sand and another molding box segment is added. Additional sand is rammed over and around the pattern. Finally a cover is placed on the box and it is turned and unlatched, so that the halves of the mold may be parted and the pattern with its sprue and vent patterns removed. Additional sizing may be added and any defects introduced by the removal of the pattern are corrected. The box is closed again. This forms a "green" mold which must be dried to receive the hot metal. If the mold is not sufficiently dried a steam explosion can occur that can throw molten metal about. In some cases, the sand may be oiled instead of moistened, which makes possible casting without waiting for the sand to dry. Sand may also be bonded by chemical binders, such as furane resins or amine-hardened resins.

2.1.3 Chills

To control the solidification structure of the metal, it is possible to place metal plates, chills, in the mold. The associated rapid local cooling will form a finer-grained structure and may form a somewhat harder metal at these locations. In ferrous castings the effect is similar to quenching metals in forge work. The inner diameter of an engine cylinder is made hard by a chilling core. In other metals chills may be used to promote directional solidification of the casting. In controlling the way a casting freezes it is possible to prevent internal voids or porosity inside castings.

2.1.4 Core (manufacturing)

A core is a device used in casting and molding processes to produce internal cavities and reentrant angles. The core is normally a disposable item that is destroyed to get it out of the piece. They are most commonly used in sand casting, but are also used in injection molding.

An intriguing example of the use of cores is in the casting of engine blocks. For example, one of the GM V-8 engines requires 5 dry-sand cores for every casting

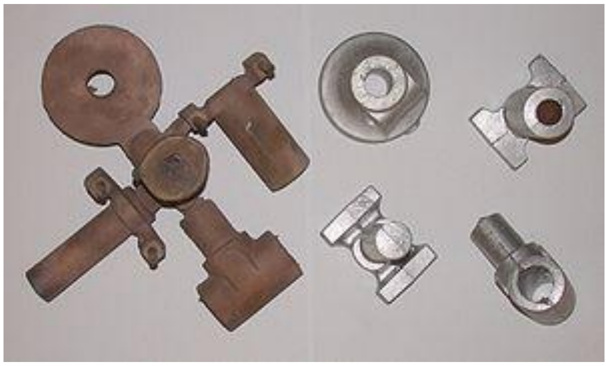
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Fig. 2: Two sets of castings (Bronze and Aluminium)

Advantages and disadvantages

Cores are useful for features that cannot tolerate draft or to provide detail that cannot otherwise be integrated into a core-less casting or mold.

The main disadvantage is the additional cost to incorporate cores.

Requirements

There are seven requirements for core:

- In the green condition there must be adequate strength for handling.
- In the hardened state it must be strong enough to handle the forces of casting; therefore the compression strength should be 100 to 300 psi (0.69 to 2.1 MPa).
- Permeability must be very high to allow for the escape of gases.
- As the casting or molding cools the core must be weak enough to break down as the material shrinks. Moreover, they must be easy to remove during shakeout.
- Good refractoriness is required as the core is usually surrounded by hot metal during casting or molding.
- A smooth surface finish.
- A minimum generation of gases during metal pouring.

Types

There are many types of cores available. The selection of the correct type of core depends on production quantity, production rate, required precision, required surface finish, and the type of metal being used. For example, certain metals are sensitive to gases that are given off by certain types of core sands; other metals have too low of a melting point to properly break down the binder for removal during the shakeout.

Green-sand core

Dry-sand cores

Types of core boxes

- half core box
- dump core box
- split core box
- left and right core box
- gang core box
- strickle core box
- loose piece core box
- Ghayoor

Induction furnace

An induction furnace is an electrical furnace in which the heat is applied by induction heating of metal. The advantage of the induction furnace is a clean, energy-efficient and well-controllable melting process compared to most other means of metal melting. Most modern foundries use this type of furnace and now also more iron foundries are replacing cupolas with induction furnaces to melt cast iron, as the former emit lots of dust and other pollutants. Induction furnace capacities range from less than one kilogram to one hundred tonnes capacity and are used to melt iron and steel, copper,aluminium and precious metals. Since no arc or combustion is used, the temperature of the material is no higher than required to melt it; this can prevent loss of valuable alloying elements. The one major drawback to induction furnace usage in a foundry is the lack of refining capacity; charge materials must be clean of oxidation products and of a known composition and some alloying elements may be lost due to oxidation (and must be re-added to the melt).

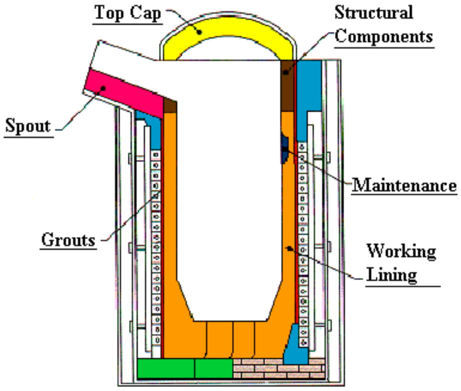


Fig : 4 Schematic diagram of Induction furnace

Advantages:

- Reduced Installation Time
- Reduced Heat-up Time
- Labor Savings
- Energy Savings
- Preferred and Ready to Install
- Improved Performance
- Product Evaluation Flexibility

2. Ladle

Fig. 5: Shifting ladle

In a foundry, a **ladle** is a vessel used to transport and pour out molten metals. Ladles range in size from small hand carried vessels that resemble a kitchen ladle and hold 20 kilograms (44 lb) or to large steel mill ladles that hold up to 300 tonnes (330 tons). Many non-ferrous foundries also use ceramic crucibles for transporting and pouring molten metal and will also refer to these as ladles.

Types

The basic term is often pre-fixed to define the actual purpose of the ladle. The basic ladle design can therefore include many variations that improve the usage of the ladle for specific tasks. For example:

- **Casting ladle**: a ladle used to pour molten metal into moulds to produce the casting.
- **Transfer ladle**: a ladle used to transfer a large amount of molten metal from one process to another. Typically a transfer ladle will be used to transfer molten metal from a primary melting furnace to either an holding furnace or an auto-pour unit.
- **Treatment ladle**: a ladle used for a process to take place within the ladle to change some aspect of the molten metal. A typical example being to convert cast iron to ductile iron by the addition of various elements into the ladle.

Pour designs

Ladles can be "lip pour" design, "teapot spout" design, lip-axis design" or "bottom pour" design:

- For lip pour design the ladle is tilted and the molten metal pours out of the ladle like water from a pitcher.
- The teapot spout design, like a teapot, takes liquid from the base of the ladle and pours it out via a lip-pour spout. Any impurities in the molten metal will form on the top of the metal so by taking the metal from the base of the ladle, the impurities are not poured into the mould. The same idea is behind the bottom pour process.
- Lip-axis ladles have the pivot point of the vessel as close to the tip of the pouring spout as can be practicable. Therefore as the ladle is rotated the actual pouring point has very little movement. Lip-axis pouring is often used on molten metal pouring systems where there is a need to automate the process as much as possible and the operator controls the pouring operation at a remote distance.
- For bottom pour ladles, a stopper rod is inserted into a tapping hole in the bottom of the ladle. To pour metal the stopper is raised vertically to allow the metal to flow out the bottom of the ladle. To stop pouring the stopper rod is inserted back into the drain hole. Large ladles in the steelmaking industry may use slide gates below the taphole.

Ladle Preparation

- Prepare the sand for lining of hand shank, treatment & cupola
- ladle by addition of silica sand, ramming mass & sodium silicate.
- Apply sodium silicate on the clean hand shank, treatment & cupola ladle shell (free from lining).
- Apply the mixed sand on the inner side of the hand shank, treatment & cupola & spout such that 5 to 10 mm thickness for hand shank & 2 to 3 inch thickness for treatment & cupola ladle is maintained.
- Give the shape of the ladle by silica sand in the inner side of the hand shank, treatment & cupola ladle.
- Preheat the ladle by cotton waste such that the sand lining becomes hard.
- After baking the hand shank, treatment & cupola ladle, lining check for the hardness of the lining and if it is ok give the hand shank, treatment & cupola ladle for pouring.

Moulding machines

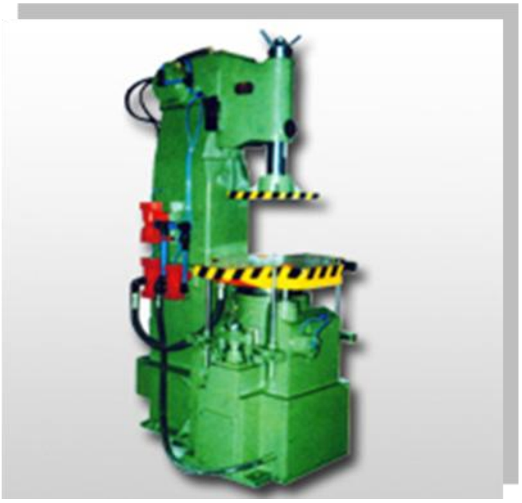


Fig. 6: Moulding machine

Moulding machine produces uniform and high hardness mould with its simultaneous jolt squeeze technology.

Advantages of machine moulding machine

- It affords great saving in time
- When the number of castings is substantial, the additional cost of metallic patterns and other equipment is compensated by the high rate of production, and the overall cost per piece works out lower than in the case of hand moulding.
- The castings obtained are more uniform in size and shape and more accurate than those obtained by hand moulding due to steadier lift of the pattern.
- a semi-skilled worker can do the machine job whereas hand moulding requires skilled craftsmanship.

In the moulding machine (jolt-squeeze) both squeeze and jolt actions can be obtained one after the other. The table is attached to a cylindrical piston, called the jolt piston, which is raised and dropped in the jolt cylinder by the action of compressed air. The jolt cylinder is an integral part of the squeeze piston which can move up and down due to air pressure in the squeeze cylinder.

Core Sand Mixer

The sand in the mixing chamber is subject to strong acceleration and shear caused by the mixing blades and stator bolts, thus achieving optimal mixing intensity.

Fig. 7: Core mixture

III. PRINCIPLE OF GATING &RISER

3.1 The gating system

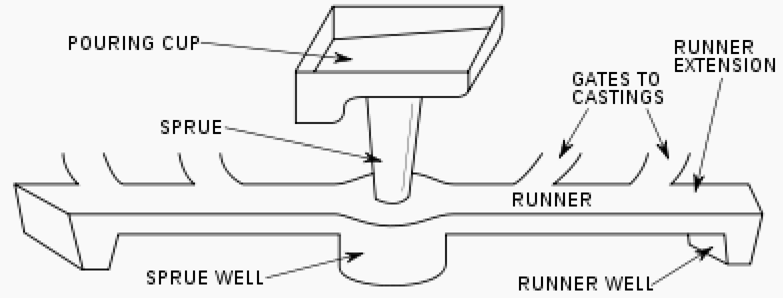


Fig. 8: A simple gating system for a horizontal parting mold.

The gating system serves many purposes, the most important being conveying the liquid material to the mold, but also controlling shrinkage, the speed of the liquid, turbulence, and trapping dross. The gates are usually attached to the thickest part of the casting to assist in controlling shrinkage. In especially large castings multiple gates or runners may be required to introduce metal to more than one point in the mold cavity. The speed of the material is important because if the material is traveling too slowly it can cool before completely filling, leading to misruns and cold shuts. If the material is moving too fast then the liquid material can erode the mold and contaminate the final casting. The shape and length of the gating system can also control how quickly the material cools; short round or square channels minimize heat loss.

The gating system may be designed to minimize turbulence, depending on the material being cast. For example, steel, cast iron, and most copper alloys are turbulent insensitive, but aluminium and magnesium alloys are turbulent sensitive. The turbulent insensitive materials usually have a short and open gating system to fill the mold as quickly as possible. However, for turbulent sensitive materials short sprues are used to minimize the distance the material must fall when entering the mold. Rectangular pouring cups and tapered sprues are used to prevent the formation of a vortex as the material flows into the mold; these vortices tend to suck gas and oxides into the mold. A large sprue well is used to dissipate the kinetic energy of the liquid material as it falls down the sprue, decreasing turbulence. The *choke*, which is the smallest cross-sectional area in the gating system used to control flow, can be placed near the sprue well to slow down and smooth out the flow. Note that on some molds the choke is still placed on the gates to make separation of the part easier, but induces extreme turbulence. The gates are usually attached to the bottom of the casting to minimize turbulence and splashing.

The gating system may also be designed to trap dross. One method is to take advantage of the fact that some dross has a lower density than the base material so it floats to the top of the gating system. Therefore long flat runners with gates that exit from the bottom of the runners can trap dross in the runners; note that long flat runners will cool the material more rapidly than round or square runners. For materials where the dross is a similar density to the base material, such as aluminium, *runner extensions* and *runner wells* can be advantageous. These take advantage of the fact that the dross is usually located at the beginning of the pour, therefore the runner is extended past the last gate(s) and the contaminates are contained in the wells. Screens or filters may also be used to trap contaminates.

It is important to keep the size of the gating system small, because it all must be cut from the casting and remelted to be reused. The efficiency, or *yield*, of a casting system can be calculated by dividing the weight of the casting by the weight of the metal poured. Therefore, the higher the number the more efficient the gating system/risers.

3.2 Riser

A **riser**, also known as a **feeder**,is a reservoir built into a metal casting mold to prevent cavities due to shrinkage. Most metals are less dense as a liquid than as a solid so castings shrink upon cooling, which can leave a void at the last point to solidify. Risers prevent this by providing molten metal to the casting as it solidifies, so that the cavity forms in the riser and not the casting. Risers are not effective on materials that have a large freezing range, because directional solidification is not possible. They are also not needed for casting processes that utilized pressure to fill the mold cavity. A feeder operated by a treadle is called an **underfeeder**.

The activity of planning of how a casting will be gated and risered is called *foundry methoding* or *foundry engineering*.

Theory

Risers are only effective if three conditions are met: the riser cools after the casting, the riser has enough material compensate for the casting shrinkage, and the casting directionally solidifies towards the riser. For the riser to cool after the casting the riser must cool more slowly than the casting. Chvorinov's rule briefly states that the slowest cooling time is achieved with the greatest volume and the least surface area; geometrically speaking, this is a sphere. So, ideally, a riser should be a sphere, but this isn't a very practical shape to insert into a mold, so a cylinder is used instead. The height to diameter ratio of the cylinder varies depending on the material, location of the riser, size of the flask, etc. The shrinkage must be calculated for the casting to confirm that there is enough material in the riser to compensate for the shrinkage. If it appears there is not enough material then the size of the riser must be increased. This requirement is more important for plate-like shapes, while the first requirement is more important for chunky shapes.

Finally, the casting must be designed to produce directional solidification, which sweeps from the extremities of the mold cavity toward the riser(s). In this way, the riser can feed molten metal continuously to part of the casting that is solidifying. One part of achieving this end is by placing the riser near the thickest and largest part of the casting, as that part of the casting will cool and solidify last.If this type of solidification is not possible, multiple risers that feed various sections of the casting or chills may be necessary.

Types

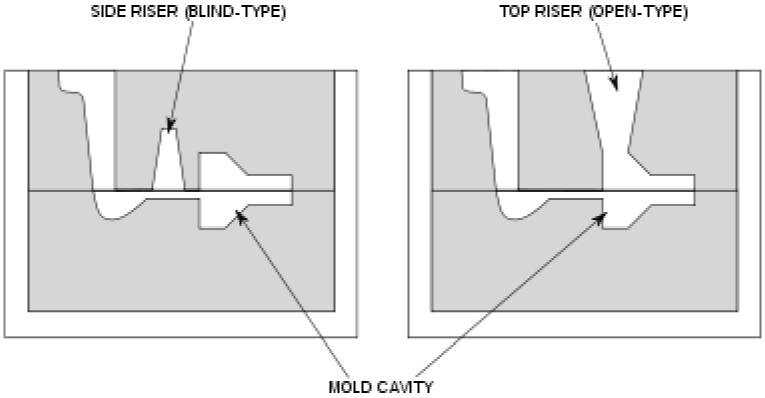


Fig. 9: Different types of risers

Risers are categorized based on three criteria: location, if it is open to the atmosphere, and how it is filled. If the riser is located on the casting then it is known as a *top riser*, but if it is located next to the casting it is known as a *side riser*. Top risers are advantageous because they take up less space in the flask than a side riser, plus they have a shorter feeding distance. If the riser is open to the atmosphere it is known as an *open riser*, but if the risers is completely contained in the mold it is known as a *blind riser*. An open riser is usually bigger than a blind because the open riser loses more heat to mold through the top of the riser. Finally, if the riser receives material from the gating system and fills after the mold cavity it is known as a *live riser* or *hot riser*. If the riser fills with material that has already flowed through the mold cavity it is known as a*dead riser* or *cold riser*. Live risers are usually smaller than dead risers. Note that top risers are almost always dead risers and risers in the gating system are almost always live risers.

Note that the connection of the riser to the molding cavity can be an issue for side risers. On one hand the connection should be as small as possible to make separation as easy as possible, but, on the other, the connection must be big enough for it to not solidify before the riser. The connection is usually made short to take advantage of the heat of both the riser and the molding cavity, which will keep it hot throughout the process.

There are risering aids that can be implemented to slow the cooling of a riser or decrease its size. One is using an insulating sleeve and top around the riser. Another is placing a heater around only the riser.

Hot tops
A *hot top*, also known as a *feeder head*, is a specialized riser that is used when casting ingots. It is essentially a live open riser, except a hot ceramic liner is used instead of just the mold material. The ingot is mostly poured and then the hot top is placed at the top of the mold. The rest of the metal is then poured. This keeps piping to a minimum. Robert Forester Mushet invented the hot top, but then called it a *dozzle*. With a hot top only 1 to 2% of the ingot is waste, prior up to 25% of the ingot was wasted.

Yield
The efficiency, or *yield*, of a casting is defined as the weight of the casting divided by the weight of the total amount of metal poured. Risers can add a lot to the total weight being poured, so it is important to optimize their size and shape. Because risers exist only to ensure the integrity of the casting, they are removed after the part has cooled, and their metal is remelted to be used again. As a result, riser size, number, and placement should be carefully planned to reduce waste while filling all the shrinkage in the casting.

One way to calculate the minimum size of a riser is to use Chvorinov's rule by setting the solidification time for the riser to be longer than that of the casting. Any time can be chosen but 25% longer is usually a safe choice, which is written as follows:

$$t_{\text{riser}} = 1.25 t_{\text{casting}}$$

or

$$\left(\frac{V}{A}\right)^n_{\text{riser}} = 1.25 \left(\frac{V}{A}\right)^n_{\text{casting}}$$

Because all of the mold and material factors are the same for n. If a cylinder is chosen for the geometry of the riser and the height to diameter ratio is locked, then the equation can be solved for a diameter, which makes this method a simple way to calculate the minimum size for a riser. Note that if a top riser is used the surface area that is shared between the riser and the casting should be subtracted from the area on the casting and the riser.

3.3 Casting defects

Any unwanted deviation from the desired requirements in a cast product results in a defect. Some defects in the cast products are tolerable while others can be rectified by additional processes like welding etc. The following are the major defects which are likely to occur in sand castings:

1. Gas defects
2. Shrinkage cavities
3. Moulding material defects
4. Pouring metal defects
5. Metallurgical defects

3.3.1 Gas Defects

These defects are due to lower gas passing tendency of the mould which is caused by lower venting , lower permeability of the mould and improper design of the casting. The lower permeability ofthe mould is due to use of finer size grains of sand, higher percentage of clay & moisture and excessive ramming of the mould.

Fig. 10: Various gas defects

The various gas defects are discussed here in detail.

Blow holes and Open blows: These are spherical, flattened or elongated cavities present inside the casting or on the surface. When present inside the casting it is called blow hole while it is termed as open blow if it appears on the surface of the casting. These defects are caused by the moisture left in the mould and the core. Due to heat of the molten metal the moisture is converted into steam, part of which when entrapped in the casting ends up as blow hole or ends up as open blow when it reaches the surface. Thus in green sand mould it is very difficult to get rid of the blow holes, unless properly vented.

Scar: A shallow blow, usually found on a flat casting surface, is referred to as a scar.

Blister: This is a scar covered by the thin layers of a metal. Air inclusions: The atmospheric and other gases absorbed by the molten metal in the furnace, in the ladle and during the flow in the mould, when not allowed to escape, would be trapped inside the casting and weaken it. The main reasons for this defect are the higher pouring temperatures which increase the amount of gas absorbed; poor gating design such as straight sprue in unpressurised gating; abrupt bends and other turbulence causing practices in the gating, which increase the air aspiration and finally the low permeability of the mould. The remedies would be to choose the appropriate pouring temperature and improve gating practices by reducing the turbulence.

Pin hole porosity: As the molten metal gets solidified it loses the temperature which decreases the solubility of gases and thereby expelling the dissolved gases. The hydrogen which is picked up by the molten metal either in the furnace from the unburnt fuel or by the dissociation of water inside the mould cavity may escape the solidifying metal leaving behind very small diameter and long pin holes showing the path of escape. The high pouring temperature which increases the gas pick up is the main reason for this defect.

3.3.2 Shrinkage Cavities

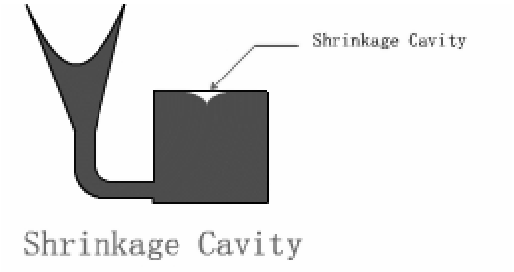


Fig. 11: Shrinkage cavity

These are caused by the liquid shrinkage occurring during the solidification of the casting. An improper riser and gating system may give this type of defect which has a shape of a funnel.

3.3.3 Moulding Material Defects

These defects are originated due to some specific characteristics of the moulding materials like insufficient strength, improper ramming etc. The various defects under this category are discussed in detail.

Cuts and Washes: Theses appear as rough spots and areas of excess metal and are caused by the erosion of the moulding sand by the flowing molten metal. This may be due to insufficient strength of mould material or the high velocity of the molten metal. The proper choice of moulding sand and appropriate moulding method together with better design of gating system which reduces turbulence by increasing the size of the gates or by using multiple ingates can eliminate these defects.

Metal Penetration: When molten metal enters the gaps between the sand grains, the result would be a rough casting surface. This is due to either use of coarse sand grains in mould material or no use of mould wash. This can also be caused by higher pouring temperature. Choosing appropriate grain sizes, together with proper mould wash should be able to eliminate this defect.

Fusion: This is caused by the fusion of sand grains with molten metal, giving a brittle, glassy appearance on the casting surface. The main reasons for this defect are the lower refractoriness of the clay used in moulding sand and very high pouring temperature. The choice of an appropriate type and amount of Bentonite would cure this defect.

Run out: This is happened when the molten metal leaks out of the mould due to faulty mould making or defective moulding flask.

Buckles: This refers to a long, fairly shallow, broad, vee-shaped depression occurring in the surface of a flat casting of a high temperature metal. At this high temperature, an expansion of the thin layer of sand at the mould face takes place before the liquid metal at the mould face solidifies.

As this expansion is obstructed by the flask, the mould face tends to bulge out, forming the vee shape. A proper amount of volatile additives in the sand-mix is therefore essential to make room for this expansion and to avoid the buckles.

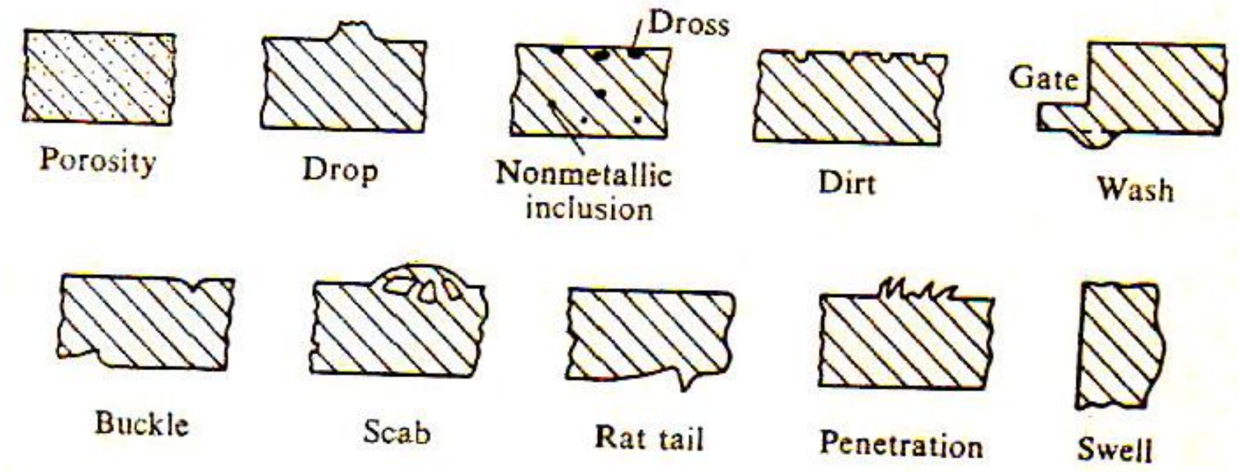


Fig. 12: Various moulding material defects

Rat tail: It is a long shallow angular depression normally found in a thin casting. The reason for its formation is the same as that of buckles. Here, instead of the expanding sand up heaving, the compressed layer fails by one layer, gliding over the other.

Scab: This refers to the rough thin layer of a metal, protruding above the casting surface, on top of a thin layer of sand. The layer is held onto the casting by a metal stringer through the sand. A scab results when the upheaved sand is separated from the mould surface and the liquid metal flows into the space between the mould and the displaced sand.

Swell: Under the influence of metallostatic forces, the mould wall may move back causing a swell in the dimensions of the casting. As a result of the swell, the feeding requirements of the casting increase which should be taken care of by the proper choice of risering. The main cause of this defect is improper ramming of the mould.

Drop: An irregularly shaped projection on the cope surface of a casting is called a drop. This is caused by dropping of sand from the cope or other overhanging projections into the mould. An adequate strength of the sand and the use of gaggers can help in avoiding the drops.

Dross: Lighter impurities appearing on the top of a casting are called dross. It can be taken care of at the pouring stage by using items such as a strainer and skim bob.

Dirt: Sometimes sand particles dropping out of the cope get embedded on the top surface of a casting. When removed, these leave small, angular holes, known as dirts.

Mould and Core shift: A misalignment between two halves of a mould or of a core may give risto a defective casting.

IV. MECHANICAL TESTING

4.1 Tensile testing

Fig. 15: Tensile testing machine

Tensile testing, also known as **tension testing**, is a fundamental materials science test in which a sample is subjected to uniaxial tension until failure. The results from the test are commonly used to select a material for an application, for quality control, and to predict how a material will react under other types of forces. Properties that are directly measured via a tensile test are ultimate tensile strength, maximum elongation and reduction in area. From these measurements the following properties can also be determined: Young's modulus, Poisson's ratio, yield strength, and strain-hardeningcharacteristics.

Tensile specimen

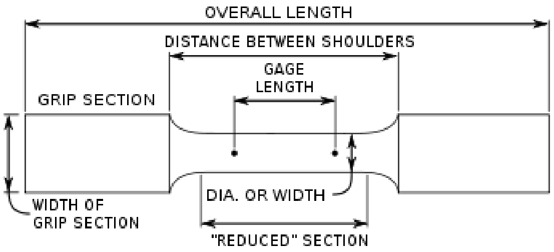


Fig. 16: Tensile specimen dimensions

A standard specimen is prepared in a round or a square section along the gauge length, depending on the standard used. Both ends of the specimens should have sufficient length and a surface condition such that they are firmly gripped during testing. The initial gauge length Lo is standardized (in several countries) and varies with the diameter (Do) or the cross-sectional area (Ao) of the specimen as listed

Equipment

The most common testing machine used in tensile testing is the *universal testing machine*. This type of machine has two *crossheads*; one is adjusted for the length of the specimen and the other is driven to apply tension to the test specimen. There are two types: hydraulic powered and electromagneticallypowered machines.

The machine must have the proper capabilities for the test specimen being tested. There are three main parameters: force capacity, speed, and precision and accuracy. Force capacity refers to the fact that the machine must be able to generate enough force to fracture the specimen. The machine must be able to apply the force quickly or slowly enough to properly mimic the actual application. Finally, the machine must be able to accurately and precisely measure the gage length and forces applied; for instance, a large machine that is designed to measure long elongations may not work with a brittle material that experiences short elongations prior to fracturing.

Alignment of the test specimen in the testing machine is critical, because if the specimen is misaligned, either at an angle or offset to one side, the machine will exert a bending force on the specimen. This is especially bad for brittle materials, because it will dramatically skew the results. This situation can be minimized by using spherical seats or U-joints between the grips and the test machine. A misalignment is indicated when running the test if the initial portion of the stress-strain curve is curved and not linear.

The strain measurements are most commonly measured with an extensometer, but strain gauges are also frequently used on small test specimen or whenPoisson's ratio is being measured. Newer test machines have digital time, force, and elongation measurement systems consisting of electronic sensors connected to a data collection device (often a computer) and software to manipulate and output the data. However, analog machines continue to meet and exceed ASTM, NIST, and ASM metal tensile testing accuracy requirements, continuing to be used today.

Process

The test process involves placing the test specimen in the testing machine and applying tension to it until it fractures. During the application of tension, theelongation of the gauge section is recorded against the applied force. The data is manipulated so that it is not specific to the geometry of the test sample. The elongation measurement is used to calculate the *engineering strain*, ε, using the following equation:

$$\varepsilon = \frac{\Delta L}{L_0} = \frac{L - L_0}{L_0}$$

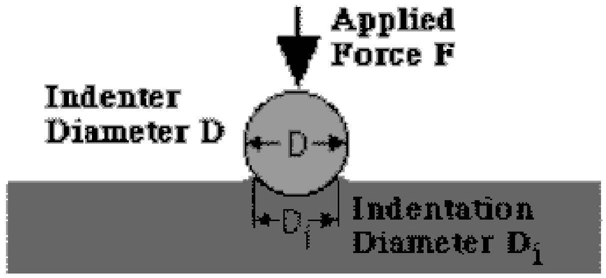
where ΔL is the change in gauge length, L_0 is the initial gauge length, and L is the final length. The force measurement is used to calculate the *engineering stress*, σ, using the following equation.

$$\sigma = \frac{F_n}{A}$$

where F is the force and A is the cross-section of the gauge section. The machine does these calculations as the force increases, so that the data points can be graphed into a *stress-strain curve*

4.2 The Brinell Hardness Test

The Brinell hardness test method consists of indenting the test material with a tungsten carbide ball of either 1, 2.5, 5 or 10 mm diameter by applying a test force of between 1 and 3000 kgf. The full load is normally applied for 10 to 15 seconds in the case of iron and steel and for at least 30 seconds in the case of other metals. The diameter of the indentation left in the test material is measured. The Brinell harness number is calculated by dividing the load applied by the surfacearea of the indentation.



$$\mathrm{BHN} = \frac{F}{\frac{\pi}{2} D \cdot \left(D - \sqrt{D^2 - D_i^2} \right)}$$

The diameter of the impression is the average of two readings at right angles and the use of a Brinell hardness number table can simplify the determination of the Brinell hardness. Modern electronic testers offer inbuilt measuring systems with either manual or computer assistedautomatic indentation measurement. A well structured Brinell hardness number reveals the test conditions, for example "75 HBW 10/500/30" which means that a Brinell Hardness of 75 was obtained using a 10mm diameter tungsten carbide ball with a 500 kgf test force for a period of 30 seconds. When testing extremely hard metals the tungsten carbide ball indenter may not be suitable as the Brinell scale is limited to materials with hardness values of approximately 650 HBW. For such materials the Rockwell and Vickers tests are more suitable. Compared to the other hardness test methods, the Brinell ball makes the deepest and widest indentation, so the test averages the hardness over a wider amount of material, which will more accurately account for multiple grain structures and any irregularities in the uniformity of the material. This method is the best for achieving the bulk or macro-hardness of a material, particularly those materials with heterogeneous structures.

V. EXPERIMENTAL DETAILS

Patterns of steering mounting bracket:

Compatibility:

Procedure

Make test specimen of molding sand by compacting bulk material by free fixed height drop of fixed weight for 3 times. It is used to determine compatibility of sands by using special specimen tube and a linear scale.

Fig. 17: Patterns of steering mounting bracket

Loss on ignition (carboneous matter)

% of loss on ignition= $\frac{w1 - w2}{w1}$ *100

W1= weight of the sample take

W2=weight of the sample after drying

Procedure:

- Take the 5gm(w1) of green sand in a Porcelain silica dish and spread it uniformly at the bottom of the dish and place in a muffle furnace at 930-970c for 75min is completely burnt.
- Remove the dish, cool it in a desicator

- After cooling the dish, weigh and calculate the %of loss in weight.

Fig. 18: Muffle furnace

Active clay

$$\% \text{ of active clay} = \frac{\text{CONSUMPTION OF METHYLENE BLUE} * \text{FACTOR}}{\text{WEIGHT OF THE SAMPLE}} * 100$$

Procedure:

- Take 50 ml distilled water in conical flask
- After boiling cool it for 10 minutes
- Add 2 ml of sulphuric acid in given flask
- Take methyl blue solution in burette
- Titrate the solutions until blue color reaches
- Then take the reading of burette

Permeability:

Procedure:

- Permeability expressed in terms of Permeability number
- A standard specimen cylinder of dimensions 150mm length and 50mm dia is used for this.
- First take 130 – 140 gm of sand sample allow the sand to flow freely to the cylinder and placed under the standard specimen rammer.
- 3 blows are given manually , then the cylinder is taken out and fit the cylinder tightly to permeability meter mercury cap, which is having 1.5mm orifice.
- Then rotate the valve guide and take the reading directly at permeability number dial.

Green compression strength

Procedure:

Make test specimen of molding sand by compacting bulk material by free fixed height drop of fixed weight for 3 times. It is used to determine Green compression strength of sands by using Green compression strength machine i.e. shown in figure.

Moisture testing:

Process:

- Switch on the infra red moisture balance. Set the reading on scale to zero by rotating the knob.
- Then take the sample and drop it on the pan till the needle reaches zero.
- Close the door of the balance & switch on the infrared lamp.
- Wait till the temp reaches 100-110c then switch off the lamp.

Fig. 19: Infrared moisture balance

- Now rotate the knob till it coincides the needle. The corresponding reading %moisture.

Preparation of molds:

Molds are prepare by using the molding machine. Molding machine produces uniform and high hardness mould with its simultaneous jolt squeeze technology.

Result:

Mold hardness=86

Core preparation

- Core sand is the silica sand with 6% sodium silicate. These mixed in a core mixture.
- Mixed sand is fill in the pattern box. Required quantity of carbon dioxide pass threw the mixed sand till the core get hard.
- Core is coated with sprit base graphite where were casting area.

Melting shop:

- By using induction furnace we melt the charge mix to above 1540c and at that temp charge poured into the ladle that is having Fe-Si-Mg alloy covered with steel scrap.
- During the solidification we add the Fe-Si as a inoculation this promotes the graphitization.
- Liquid metal poured into mold
- The pouring rate should be 3Kg/sec
- The cast is cooled for 45min
- Knockout after 45min

Ferro lab:

Melting temp=1542°C
Ferro lab reading:
%C=3.55
%Si=1.67Required Ferro lab reading
%C=3.70
%Si=1.85

Tensile testing:

Formulas:

Tensile strength= $\frac{\text{BREAKING LOAD}}{\text{AREA}}$

Yield strength= $\frac{\text{YIELD LOAD}}{\text{AREA}}$

%elongation== $\frac{\text{CHANGE IN LENGTH}}{\text{ORIGINAL LENGTH}} * 100$

Manganese test:

Equipments:

Hot plate, chemicals, glass sware and analytical balance

Method of chemical analysis:

- Take approximately 0.5 gms of sample in a clean 250ml beaker.
- Add 30ml of nitro-sulfuric acid mixture and heat on a plate until complete dissolution the sample.
- Filter off the graphite &silica precipitate with No.1 filter paper.
- Take the filtrate in a 250 ml conical flask.
- Add 25 ml of silver nitrate solution followed by approximately 2 gm of ammonium per sulphate.
- Heat the solution on hot plate until pink color formation.
- Cool rapidly to room temp titrate immediately with sodium arsenate solution followed by 2 to 3ml of Nacl solution until a clear yellow color is indicated which does not change on further addition of arsenate solution.

Formula:

%Mn= $\frac{\text{VOLUME OF SODIUM ARSENATE} * \text{FACTOR}}{\text{WEIGGHT OF THE SAMPLE}}$ *factor

VI. RESULTS

Composition of SG 400/12

Table. 3: Composition of SG iron

ELEMENT	Wt %
%C	3.59
%Si	2.6
%Mn	0.29
%Cu	0
%P	0.05
%S	0.04
%Mg	0.04

LAB RESULTS

Table. 4: Lab results

S.NO.	NAME OF TEST	RESULT
1	Compatibility	44
2	Loss on ignition (%)	4.8
3	Active clay (%)	8.9
4	Permeability	160
5	GCS	1170
6	Moisture (%)	3.9

MECHANICAL TESTING LAB RESULTS

Table.5: Mechanical testing lab results

S.NO.	NAME OF THE TEST	RESULT
1	Tensile strength	48.89kg/mm²
2	Yield strength	32.6 kg/mm²
3	Elongation (%)	16

MELTING SHOP RESULTS

Table. 6: Melting shop results

Melting time	55min
Liquid pour metal	650kg
Pig iron	100kg
CRCA	300kg
Foundry return	255kg
Fe-Si	Required
Fe –Si-Mg	10.5KG
Recovery steel	5kg
Taping temp	1530-1570°C
Pouring temp	1370-1430°C

VII. CONCLUSION

Following conclusion are drawn from the present project.

- The casting of the steering mounting bracket has been done good quality.
- The mechanical property like tensile strength, yield strength & brinell hardness found to be good.
- The micro structure spheridisation of graphite which is suitable for steering mounting bracket.

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