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APPROACH TO MINIMIZE VARIOUS SURFACE AND SUBSURFACE DEFECTS

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Abstract-*This paper presents various approaches to analyse the cause of generation of surface and subsurface defects produced during casting and suggests various remedial measures to minimize them. Casting is a cascade process involving number of processes like making of pattern, pouring of metal, mould making, solidification, removal of mould, etc. But, it cannot be assured that the component or parts produced by these processes may always be defect free. So there is a need to eliminate these defects produced due to one or the other reasons. Therefore this paper provides an introduction to the nature, origin, and remedies of the major defects in casting.*

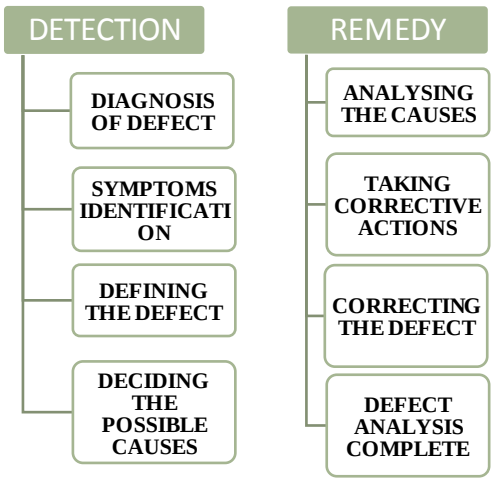
Keywords-*Defectsin Casting, Quality Control in Casting, Root Cause Analysis, Corrective and Preventive Actions.*

I. INTRODUCTION

Casting is a process of manufacturing which involves pouring of liquid material into a hollow cavity of the mould and then allowed to solidify to get the desired shape. This process of fulfilment of finished product carries a lot of risk of occurrence of failure. These failures can negatively bear upon nethermost line of foundry. These failures may arise from a single clearly defined cause which enables the remedy to be more specific and straightforward.Defects however may result from a combination of factors, so that the necessary preventive measures are more dubious.
Due to modern technology, foundries have intricate inspection equipments which are able to have a close control and standardization of all aspects of production technique that offers the best protection against these small and a wide variety of surface and subsurface defects.

II. ANALYSIS OF DEFECT

The proper analysis of a particular defect is the prerequisite to correcting and controlling the quality of various castings. Once the defect has been properly identified and diagnosed, all the causes must be examined and inspected in order to pinpoint the true root cause of the problem.



III. CLASSIFICATION OF DEFECTS

A casting defect is a deformity or imperfection in the metal casting process that is inadmissible. Some defects can be abided while others can be refurbished, otherwise they must be eliminated. These can be broken down into three main categories as:

2.1 Surface defects
2.2. Subsurface defects
2.3. Visible defects

2.1. SURFACE DEFECTS

These defects arise due to design and quality of sand moulds but their main cause is poor ramming.

2.1.1. *Blowdefect*

When the molten metal form is being displaced by the gases, these results into the formation of a very large sized cavity .these are smooth round holes clearly perceptible on surface of casting.
This cavity on the surface of the casting is called blow.

2.1.1.1. *Causes*

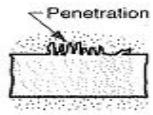
- Due to entrainment of air which is normally caused by incorrect running system design.
- Due to the gas that is coming from the cores

2.1.1.2. *Solution*

- Ramming should not be too hard.
- Improvement in the running system
- Venting should be adequate
- Sand of proper grain size should be used.
- Moisture content in sand must be well adjusted...
- Use of less volatile binders.
- Fill the mould rapidly.

2.1.2.*Penetration of metal*

Strong projections or crust at surface, of distorted shape which are the result of a large quantity of impurity, inadequate refractoriness, poor quality of mould washes, and metal having spongy like appearance.When molten metal is being poured it enters into the gaps between sand grains which results in a rough casting surface.



2.1.2.1. *Causes*

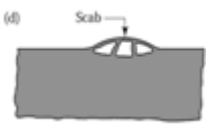
- No mould wash is applied on the surface of mould.
- Sand has too high permeability.
- Soft ramming causes metal penetration.
- Large grain size& low strength.

2.1.2.2. *Solution*

- Apply mould wash on surface of mould.
- Less coarse sand to be used.

2.1.3. *Scabs*

Patches of sand on upper surface of casting component is called scab. When the metal is being poured in the cavity the gases are disengaged with such terrible violence so as to break up the sand that is afterwards washed away. This resulting cavity is then filled up with the metal.



2.1.3.1. *Causes*

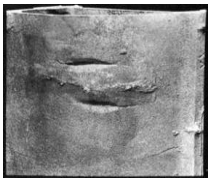
- High moisture content of sand.
- Low permeability of sand.
- Improper adhesion of ceramic to wax.
- Uneven ramming of the moulds

2.1.3.2. *Solution*

- Proper application and formulation.
- Proper adhesion of ceramic to wax.

2.1.4. *Buckle*

A shoal, V depression extending in an approximately straight line along the entire flat surface of the castings is called as buckle. Due to very high temperature of molten metal, expansion of thin layer of sand at mold face takes place. As this expansion is obstructed by the flux, the mould tends to bulge out forming a V shape.



2.1.4.1. *Causes*

- High temperature of the pouring metal.
- Due to insufficient hot deformation of sand, the sand gets expanded by the heat of the metal.
- Poor design of casting.

2.1.4.2. *Solution*

- Mixing of wood flour with the sand.
- Suitable temperature of molten metal.

2.1.5. *Fins*

A thin projection of metal after casting is called as fin. Fins occur at parting of mold or core sections. If molds and cores are incorrectly assembled it will lead to the formation of fins.

2.1.5.1. *Causes*

- High metal pressures due to too large downsprue.
- Insufficient weighing of moulds.
- Improper clamping of flasks also produces this defect.

2.1.5.2. *Solutions*

- Proper parameters of casting.
- Weighing of moulds to be proper.

2.1.6. *Dirt*

Sometimes sand particles drooping out of cope gets entrenched on the uppermost surface of casting.
When removed, these leave large angular holes called as dirt.

2.1.6.1. *Causes*

- Improper casting operation.

2.1.6.2. *Solutions*

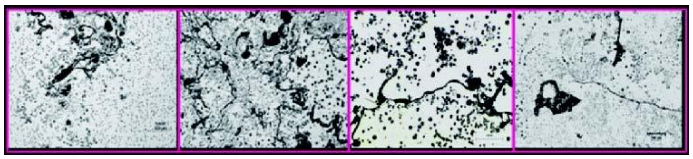
- Cautiously performing the casting operation.

2.2. SUBSURFACE DEFECTS

Internal defects occurring beneath the surface are called subsurface defects. These occur mainly due to trapped gases and dirty metal. Gases get trapped due to improper ramming and venting. These defects also occur when excessive moisture or excessive gas forming materials are used for mould making.

2.2.1.*Dross*

Dross is a manifestation of endogenous inclusion. It is a lump of solid scum floating on or dispersed in the molten metal. Dross, as a solid is distinguished from slag which is a liquid.
Further, dross are magnesium silicates that can be formed during casting, in casting flow or in sprue basin, in cast iron runners at level of first input cast iron.



2.2.1.1. *Causes*

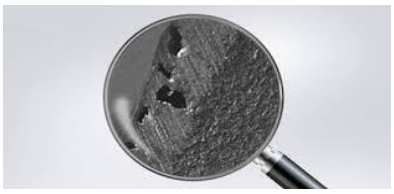
- It is a reaction product formed during Magnesium treatment.
- Successive reoxidation phases of magnesium

2.2.1.2. *Solutions*

- Deoxidation and modification of casting temperature of low melting slags in furnace with Silicon carbide (SiC).
- Keeping Magnesium under 0.40%.
- It can be taken care at pouring stage by using items such as strainer and skim bob.
- Keeping Silicon percentage low (within a threshold not exceeding 2%).

2.2.2. *Pinholes*

These are small gas holes occurring sporadically over large areas either over surface or just below the surfaceof cast piece made up of cast iron with lamellar graphite, vermicular graphite and in malleable steel and iron castings.
They can vary from spherical blisters to bare metal surface or covered with small graphite skins to larger deformed cavities which are accompanied by occurrence of oxidation or by slags.



2.2.2.1*Causes*

- Excessive hydrogen content in the melt that can occur due to hydrogen carriers
- Unprotected ferrous alloys that often adsorb water
- Emulsions and oil that give off the hydrocarbons in particular.
- Too much nitrogen in sand with excess moisture content.
- Too much nitrogen in core sands or too high nitrogen -hydrogen compounds in the core molding material binders

2.2.2.2 *Solutions*

- Decreasing moisture or organic content of the sand.
- Decreasing the amount of gases in the sand.
- Proper dressing and drying of the cores.
- Decreasing the content of hydrogen gas in the melt.

2.2.3.*Blisters or Blowholes*

Blowholes, blisters or gas cavities are gas bubbles of large size with well round cavities having a smooth and clean surface. When excessive gas evolvedduring pouring of metal is not able to pass through the mass of molten metal as it

solidifies, so the air gets entrained within the casting which leads to the formation of large sized holes inside the casting called blisters.

2.2.3.1. *Causes*

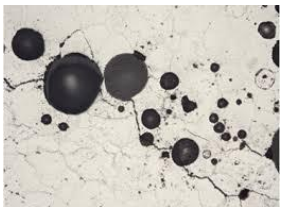
- Pouring temperature is too low.
- Cores are not vented and dried properly.
- Inadequate permeability of gas of molding sand.
- Poor venting of the moulds.
- Due to failure to connect flow off in gating system.

2.2.3.2. *Solutions*

- Flow off to be directly connected on top surface of long member
- Improvement in gating system.
- Proper foundry practices including melt preparation and mold design.
- Proper ventilation of the cores.

2.2.4. *Gas Porosities*

Formation of tiny bubbles inside the casting after it has freezed off during solidification. As it is seen that the liquid state of metal is able to hold large amount of dissolved gas in itself, whereas the solid state of the same metal is not able to sustain the dissolved particles so the gas forms tiny bubbles within the casting as it solidifies. Whirling flow causes these bubbles to enlarge. These entrained pores may reduce the strength in the vicinity. Hydrogen, oxygen, and nitrogen are the three most encountered gases in porosity.



2.2.4.1. *Causes*

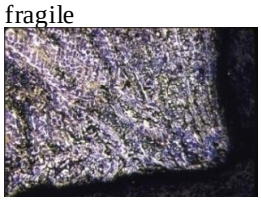
- Slow pouring speed.
- Scum or impurities on the surface of metal
- Violent nature in which metal is instilled into a die during casting process.
- Gushing temperature of liquid metal is very low.

2.2.4.2. *Solutions*

- Pertinent venting whether vacuum or passive venting.
- Convenient runner design.
- Remove scum or impurity from metal surface.
- Venting of cores and moulds should be appropriate.

2.2.5. *Hard Inclusions or Hard spots*

Imperfections displayed on piece surface after polishing. These are more or less minutely diffused and sometimes large. In this type of defect the cast component may appear brittle. If bent slightly this may sometimes display cracks. Fundamentally they are huge and hard relief spots which the mechanical finishing cannot wipe out,
But usually stresses even with more impact. In fact by asserting on polishing the hard inclusion zone, the
Material around the defect is removed, since it is fragile



2.2.5.1. *Causes*.

- Defilement of the production process.
- Contagion by foreign material like carbon, silica, etc.
- Wrong use of master alloys.
- During the process of agglomeration.

2.2.5.2. *Solutions*

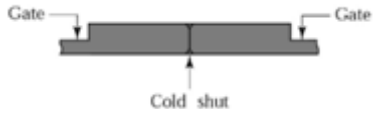
- Advancement in the production process.
- Improvement in the gating system.

2.3. VISIBLE DEFECTS

These defects are visual in nature and there is no need to scrap the work piece.

2.3.1. *Cold lap*

Cold lap is a defect in which the discontinuity is formed due to the imperfect fusion of two streams of metal in the mould cavity, leaving a weak spot. It is because of low melting temperature or poor gating system. This defect involves material freezing before it completely fills the mould cavity.it has characteristic appearance and may vary in depth.



2.3.1.1. *Causes*

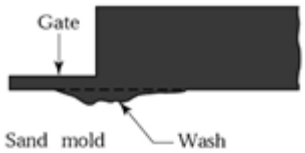
- Too thin Cross sections and wall thickness.
- Lack of fluidity.
- Too low mould or melt temperature.
- Faulty gating system and design.

2.3.1.2. *Solutions*

- Fluidity increased by changing chemical composition of metal or increasing the pouring temperature.
- Improvement in the design.
- Proper gating system.

2.3.2. *Wash*

Low projection on the drag surface of a casting commencing near the gate is called as wash. It reduces in height as it ranges from one end of casting to the other end. It usually occurs with bottom gating castings in which molding sand does not have sufficient hot strength and when too much metal is made to flow through one gate only into the mold cavity.



2.3.2.1. *Causes*

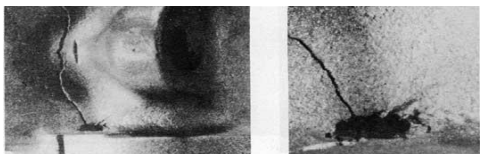
- Erosion of sand due to high velocity liquid metal.
- Insufficient hot strength of sand.

2.3.2.2. *Solutions*

- Proper strength of the sand.
- Reduce liquid metal velocity.

2.3.3. *Shrinkage*

As the molten metal solidifies it reduces in volume .This is called as shrinkage. This shrinkage is an important issue in casting. This reduces the volume of the cast to 5-10%. Exception of this is grey cast iron which expands upon solidification due to phase changes. The radius of good shrinkage control should be from one half to one third of the section thickness.



2.3.3.1. *Causes*

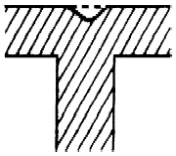
- Molds are improperly gated.
- Contraction of metal during solidification.

2.3.3.2. *Solutions*

- Decreasing the number of walls.
- Increasing the draft angle.

2.3.4.*Suck in defect*

These are the shallow depressions occurring at the bulky sections of the casting piece on its surface. The surface of the depression is the same as that of the other areas of casting.



2.3.4.1. *Causes*

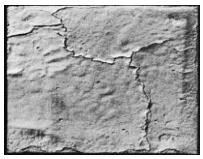
- Improper gating system.
- Contraction of metal during solidification.

2.3.4.2. *Solutions*

- Improvement in the gating system.

2.3.5. *Rat tail*

These are long shallow angular depressions found in the thin castings. This appears as an irregular line on the surface of casting. This is somewhat similar to buckle defect.



2.3.5.1. *Causes*

- Depression of mould under compression.
- Buckle is more severe defect than rattail under compression.

2.3.5.1.*Solutions*

- Mould should be allowed for expanding properly rather than forming compressed layers.

2.3.6. *Shift defect*

A shift in the casting results in the disparity of the portions of casting usually along the parting line. Lack of adjustment or misalignment in casting causes mismatch in the sections.

2.3.6.1. *Causes*

- Misalignment is a common cause of shift.
- Carelessness in placing cope on the drag
- Dowel pins are of inaccurate pattern.

2.3.6.2. *Solutions*

- Checking of pattern flux locating pins before using them.
- Ensure proper alignment of pattern for die boxes.

2.3.7. *Warped casting*

Warping is an undesirable deformation in a casting which occurs during or after solidification. Large and flat sections are particularly prone to wrap edge.

2.3.7.1. *Causes*

- Insufficient gating system that may not allow rapid pouring of metal.
- Due to low green strength of the sand mould or inadequate / inappropriate draft allowance in the pattern / mould cavity.

2.3.7.2. *Solutions*

- Normalising heat treatment to reduce residual stresses.
- A straightening between quench and aging is required.

IV. CONCLUSION

The purpose of this paper was to outline several casting defects and their corresponding remedial measures, and general recommendations to achieve a good & best quality casting. Only mere inspection of the finally produced casting product will not help in improving the quality of the produce, rather these defects in the casting need a careful observation, identification, analysation, and correction. Therefore, this study will definitely be helpful in increasing the productivity and yield of casted components.

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