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Causes of Casting Defects with Remedies

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***Abstract*—- Die casting is an efficient, economical process, offering border range of geometrically complex components and shapes than any other manufacturing technique. But there are defects in casting observed. In order to identify the casting defect, the study is aimed in the research work. The main objective of the current paper is finding different defects in aluminum-alloy die casting and providing their remedies with their causes. In this paper casting defects are critically discussed and classified according to their root causes of occurrence.**

Keywords— Die Casting; Defects in Casting; Causes and Remedies for Casting Defects

I. INTRODUCTION

Casting defects may be defined as characteristics which create a deficiency or imperfection to quality specification imposed by design and service requirement. Casting defects are caused by non optimized process, failure of material, casting equipment. So the defects can be tolerated and repaired. In aluminum die casting the molten aluminum is poured or injected into metallic die. There are many sources to cast defects and have many names. In this paper an attempt has been made to provide al casting defects with their causes and remedies.

2. CLASSIFICATION OF CASTING DEFECTS

In present paper classification of defect are based on their sources of defects presented in aluminum die casting. In this classification defects are groups according to their sources. Each of these groups includes surface and bulk defects. The causes and remedies of each kind of defects are explained in this paper.

Classification according to the source of defects:-

A) Metallurgical defects :
Porosity, sinks, inclusion, dross, soldering.

B) Defects due to heat:
Hot tears, cold shut, thermal fatigue.

C) Mechanically induced defects:
Surface marks, bending, undercuts

3. METALURGICAL DEFECTS

Metallurgical defects are caused by improper alloy composition, melting temperature, defective mechanical properties, internal stresses etc.

3.1 POROSITY

Porosity is often used by both casting suppliers and customers when talking about casting defects. Porosity describes the presence of voids inside casting of different size, shapes, surface constituents. Porosity can be divided into two types.

I) Gas porosity
II) Shrinkage porosity

3.1.1 Gas porosity

Gas porosity in casting is due to presence of gas which is in the form of trapped air, moisture from water based die lubricant, dissolved hydrogen in air. When the pouring of metal starts the air which is present in the cavity before pouring is compressed and the pressure rises. It forms the bubbles after it has cooled.

3.1.1.1 Causes of gas porosity

- Speed of metal pouring is too slow .
- Presence of gas in metal.
- Mould is too hot.
- Presence of moisture in flux.
- Incomplete casting.
- Metal section is too thin.
- Overheated moulds.
- Temperature of pouring metal is low.

3.1.1.2 Remedies

- Pouring of metal is done as rapidly as possible without interaction.
- Use vacuum degassing. Melt the metal in vacuum.
- Keep the temperature of mould low.
- Use adequate venting of moulds and cores.
- Have sufficient metal in ladel to fill the mould.
- Improve the gating system.
- Modify the casting design to avoid the thin metal section and improve runner design.
- Increase the metal pouring temperature.

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Fig 3.1 Gas porosity

3.1.2 Shrinkage Porosity

Shrinkage porosity is one of the most common defects to rejection of aluminum casting. It can be described as internal cracks in casting which comes from several sources.

3.1.2.1 Causes

- Increased metal concentration at specific region.
- Complexity in casting geometry.
- Pressure of metal is too low.
- Poor gating and runner design.
- Metal is contaminated.
- Reduced metal volume during solidification

3.1.2.1 Remedies

- Design the die with extra tolerance.
- Use simple geometry in casting.
- Increased metal pressure.
- Modify the getting and runner design.
- Use simulation software to improve runner in order to have optimum filling of cavities.
- Remove the contamination, clean the metal surface.
- Provide core hole in centre and offset the ribs.

Fig 3.2 Shrinkage Porosity

3.2 Sinks

Sinks form when there is presence of sub-surface cavity. A sink is depression impacting of surface of part that does not mimic the mould surface. Sinks are often visible because they reflects light.

3.2.1 Causes

- Insufficient metal can be main reason for sinks.
- Gate seal time is slow.
- Low injection speed.
- High volumetric shrinkage.
- Short cooling time of metal.
- High temperature of metal.

3.2.2 Remedies

- Use extra metal while pouring to avoid the sinks.
- Increase the gate seal time.
- Increase the injection speed to decrease viscosity and allow more backing pressure.
- Relocate gates to problem areas.
- Increase the cooling time of metal.
- Lower the temperature of metal.

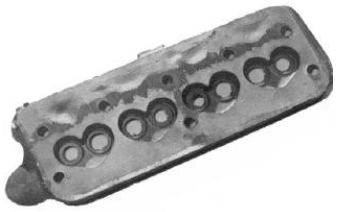

Fig 3.3 Sinks

3.3 Blister

In blister the thin film of small surface blows up from the part surface when the internal pressure of surface gas-related porosity plastically deforms the metallic surface. Blister represents an example of defect of metallurgical defect.

3.3.1 Causes

- Excessively high injection rates.
- Pressure of gas across the surface during fill.
- Removal of parts which are at high temperature are ejected from die.
- High temperature of die surface.

3.3.2 Remedies

- Lower the injection rates.
- Use vacuum filling in casting.
- Use temperature sensors near the die.
- Lower the die surface temperature.

Fig 3.4 Blister

3.3 Soldering

Soldering is one of the main and major casting defects in aluminum die casting process. Soldering occurs when molten aluminum sticks the surface of die steel and remain there after the ejection of casting. Soldering occurs after just few casting cycle.

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3.3.1 Causes

- Poor gate design.
- Inadequate die cooling.
- Poor die surface polishing.
- High temperature of die.
- Improper amount of iron content in alloy.

3.3.2 Remedies

- Give more time for cooling.
- Maintenance of die surface.
- Lower the temperature of die.
- Use proper lubricant.
- Use proper range of iron which is between 0.8% to 1.1%.

Fig 3.5 Soldering

3.5 Segregation

Segregation occurs due change in chemical composition of metal. Segregation is distinguish between two types. Microsegregation and Macrosegregation. Microsegregation refers to localize difference between dendrite arm. Distance involved is about 10 to 100µm which is small for diffusion to be significant mechanism and this is not in case of microseggregation.

3.5.1 Causes

- Local and non equilibrium composition can lead to Segregation.

3.5.2 Remedy

- Segregation can be removed by homogenization heat treatment.

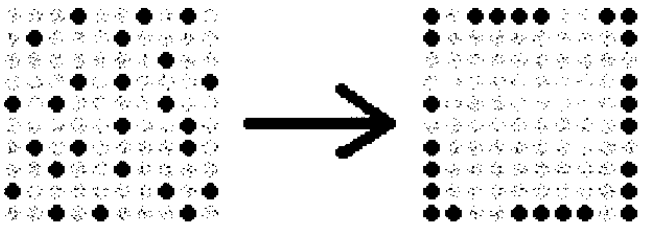

Fig 3.6 Segregation

3.6 Inclusions

Inclusions are due to the presence of forging, non metallic particles in cast metal. These are may in the form of oxides, slag, dirt, sand or nails. These inclusion can limit mechanical properties and fatigue performance as well as lead to cosmetic defects.

3.6.1 Causes

- Sand, dirt are not properly cleaned from moulds.
- Improper gating system.
- During solidification insoluble inter-metallic compounds formed and segregate concentrating in residual liquid.
- Alloy additions which have not completely dissolved in melt.

3.6.2 Remedies

- Regular cleaning of die.
- Improve gating system.
- Use clean and pour molten metal.
- Use small piece of alloying material and master metal alloys in making up change.

Fig 3.7 Inclusion

3.6 Dross

Dross is nothing but the metal loss. Dross in aluminum casting contains 60.65% by weight metallic aluminum. Drossing is generated due to melting and holding of aluminum. During melting, aluminum oxide(AL203) and other oxides which get collected on melt surface due to difference in densities.

3.6.1 Causes

- Reaction result between high temp liquid aluminum and air in melting is formation of oxides.
- Thermite reaction causes the dross.
- Higher the temperature of metal.

3.6.2 Remedies

- Lower the reaction time which reduces the formation of dross.
- Avoid the stirring which causes the thermite reaction and oxidation.
- Lower the temperature of the metal.

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Fig 3.8 Dross

4 DEFECTS DUE TO THERMAL EFFECT

Thermal defects occurs due to pressure of thermal stress in thermal origin, improper interaction of fluid and incorrect eat removal rates.

4.1 Cracks

Cracks are usually irregular and oxides so that fracture appears dark. Crack is geometrical discontinuity in casting. Generally crack occurs when casting is still hot and contracting. Cracks can be easily seen with the naked eye and other cracks are difficult to see without magnification.

4.1.1 Causes

- More stress localization at particular area.
- High thermal concentration.
- Excessive injection forces.
- Damaged die cavities.
- Insufficient draft in die section.
- Faulty die design.
- Shrinkage of casting in die.

4.1.2 Remedies

- Proper design of casting.
- Use chillers in casting areas
- Give proper time for cooling of metal.
- Reduce proper pouring temperature.
- Provide feeders.
- Avoid sharp corners. Round-off the corners.
- Reduce die strength by adding saw or coal dust.

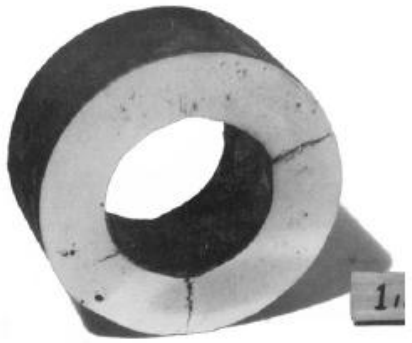

Fig 4.1 Crack

5 HOT TEARS

Hot tears is one of the main casting defect. It is due to formation of irreversible failures of semisolid casting. Hot tears occurs in last stage of solidification.

5.1.1 Causes

- Thermal contraction.
- Abrupt section changes in casting.
- Improper placement of gates.
- Incorrect metal pouring temperature.
- Faulty solidification methods.
- Thin sections.

5.1.2 Remedies

- Provide adequate fillet at junctions.
- There should be uniform thickness through out the section.
- Placement of gate should be accurate near the die.
- Use accurate metal pouring temperature.
- Use standard solidification method.
- Use minimum permissible amount of thickness. Which is depends upon the casting process.

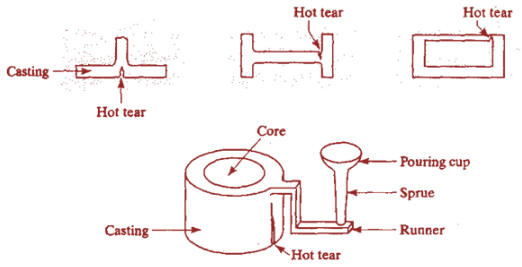

Fig 5.1 Hot tears

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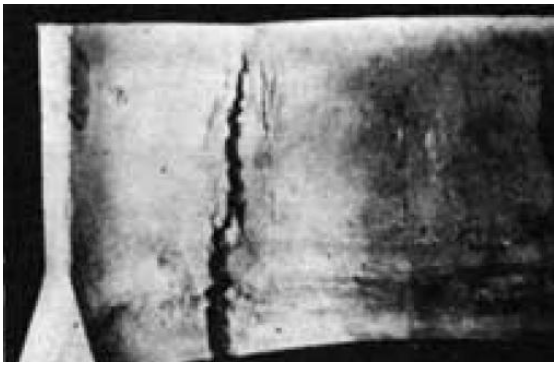

Fig 5.2 Hot tears in part

6. COLD SHUT

Cold shut forms when small droplets of metal fall into casting ,mould. Solidify and fail to combine when remaining metal introduced to mould. Cold shut is crack with round edges. In cold shut two different metal stream do not forged together .

6.1.1 causes

- Lower fluidity of mould.
- Thin section of casting.
- Low pouring temperature of metal.
- Inadequate gating.

6.1.2 Remedies

- Use different composition of metal.
- Use permissible minimum thickness suitable for casting process.
- Increase the pouring temperature.
- Use proper placement of gating.

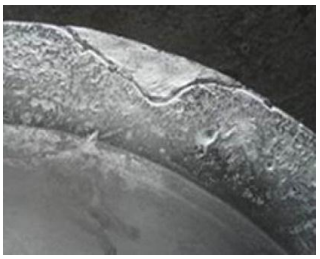

Fig 6.1 cold shut in part

7. MISRUN

When there is incomplete filling of metal in mould cavity and leaving unfilled portion called misrun.

7.1.1 Causes

- Thickness of section is too small.
- Too long die cavity fill time due to which entire section is not filled before the metal solidifies.
- Long flow distance inside die cavity.
- Inadequate venting.
- Interruption in pouring.
- Temperature of metal is too low.

7.1.2 Remedies

- There should be uniform thickness throughout the section.
- Decrease the cavity fill time. Modify the gating design.
- Decrease the flow distance by modifying the casting design.
- Provide proper venting.
- Pouring should be done without interruption.
- Increase the temperature of metal.

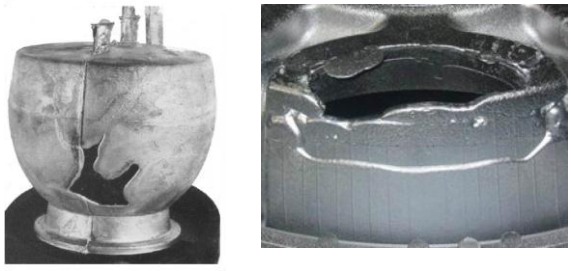

Fig 7.1 Misrun in part

8. THERMAL FATIGUE

In aluminum die-casting dies are subjected to high thermal stress. Thermal fatigue is due to thermal cycling which shorten the life of die. A net textured of cracks forms on the surface die.

8.1.1 Causes

- When the die are continuously subjected to the high temperature.
- When the edges and corners are with small radius.
- When the temperature gradient near the gate is high.

8.2 Remedies

- Cooling of die for particular period of time is needed.
- Give permissible radius for edges and corners.
- Lower the temperature gradient near the gate.

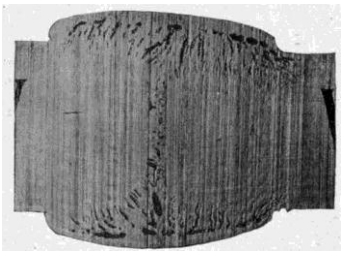

Fig 8.1 Thermal defect

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9. MECHANICALLY INDUCED DEFECTS

Mechanically induced defects such as Surface marks, undercuts and bending occurs during ejection of casting and due to insufficient draft angle. Under cuts are formed due to erosion of sand by the stream of molten metal. It shows the pattern around the gates and causes dirt in casting. Bending and surface marks are caused by external pressure loads, improper ejection methods. These defects can be avoided by giving proper draft angle and using standard ejection methods and modified casting designs.

10. CAREFUL CONTROL OF LARGE NUMBER OF VARIABLES NEEDED-

- Characteristics of metals & alloys cast
- Method of casting
- Mould and die materials
- Mould design
- Process parameters- pouring, temperature,
- Gating system
- Rate of cooling

11. DESIGN MODIFICATIONS TO AVOID DEFECTS

- Avoid sharp corners
- Maintain uniform cross sections
- Avoid shrinkage cavities
- Use chills to increase the rate of cooling
- Stagger intersecting regions for uniform cross sections.
- Redesign by making parting line straight.
- Avoid the use of cores, if possible
- Maintain section thickness uniformity by redesigning
- Allowances for shrinkage to be provided
- Parting line to be along a flat plane- good at corners or edges of casting
- Draft to be provided
- Permissible tolerances to be used
- Machining allowances to be made

- Residual stresses to be avoided
- Large flat areas to be avoided- warping due to temperature gradients

12. CONCLUSION

In this research paper different casting defects are studied. By referring different research papers causes and their remedies are listed. These will help to quality control department of casting industries for analysis of casting defect. This study will definitely be helpful in improving the productivity and yield of the casting. One of the side this classification of defects helps in die caster in the stage of identification of the defects can be detected. Rejections of the casting on the basis of the casting defect should be as minimized and all the above research is heading in the same direction

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