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Various Processes in an industry and Casting Defects

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***Abstract*— To provide an introduction to the causes and remedies of the main solidification defects in casting. The students should be able to diagnose the major defects in casting and propose methods of preventing them**

***Keywords*— Component; formatting; style; styling; insert**

I. INTRODUCTION

Casting is manufacturing process by which a molten metal such as metal or plastic is introduced into a mould, allowed to solidify within the mould, and then ejected or broken out to make fabricated part. Casting is used for making parts of complex shape that would be difficult or uneconomical to make by other methods such as cutting from solid material Casting may be used to form hot, liquid metals or melt able plastics [thermoplastics], or various materials that cold set after mixing of components such as certain plastics resins such as epoxy, water setting materials such as concrete or plaster and a material that become liquid or plastic when moist such as clay, which when dry enough to be rigid is removed from the mould, further dried and fired in a furnace.

Sand casting: The various processes are made for the production of casting components which are discussed as follow:

1. Inspection of mild steel scrap
2. Inspection of alloys and chemicals
3. Charge mixing
4. Sand testing
5. Moulding
6. Core making
7. Core fitting
8. Melting of scrap
9. Pouring
10. Shake out
11. Fettling
12. Shot blasting
13. Grinding
14. Removal of extra material
15. Testing

Sand preparation: Sand is prepared for the moulds by mixing the type of material as ratio given as follows: -

1. Silica sand

1.1) Silica facing sand

Silica sand old	94%		
Sodium silicate	6%		
Mulling time	20-25 min		
Moisture	Winter	Summer	Rainy day
	1.5-1.8%	1.5-1.7%	1.5-2.0%

1.2) Silica baking sand

Silica sand old	96%		
Sodium silicate	4%		
Mulling time	20-25 min		
Moisture	Winter	Summer	Rainy day
	1.5- 1.8%	1.5-1.7%	1.5 – 2%

2. Core sand

Silica sand new	93%		
Sodium silicate	5-6%		
Wood flour dextrin	2% 1%		
Mulling time	20-25 min		
Moisture	Winter	Summer	Rainy day
	1.5-1.8%	1.5-1.7%	1.5-2%

Core making: To provide the holes in the casting components cores are separate placed which are made of special core sand that is generally required to form the hollow interior of the casting or a hole through the casting. These are placed after the mould preparation.

Core sands: The ingredients of core sand are sand and binders. Core sands are usually silica. Sands that contain more than 5% clay cannot be used for cores. Core sand has no natural bond. Hence some other materials are added to sand before and after the cores are baked. The binder used in foundry is molasses.

Core making consist of following processes:

- Core moulding: Cores are made manually. Normally a core box is required for the preparation of core. Green sand cores are made by ramming the sand mixture

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into boxes the interior of which are desired shapes and dimensions.

- Core Baking: After the cores are prepared and placed on to the metal plates or core carriers they are baked to removed moisture and develop strength of binders in the core ovens at the temp. of 150-400ºC. Batten type ovens are used for this purpose.
- Core finishing: After the baking operation the cores are smoothened. All rough edges, unwanted fins are removed by filling. After this the core dressing is done by applying a thin layer of refracting coating to the surface.
- Melting: Melting coupla furnaces have been implied in this industry. The principle of melting is done by coupla furnace. Metal is placed on the top ,hot air is blowed which send this metal to hot area of furnace where it melts and produce molten metal.
- Pouring: Pouring equipment's used are pouring ladles, which are used to carry molten metals from the furnace to the moulding box. The most common used ladles in the shop is shank ladles, it resembles a bucket long removable handle shank. It is handled by two men. It holds from 30150 kg of molten metals.
- Shake out: After the molten metal has been poured into the mould, it is permitted to cool & solidify for a short time period and when casting has solidified it is removed from the mould box. This process is called shake out.
- Fettling: The operation of removing unwanted parts, cleaning and finishing the casting is called as fettling. In the fettling first cores are removed from the casting surfaces. After this the gates, risers& runners are removed. The cleaning of casting surface is done by using hand methods and mechanically. In hand methods wires brushes and wires are used. In mechanical methods a shot blasting machine is used.
- Shot blasting: Shot blasting consist of attacking the surface of material with one of many types of shots. Normally this is done to remove something on the surface such as scale, but it is also done sometimes to impart a particular surface to the object being shot blasted, such as rolls used to make 2D finish. The shot can be of sand, small steel balls of various diameter, granules of silicon carbide etc. This device is spinning pedals which hurl the shot of their blades.

II. PROJECT WORKING

Classification of main defects: The aim of project is to introduce the formation and prevention of solidification defects and slag problems in castings. Solidification defects can be sub-divided into two main categories:

[1] Gas porosity
[2] Shrinkage porosity

[1] Gas Porosity: -

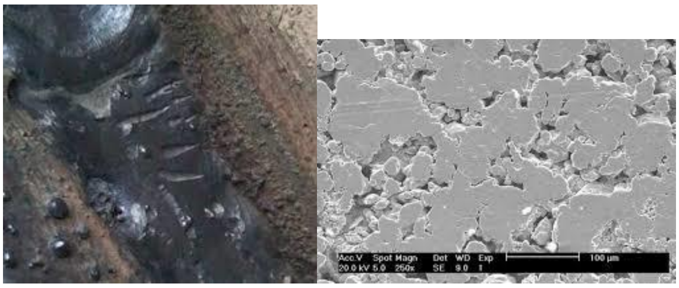

Fig. 1 Gas Porosity

This can be due to following three causes:

- Gas precipitation: Firstly, gas held in solution in the molten metal can be precipitated as metal solidifies, simply as a result of the reduced solubility on freezing.
- Air entrapment: Secondly, if the mould is filled under very poor conditions, air can enter in the metal in metal stream and then trapped as metal solidifies.
- Gas coming from cores: Finally, the sand binders used to make the moulds and cores often break down when contact with molten metal and gaseous decomposition products can force their way in solidifying metal, leading to defects which are normally known as blows.

These different types of gaseous porosity defects vary in their size, distribution, distance below the casting surface and morphology. It follows therefore that the cause of such defects in a real casting can be deduced from a careful examination.

a) Gas precipitation

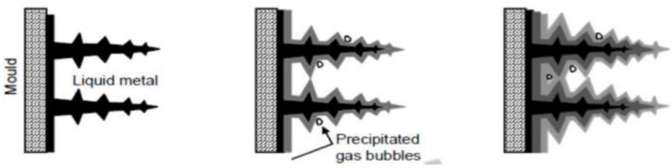

Fig. 2 Gas Precipitation

The first type of gas defect that we shall consider is that caused by precipitation of gas from the solution in the liquid metal but we will initially need to understand how the gas gets into metal in the first place in the case of M S we are particularly concerned about the hydrogen which can come from several sources:

- Melting and/or subsequent handling: Common problem hydrogen pick up from the use of damp refractories in furnaces or ladles. Another source is from burning hydrocarbon fuels, such as gas/oil.
- Reaction with the mould during passage through running system.
- Reaction with the mould and core materials during &/or after filling

In practice however source [1] above is usually the only mechanism under the direct control of casting technologist by employment of affective degassing of the liquid metal prior to casting. Gas solution in the liquid metal is in the form of atoms. These can defuse to the surface combine to form gas

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molecules, and evaporate into the environment the rate of transfer of gas depending, of course, on the ratio of surface area to volume. There are various rate controlling steps in the transfer from the furnace to the atmosphere and vice versa, and any or all of them may be operative in different situations.

The environment of the furnace is complex: the top surface of the liquid may be in contact with the air and so able to equilibrate directly with the atmosphere. However, in many cases, a surface oxide film may be present, or a slag or flux layer. These additional layers will present a further barrier to the passage of gas atoms emerging from the metal, slowing equilibration in furnaces even further.

Changing rapidly as waste combustion products, high in water vapour, are directed onto the surface, or blow across from time to time. The environment of the liquid metal in the mould is perhaps a little clearer. If the mould is a metal die, then the environment is likely to be dry and thus relatively free from water vapour and its decomposition product, hydrogen. The liquid metal may lose hydrogen to this environment, since the equilibrium pressure of hydrogen in the melt will be less than that of the partial pressure of the environment.

In contrast, if the mould is made from sand, either chemically-bonded or especially if bonded with a clay-water mixture as in a greensand mould, then the environment all around the metal will contain nearly pure steam at close to one atmosphere pressure.

e.g. $3\ H_2O + 2\ Al = 3\ H_2 + Al_2O_3$

Thus, steam will yield equal volumes of hydrogen gas, still at one atmosphere pressure. It is likely that the melt will gain hydrogen in this environment.

Gas precipitation from solution in the metal leads to small bubbles, normally in the size range 0.05 - 0.5 mm, as a result of the high internal pressure of gas due to the micro segregation between the dendrite arms. The bubbles are distributed uniformly throughout the casting, with the exception of a bubble-free surface layer about 1 - 2 mm deep.

Smaller bubbles than this will disappear, slowly dissolving away as they are compressed by the effect of surface tension. Larger bubbles will grow. Sizes up to 25 - 100 μm are common. Up to 500 or even 1000 μm is rarer.

The final point about gas porosity is that nucleation of gas bubbles continues as metal continues to solidify. This leads to an even distribution (with the exception of the first one or two mm at the surface of the casting).

b) Air Entrapment

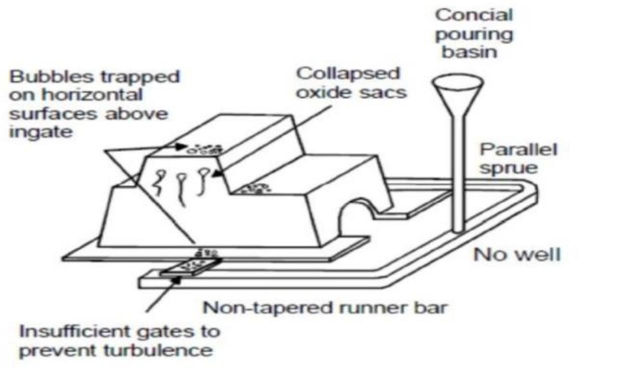

Fig. 3 Air Entrapment

Moving on to the entrapment of air, we shall take as an example a sump casting that has been deliberately made badly using a conical pouring basin, a parallel downs rue and no well base.

In addition, we have a non-tapered runner bar and insufficient gates. As we now know from, such a running system generates surface turbulence in the metal stream as it fills the mould, leading to a chaotic, scrambled mess of metal and air. The air cannot escape easily because it is held in place by the oxide film. Furthermore, as the air bubbles move through the molten metal, they leave behind a collapsed sac of oxide, forming a bubble trail which is another form of defect in the casting.

The bubbles tend to get trapped on horizontal surfaces, such as above ingates, on the cope surfaces or under any window-type features in the vertical sides of a casting. These bubbles are intermediate in size between those precipitated from solution and those blown from cores. They are also irregular in size, reflecting the randomness, or chaos, inherent with turbulence. They normally fall into the size range 0.5 - 5 mm and are often only found when ingates are cut off or the casting is shot blasted or machined.

Since they arrive with the incoming metal, they are always close to the casting surface, and usually only the thickness of the oxide skin separates them from the casting surface. This partly explains the size range of the bubbles: they are only the remnants which were too small to generate sufficient buoyancy force to break through the oxide on the surface of the liquid, whereas their bigger neighbours escaped.

When viewed on a polished cross section under the optical microscope, the bubbles are always seen to be associated with considerable quantities of oxide films - the remnants of bubble trails.

It is important to diagnose this type of defect correctly. It is all too often thought – incorrectly - to be 'gas' but the problem will certainly not be solved by degassing the metal. The solution will almost certainly lie in the design of the running system (i.e. the methoding) of the casting.

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c) Gas coming from cores

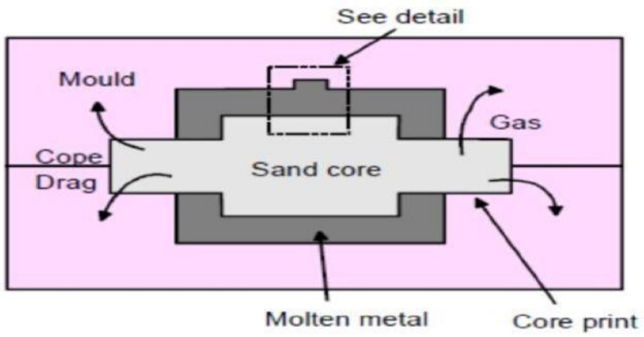

Fig. 4 Gas coming from Cores

The final type of gas defect is blown from cores. When a metal is poured into a sand mould containing cores, the gas present in the core expands and attempts to escape. Furthermore, the resin binders used in core manufacture start to break down and generate additional gas. The gas can escape from the core via the core prints, but if the core prints are too small or if the mould and core have a low permeability, the gas pressure will build up inside the core. If the pressure reaches the level where it exceeds the opposing pressure of the molten metal, a bubble can be formed in the metal and float up towards the top of the casting. Such 'core blows' are large - typically 10 - 100 mm. The gas pressure in an enclosed core takes some time to build up, so any bubble is released after some freezing has already occurred. Thus core blows are usually trapped under a substantial thickness of solidified skin. If such bubbles are sufficiently large, their top surface will follow the casting contour and their lower surface will be horizontal. They may be located above the core which has caused the blow, but often they are sufficiently large and mobile to migrate to the highest portion of the casting, and can make this region completely hollow.

A succession of bubbles from core outgassing will leave bubble trails. This combination of core blow and associated bubble trails constitutes a serious defect which not only mechanically weakens the casting, but also creates a leak path, thus harming a casting destined for an application requiring leak-tightness.

The solutions to this problem include:

[1] Ensuring that the cores are properly vented, i.e. that there is a means for the gas to escape to the atmosphere.
[2] Using sand binders which are low in volatile content and/or which break down slowly.
[3] Filling rapidly to a hydrostatic pressure in the liquid metal above that of the pressure of gas in the core, thus suppressing the expansion of gas out into the liquid.

The minimum thickness of the bubble in a liquid aluminium alloy when lodged under a horizontal flat surface is usually approximately 12 mm (this corresponds to the thickness of a sessile drop of aluminium sitting on a flat substrate - the bubble can be thought of as a negative sessile drop of negative density!). This dimension is controlled by the ratio of surface tension and density (for grey cast iron the sessile drop and sessile bubble are closer to 7 mm thick). The diameter of the bubble can of course be any size, depending on the amount of gas released by the core, and is typically 10 to 100 mm.

[2] Shrinkage Porosity:-

The second type of defect that we need now to consider is shrinkage porosity, which is conventionally sub-divided into macro porosity and micro porosity. In reality, there is no fundamental difference between these two forms of porosity - one gradually changes into the other as a function of the freezing range of the alloy. As we will see, it is also possible to identify intermediate types of shrinkage porosity, notably layer porosity in long freezing range alloys.

a) Macro porosity

The best-known form of macro porosity is the 'pipe' formed as a simple ingot of a short freezing range alloy solidifies. Solidification starts along the walls and at a slower rate on the top surface. As progressively more metal solidifies, the volumetric contraction is compensated for by the concurrent sinking of the liquid surface, forming a smooth conical funnel or long 'tail' inside the ingot known as shrinkage pipe or piping. It was a commonly held belief that there are two forms of pipe - primary and secondary - the latter appearing to be discrete islands of porosity below the primary pipe. This is, in fact, an incorrect interpretation of two-dimensional sections of such features - the two are interconnected, constituting the same feature, and there is no distinction between them.

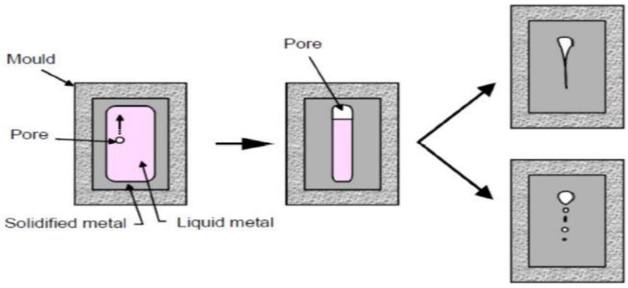

Fig. 5 Macro porosity

It should also be appreciated that there is a difference in appearance only between the shrinkage porosity found in short and long range freezing alloys. In a short freezing range alloy, a shrinkage cavity will take the form of a shrinkage pipe, which can have a mirror smooth finish (in common with most of the forms of gas porosity!). In a long freezing range alloy, the shrinkage pipe takes on the character of a sponge, in which the appearance on a polished section is of separate, isolated inter-dendritic micro porosity (i.e. the cuspoid morphology found for all other types of shrinkage). This again is an illusion of the sectioning technique. The defect is actually a macro pore which is traversed by a forest of dendrites, and leads to widespread misinterpretation on a transverse section as an array of separate micro pores.

It is also of interest to consider where a single isolated area of macro porosity occurs. It is a common mistake to assume that it will be located in the thermal centre of the isolated region. This is certainly not the case. This shows a totally enclosed ingot solidifying in a mould. A pore could be nucleated anywhere in the entrapped liquid, and will in fact float upwards until it reaches the top of this enclosed volume.

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The advance of the front at the top of the entrapped liquid volume is locally retarded by the pore which, when coupled with the geometry of the casting, leads to a long tapering extension to the cavity formed in the casting.

If this tubular cavity is not completely straight, it can easily be misinterpreted as being isolated areas of 'secondary pipe' on a cut section. It should also be clear that this simple shape of shrinkage pore reflects the simple shape of the casting. As the shape of the casting becomes increasingly complex, the shrinkage porosity will become correspondingly more complex.

So, the characteristic of macro porosity is that it is located towards the centre of a casting, although normally above the thermal centre. It is associated with the geometry of the casting, and usually lies along the centreline of symmetrical castings. As a result, it is also known as centreline porosity, or centreline shrinkage.

b) Micro porosity

I would now like to turn to micro shrinkage porosity. This is particularly a problem in long freezing range alloys and/or when the temperature gradient is low. These conditions create an extensive and uniform pasty zone which is favoured by:

[1] metals of high conductivity;
[2] high mould temperatures, as in investment casting;
[3] Thermal conductivity of the mould, as in sand, investment or plaster low moulds.

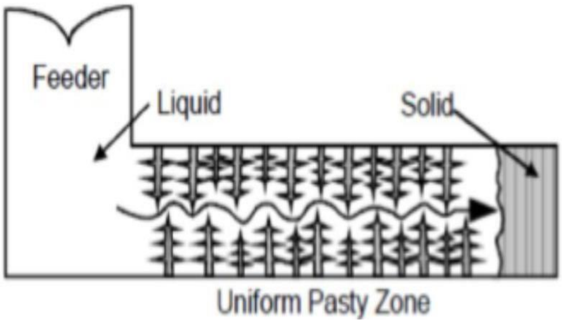

Fig. 6 Micro porosity

In such cases, towards the end of solidification, there will be a 'pasty' or 'mushy' zone consisting of a forest of dendrites enclosed in the remaining liquid.

Casting Defect Pictures

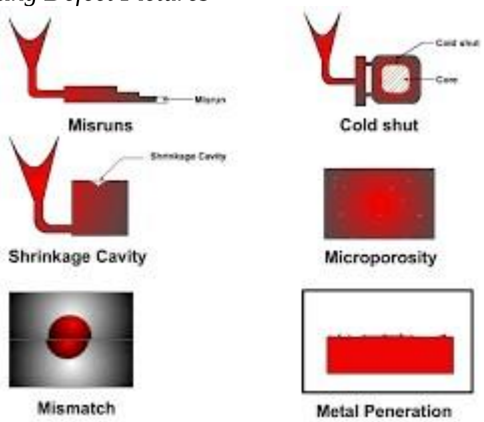

Fig. 7 (a)Misruns (b) cold shut (c) Shrinkage Cavity (d) Micro porosity (e) Mismatch (f) Metal Penetration

III. RESULTS AND DISCUSSION

Improvement in mould cleaning process:

The hose (pipe) of air size for cleaning moulds in foundry should be in minimum of half inch. With small hose we can't properly clean large depth moulds (mainly in pit moulding case). Due to un-proper cleaning of mould free sand remain inside the mould, and get mixed with molten metal to produce various defects.

Precautions during refractive paint process:

Not properly painting of mould with refractive paint, produce pin holes on surface and gas porosity in casting. Thus following points during apply of refractive paint to mould should take in consideration:


Fig. 8 Improper paint

- Proper mixing of paint before use is must.
- Use paint gun to paint mould.
- Apply paint in thin layer and constant on all the mould.
- Never paint the mould from that place where direct contact of molten metal is not to be there.
- Paint should be so it can-not get removed on rubbing with hand.
- Properly heat the mould after paint applied.

Precautions during mould closing:


Fig. 9 Improper mould closing

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During mould closing always remembers these points:

- Never close mould more than 3 hours before pouring. It is cause of surface pin holes and gas porosity.
- Never paint inside mould after closing (even sprue and risers should paint before closing). It is cause of surface pin holes and gas porosity.
- Never heat mould after closing. It is cause of surface pin holes and gas porosity. iv. Never close the venting of mould and core. It is cause of gas porosity.
- Always use plain surface (or single plate) below mould, to prevent mould breakdown from bottom during pouring.
- Ensure about weight kept on mould should double weight than casting weight to prevent mould casting.

Pouring precautions:

Always measure and ensure about metal temperature before pouring. If temperature is not in more than proper range this leads to slag formation from sand of mould as well as gas holes. If pouring temperature is less this may lead to casting defects such as misran etc.

Proposal for pouring process improvement:

Use of bottom ladle: Use of bottom ladle has following advantages:

- Reduction in slag pouring problem with molten metal in mould cavity.
- Maximum of molten metal in ladle can poured in mould easily.

IV. CONCLUSION

There will be a reduction defects in castings, leading to soundness of castings. As these projects will be a best option to get improved any foundry for look as well as quality. Still there is lot of work is need to be done on these topic to reach near 100% effectiveness.

CNC MILLING

Introduction: Milling is the machining process of using rotary cutters to remove material from a workpiece advancing in a direction at an angle with the axis of the tool. It covers a wide variety of different operations and machines, on scales from small individual parts to large, heavy-duty gang milling operations. It is one of the most commonly used processes in industry and machine shops today for machining parts to precise sizes and shapes.

Milling:

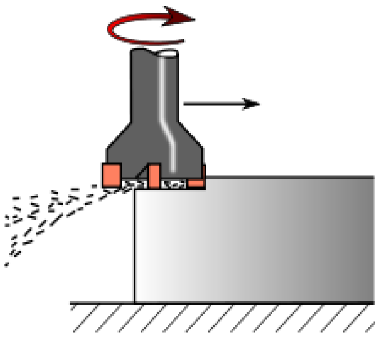

Fig. 10 Milling Operation

Milling can be done with a wide range of machine tools. The original class of machine tools for milling was the milling machine (often called a mill). After the advent of computer numerical control (CNC), milling machines evolved into machining centres (milling machines with automatic tool changers, tool magazines or carousels, CNC control, coolant systems, and enclosures), generally classified as vertical machining centres (VMCs) and horizontal machining centres (HMCs).

After research, conclusion was that I have analysed whole casting process as under listed point considerations in various departments:

Causes of Casting Defects

Method design section	Moulding section	Melting section
Wrong position of riser	Poor sand quality	Pouring temperature
Wrong size of riser	Mould moisture	Pouring time
	Mould paint	Scrap quality
	Poor venting	Holding time

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