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CASTING DEFECTS IN GRAY IRON PIECES

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Abstract: The study conducted delved into the most common defects occurring in the casting department of a company specialized in manufacturing gray iron hydraulic valves. The entire process of crafting these metal components was closely monitored through every stage. Over the course of a month, components comprising industrial hydraulic valves were collected from the casting area, where they were produced using a cupola furnace and subsequently poured into green sand molds. After solidification, these components underwent rigorous inspections. If any piece exhibited defects, it was separated for identifying and analyzing the potential causes that led to these defects. The evaluation covered various aspects, including surface quality, chemical analysis, mechanical properties, and metallographic analysis of the components. These findings enabled the identification of the root causes of defects, leading to the implementation of preventive measures aimed at enhancing product quality and, in return, ensuring customer satisfaction.
Keywords: Defects, Grey iron, Casting.

INTRODUCTION

Foundry processes currently constitute one of the strongest established manufacturing processes in the region. It should also be noted that there are numerous contingencies that cause difficulties in a casting operation and lead to quality defects in the product. Iron castings are iron-carbon and silicon alloys, with carbon content ranging from 2 to 5%, silicon from 2 to 4%, manganese up to 1%, and sulfur and phosphorus in very low contents. These irons are characterized by their ability to be melted in a cupola furnace to obtain pieces of varying sizes and complexity, but they cannot undergo plastic deformation. In general, they are not ductile or malleable, but they are machinable, brittle, and resistant to corrosion and wear (Mullins).

Many types of defects in foundries are caused by the flow of liquid metal in the cavities and the contraction of the metal during solidification, among other factors. If the metal is prevented from freely contracting during solidification, as mentioned earlier, cracks occur in the material. Although many factors influence this, the presence of coarse grains and low-melting-point alloying elements increases the tendency to cracking. Therefore, mold and core design should take these tendencies into consideration. There are many other types of defects in castings, such as those due to trapped gases, the presence of oxides and contaminants (Askeland). This study collected metallic parts that most frequently exhibited the same defect and proceeded to identify the type of defect, implementing process improvements and generating a preventive plan.

EXPERIMENTAL DEVELOPMENT

The industrial valve production process was monitored at each stage for a period of 1 month. Defective pieces were collected, and the defects that occurred most frequently were identified. These pieces were separated and subjected to characterization, including metallographic testing, hardness testing, chemical analysis, and tensile testing. Once the defect was identified and based on the results obtained, as well as field monitoring of the operation charts performed by the worker, improvements were implemented in the manufacturing stages in the core area, molding, casting, and finishing. This was done to determine the root cause of the defect and to prevent it in the future.

RESULTS, DEFECTS, AND PREVENTION

RESULTS

CHEMICAL ANALYSIS

Chemical analysis of the samples that exhibited defects was carried out using the ASTM E-1019 infrared detection technique to determine the percentage of carbon (C) and sulfur (S), as well as the rest of the elements by X-ray Fluorescence Spectrometry. The results obtained are shown in Table I.

Element	Weight %
C	3.40
S	0.10
Mn	0.32
P	0.06
Si	2.80
Cr	0.20
Ni	0.22
Cu	0.20
Mo	0.03
Mn	0.08

Table I. Percentage Values of Elements Present in a Defective Gray Iron Piece Sample

Based on the results of the chemical analysis obtained, the elements are within the values for gray iron.

TENSILE TEST

A tensile test was conducted in accordance with the ASTM A-48 standard. The results obtained are shown in Table II.

Identification	Maximum stress (Psi)	Yield Stress (Psi)	Elongation %
Gray Iron Sample	31,024	29,600	N/A

Table II. Tensile Test Results on Defective Gray Iron Piece Sample

Based on the results obtained, it is considered as Class 30 gray iron.

HARDNESS TEST

A total of six indentations were made across the thickness of the gray iron sample using a tungsten ball indenter with a diameter of θ=10.0 mm, applying a load of 3000 kgf. The results obtained are shown in Table III.

Identification	HB Readings	Average HB Hardness
Gray Iron Sample	202,203,203	202
	201,202,203	

Table III Hardness Test (HB) Readings on Gray Iron Sample

Values around 202 HB were obtained, which correspond to the specification for this type of iron.

METALLOGRAPHIC TEST

Metallographic analysis was conducted on the samples exhibiting defects, and the microstructures obtained are typical of this type of iron (Type VII laminar graphite, with a distribution type A, size 2, uniformly distributed in a fully pearlitic matrix). See Photomicrographs 1 and 2.

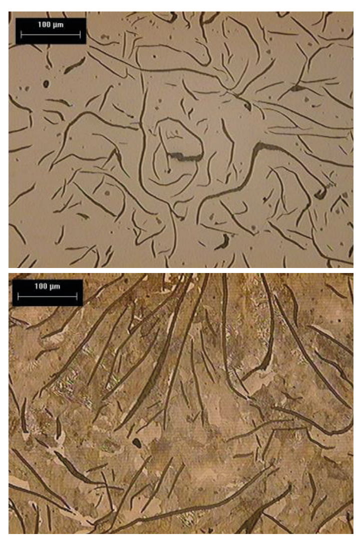

Fig. 1 and 2 show the microstructure of graphite distributed in a laminar form in gray iron at 100X magnification.

DEFECTS

SHRINKAGE VOIDS

These are cavities with a spongy appearance, or they can also appear as sinkings or depressions in the material. They are spherical contractions starting with greater thickness and ending in thinner sections. They are commonly found in thick sections, section transitions, and heat retention areas. See Figure 3.

Fig. 3 shows a gray iron metallic piece with a shrinkage void at the center.

HOW TO PREVENT

- Increase the height of the pouring basin and sprue.
- Avoid using very small risers.
- Use sand with proper compaction and moisture.
- Ensure that the molten metal does not have a low carbon content.
- The specified silicon content should not be low.

GAS DEFECTS

These are blowholes or holes in cast pieces with spherical, flattened, or elongated cavities, and they are related to the pressure of a gas originating from the core or trapped air within the mold. See Figure 4.

Fig. 4 shows a gray iron valve in which a defect due to trapped gas during solidification in the mold can be observed.

HOW TO PREVENT

- Ensure an adequate number of vents in the mold.
- The sand should not have a high moisture content.
- The sand must have good permeability.
- Use paint with good flow, applying at least two coats.
- Avoid poorly baked or excessively resinous cores.

DEFECTS DUE TO INCLUSIONS OR SLAG

These are particles, either on the surface or beneath the surface, made of sand, slag, oxides, or other materials embedded in the metal. They can originate from the poured metal or contamination in the molds and cores. See Figure 5.

Fig. 5: Valve cover, showing an inclusion defect.

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HOW TO PREVENT

- Round the corners of the formed mold.
- Place cores with precision and air vent them properly.
- Avoid using low green strength sand.
- Ensure cores are not broken and avoid excessive paint.
- Properly skim and pour at the ideal temperature.

CONCLUSION

Based on the study conducted on Gray Iron Hydraulic Valves, the product is considered to be within specification. However, it is noted that these defects are primarily a result of process development variables, such as inadequate pouring temperature, mold moisture, improper sand mixtures, incorrect pouring velocity, among others, related to process standardization.

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