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EXPERIMENTAL STUDY, ANALYSIS, AND SYNTHESIS OF DEFECTS IN THE CASTING OF ALUMINUM INGOTS

Oybek Oripov[1*],
Gavhar Narmayeva[1],
Jamoliddin Kuljonov[1],
Muqaddas Abdushukurova[2]
[1]Samarkand State University, Samarkand 140104, Uzbekistan
[2]National University of Uzbekistan named after Mirzo Ulugbek, Tashkent 100174, Uzbekistan
Author: oripovoybek0103@gmail.com (O. Oripov)

ABSTRACT
The goal of any enterprise is to increase the quality and productivity of production products. Casting defects are the only limitation in any casting process. The sandblasting process faces the same problem. It is very important to determine the optimal conditions for obtaining minimal casting defects. A simple method that most companies use is trial and error. But due to error-prone results and expensive and time-consuming restrictions, this method causes a lot of costs to the company. In this article, an attempt has been made to minimize casting defects by following proper practice during sand casting. From Casting Defects and their Remedies, it has been found that defects can be reduced by controlling the quality of molding sand, such as sand grain size, clay content, and moisture content. From the sand test, it was found that the clay content of the molding sand is very high and the sand particle size is coarse. This resulted in various sand-casting defects such as impact holes, compaction, sand inclusions, etc. It is very important to take preventive measures to improve quality and productivity at the industrial level. Sand casting defects can be successfully reduced by following proper practices such as proper melt treatment, optimum sand quality, correct casting temperature. All rights reserved. Sand casting defects can be successfully reduced by following proper practices such as proper melt treatment, optimum sand quality, and correct casting temperature. All rights reserved. Sand casting defects can be successfully reduced by following proper practices such as proper melt treatment, optimum sand quality, and correct casting temperature.

Keywords: Casting defects; sand grains; clay; solidification; compaction; molding; aluminum components; CAD modeling.

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1. Introduction

Sand mold casting is used for small-volume production. The sand prepared or used in this casting is used to make molds. The liquid metal is then poured into molds to obtain cast products. The quality of sand casting depends on the composition of the casting sand, the quality of the pattern, and the melting process. Dimensional accuracy of the material, surface finish, and pattern plays a very important role in casting quality and reducing casting defects. To minimize casting defects, allowances are made for patterns according to the casting material. The properties of sandblasting, such as permeability, strength, fire resistance, and collapse, are properly controlled, which reduces the number of casting defects in sand-filled products. The gating system must be properly designed so that the mold cavity is filled in the minimum possible time, which reduces the chance of incorrect casting defects. It also helps the liquid metal to flow without turbulence. As a result, defects caused by air aspiration can be reduced. Casting defects such as shearing and washing can be reduced by maintaining directional hardening during casting. Thus, the erosion of the mold walls can be controlled. This leads to increased productivity and reduced casting defects. Sandblasted aluminum components are widely used in many applications such as agricultural equipment, automotive, and transportation industries. But reducing sand casting defects is very important, so every step is very important to identify the causes of sand casting defects, such as the melting process, casting technique, solidification process, and mold removal. Finally, cleaning, finishing, and inspecting castings are also very important. The smelting process involves melting metals and treating them with a solution. Melt processing includes fluxing, degassing, and alloying processes. Thus, casting defects caused by gases such as O_2 and H_2 in cast products can be minimized. The correct temperature during melting is essential to maintain fluidity during the solidification process.

Metal hardening in sand casting is very important to reduce casting defects. Defects in the solidification process can be reduced by properly designing the gating system to achieve directional solidification during sandblasting. Casting defects such as shrinkage and hot cracks can be reduced. The mold removal step involves removing the mold without causing any damage. There is no problem with disposable molds that are destroyed after each casting. However, proper care must be taken to avoid casting defects in the castings in the molds used frequently. Cleaning and finishing castings are very important to reduce texture defects. This involves removing extra metal in the form of the door and riser using a grinding process.

1.1. Casting defects and methods of their elimination

a. Gaseous defects. These defects include impact holes, pinholes, porosity, and air inclusions. These defects are related to moisture evaporation, low permeability, poor ventilation, and poor door system. The gating system must be properly designed to avoid gaseous defects.

b. Shrinkage Defects – Shrinkage defects are associated with unfavorable temperature gradients, low fluidity, and lack of directional solidification. These disadvantages can be minimized by the proper placement of the chills and the design of the feeding system. Improvements can be made by improving the liquid injection temperature and proper positioning of the riser in the mold box.

c. Defects of poor molding material – due to improper properties of casting sand, casting defects such as cutting, washing, penetration, swelling, and falling are formed in cast products. The main reasons for the aforementioned defects are poor strength, poor refractoriness, poor compressibility, and large sand grains. Cuts and washes are caused by erosion of molding sand as a result of turbulence during the sand casting process. Penetration casting defects are associated with high melt temperatures and coarse sand. Sometimes sand is fused with molten metal due to poor refractoriness, so the right clay should be used. In the swelling defect, the volume of the casting increases, which can be minimized by the correct selection of the lifter. Sand casting defects can be avoided by proper compaction of molding sand

d. Poor Cast Metal Defects – Casting defects such as gas/sand inclusions can be reduced by choosing a good quality melt metal. Casting defects such as cold sealing and misalignment can be avoided by increasing the fluidity of the molten metal. Cold shuts can be reduced by a proper gating system and by increasing the pouring temperature of the molten metal

e. Metallurgical Defects – Casting defects such as hot cracks are associated with low strength of the molten metal at high molten metal temperatures. This results in high residual stresses in cast products. Casting defects such as hot spots are associated with high cooling rates in certain parts of castings. They can be minimized by using chills in these sections of castings.

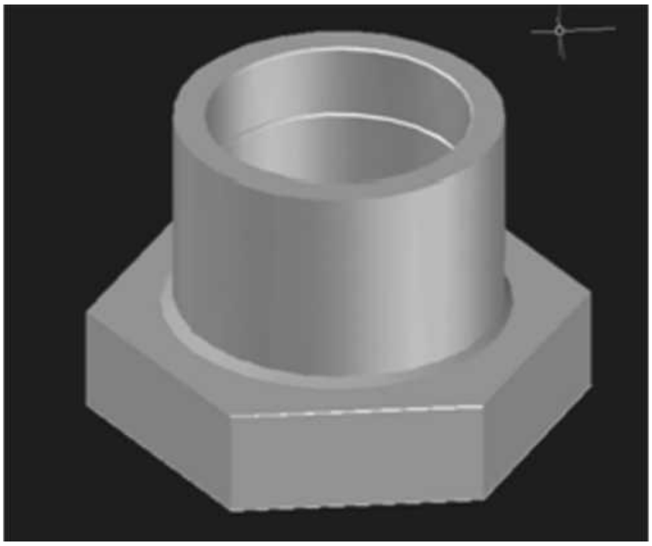

Figure 1. CAD modeling of the socket pattern.

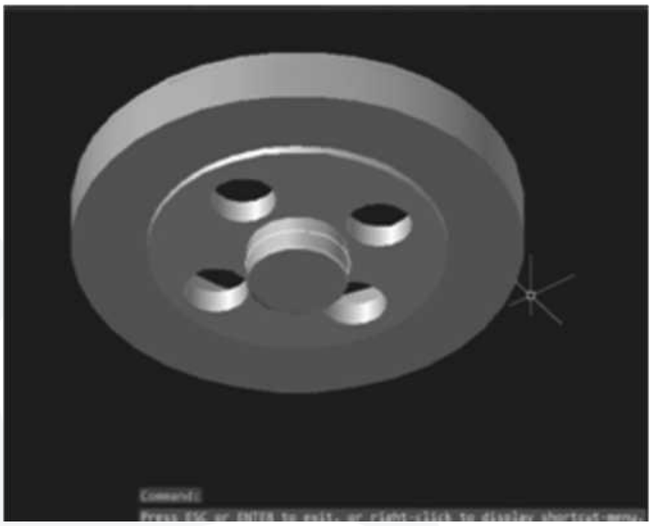

Figure 2. CAD modeling of the connection

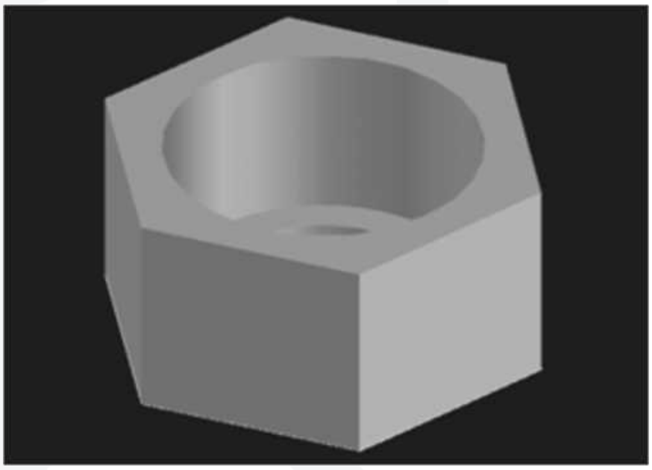

Figure 3. Hexagonal nut

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2. General information about literary sources; Literature review

In [1], the casting defects of gray cast iron cylinder liners were studied to identify the possible causes and to take measures to eliminate them, as well as to consider the optimization of the effect. The use of computer-aided manufacturing is explored [2] to eliminate casting defects such as porosity, holes, and shrinkage voids. In [3], casting defect analysis is proposed using a method that combines computer-aided casting simulation and design experiments and subsequent optimization of process parameters leading to rejection minimization. The effect of riser location and heat dissipation rate on casting defect is discussed here [4]. The rate of heat dissipation is proportional to the ratio of the surface area to the volume of the casting, which reduces casting defects due to the directed and faster solidification of liquid metals. In [5], casting defect locations were identified using transient heat transfer analysis during solidification simulation, thereby eliminating defects such as porosity and shrinkage and effectively assisting component design. Analysis of green sand casting process parameters of SG cast iron solid coupling [6], to determine the effect and level of process parameters on casting defects and achieving optimal settings. In [7], the precise numerical control casting method requirements are discussed, which can help to cement the intelligent and numerical control of casting.

Figure 4. Electric stove.

Figure 5. Casting the socket with sand.

Fig. 6. Casting the propeller with sand.

FEM-based software analysis is performed on two feeder systems [8] to identify hot spots of casting defects for design and optimization considering convective and conductive heat transfer during sand casting. And [9], optimization of the gate system in sand casting for Aluminum-based A356 alloy is carried out by determining important process parameters using dispersion analysis and the Taguchi method to reduce casting defects and improve casting quality. Response surface methodology is then used to establish the relationship and response objects in the process parameters. Optimization of process parameters such as casting temperature, moisture content, and binder percentage for aluminum-magnesium alloy casting is carried out using the Taguchi method. [10-13], to reduce casting defects and increase the yield percentage of casting acceptance. The review mainly shows work on the optimization of various parameters of the casting process to reduce casting defects and thereby improve quality. Experimental and FEM-based software analyses are used to achieve optimal parameters. It suggests taking preventive measures and following good sandblasting practices to improve quality and productivity.

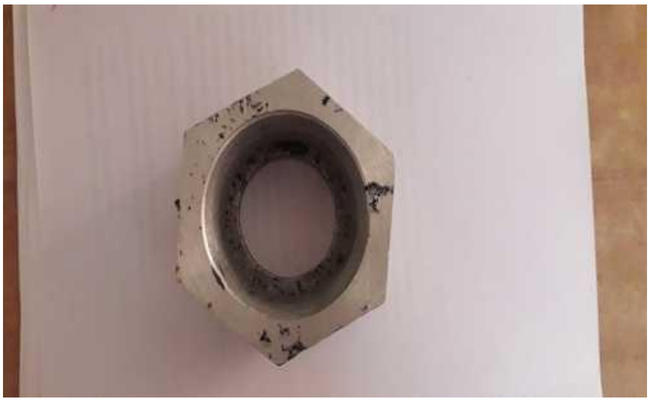

Figure 7. Sandblasting the hex nut.

Figure 8. Casting the coupling with sand.

3. Experimental work

The following steps are used in the analysis of casting defects.

3.1. Cad modeling of patterns

At this stage, the drawings of all patterns were made using CAD modeling software (Fig. 1. Fig. 2. Fig. 3).

3.2. Production of patterns

Metal patterning is done with appropriate patterning allowances such as shrinkage to compensate for all losses caused by casting temperature, machining allowance, and melt inclusions to minimize casting defects.

3.3. Casting products with sand

The rest is done with the help of a pattern with the correct design of the door system. After that, the pattern is removed to get the mold cavity. The metal is melted in an electric furnace as shown in Figure 4 Using proper casting practices to achieve directional solidification in the process. Finally, the metal is allowed to cool. The mold is broken to obtain a hardened casting and cleaning is done using grinding and sand/blasting machines.

3.3.1. Molding sand testing

In the foundry laboratory, the following tests were conducted to measure the quality of the sand used to make the molds.

a. Clay Content Test – Conducted to measure the amount of clay present in foundry sand. In this test, 100 g of sand sample was taken and 25 cc of standard NaOH solution was used for testing in the experiment. Other equipment is a mud washer, oven dryer, and weigh scale.

Clay content = [Initial weight of sand sample - Final weight of sand sample]
= 100 g-47.3 g = 52.7 g

Grain fineness number - Determination of foundry sand particle size Sieve particle size. The sieve shaker was exposed to sunlight for 15 minutes, and then the silica sand grains in each sieve were weighed using a weighing machine.

Grain Fineness Number (GFN) = Total Product / Sum of Percent Weight Retained in Each Sieve
= 1673.3/99.93 = 16.74

The experimentally determined grain fineness number of 16.74 was too small. This indicated the presence of very coarse sand particles in the casting sand.

3.3.2. Materials and methods

LM 6 for sand casting aluminum alloy is used for various industrial components such as sockets, impellers, hex nuts, and coupling. The aluminum alloy was melted using an electric furnace as described above.

a. Pouring sand into the outlet
b. Casting the propeller with sand
c. Sandblasting the hex nut
d. Coupling with sand
e.

3.4. Casting defects and methods of their elimination

3.4.1. Blow holes

These defects are found in the casting as shown below Fig. 5-8 and are further divided into pin holes, end ogenous and exogenous impact holes. These defects are associated with air compression during the casting of liquid metal. In aluminum castings, pinholes are formed due to the evolution of hydrogen gas due to its lower solubility

during solidification.
Remedies – Impact pitting can be reduced by avoiding excessive sand compaction, using dry frost, and using fine grains.

3.4.2. Compression

Compression defects observed in the casting as shown below in Fig. 6, 7, and 8. The main causes are the displacement of the mold walls due to the high pressure of the liquid metal. Other reasons are incorrect placement of chills in the cavity of the mold and sudden changes in the thickness of the sections.
Remedies – These defects can be avoided by a proper feeding system and proper positioning of the lifter in the mold. Proper use of cold to promote directional solidification also helps minimize shrinkage defects.

3.4.3. Addition of sand

This is one of the most common defects in sand casting, and how found in all castings Figs. from 5 to 8. This is caused by the erosion of sand by the hot metal during the casting of liquid metal. Other causes are uneven mixing of sand and improper casting practices.
Treatments – This can be prevented by using more bentonite in the molding sand. Proper casting time and uniform collision are other measures to minimize sand inclusions.

3.4.4. Blinks

It is excess material from the casting that appears as a thin layer perpendicular to the face of the casting. As shown, it is found in castings Figs. 5 and 8. This is due to high injection pressure and poor pattern design. Other causes are improper compaction and improper cleaning in mold boxes.
Remedies – This can be minimized by sealing the mold box near the parting line. Another safety measure is to properly adjust the core in the mold cavity.

3.4.5. Copper run

This is Figure 8 associated with the lower liquid of molten metal. Other reasons are insufficient ventilation and back pressure during pouring. This can be reduced by properly designing the door system. In the liquid metal casting process, the casting temperature must be high to maintain fluidity. Other safety measures include cleaning the mold box before the casting process.
Other means to prevent casting defects include proper pattern selection, the use of

additives in molding sand, and proper feeding practices during casting.

4. Conclusion

Defects can be minimized by controlling the quality of the molding sand, as identified in Casting Defects and Methods of Remedy. The clay content in the molding sand was too high. Second, the size of the sand particles must be good. It was very important to control the quality of cast products in sand casting by applying the steps mentioned above. Proper coating system design and proper casting temperature also play an important role in reducing casting defects.

References

1. N. Kammar, PP Kulkarni, A study on minimization of critical defects in casting process considering various parameters, Int. J. Innov. Res. Sci. Most. Technol. 5 (2016) 8894-8902.
2. AA Chalekar, SA Daphal, AA Somatkar, SS Chincanikar, Minimizing Investment Filling Defects Using Computer Simulation - A Case Study, J. Mex. Most. Automatic. 5 (2015) 43-46.
3. UA Dabade, RC Bhedasgaonkar, Design-assisted casting defect analysis experiments (DoE) and computer-aided casting simulation techniques, Procedia CIRP 7 (2013) 616-621.
4. V. Bijagare, V. Deulgaonkar. 2015, "Modeling and Numerical Element Analysis for Casting Defect in Thin-Walled Structures", 3, 77-82.
5. BV Patel, D. Diwedi, Numerical element analysis of L shape stiffening using casting ansys parametric design, Int. J. Emer. Most. Res. Technol. 3 (2015) 87-95.
6. S. Guharaja, A. Noorul Haq, KM Karuppannan, Optimization of green sand casting process parameters using Taguchi method, Int. J. Adv. Manufacturer. Technol. 30 (2006) 1040-1048.
7. XY Ji, H. Ye, JX Zhou, WL Deng, Numerical control technology and its application to investment foundries, China Foundry 13 (2016) 301309.
8. H. Hussain, AI Khandwawala, Optimum Design of Dumbbell Feeder for Sand Cast Steel: Simulation Studies for Techno-Economic Feasibility, Am. J. Mech. Most. 2 (2014) 93-98.
9. WJ Chen, CX Lin, YT Chen, JR Lin, Gating system optimization design using Taguchi method and culture-based QPSO algorithm for aluminum A356 sand casting using multi-objective, Adv. Mex. Most. 8 (2016) 1-14.
10. Gupta, NM Suri, 2015, "Optimization of process parameters to minimize defects in Al-alloy casting", 2, 1774-7.

11. Urinov, K. O., Jumanov, K. A., Khidirov, A. M., Urinov, S. K., Abdiyev, J. M., Jumaboyev, T. A., & Eshmirzayev, M. R. (2020, April). Magnetocaloric effect in polycrystalline cobalt. In *Journal of Physics: Conference Series* (Vol. 1515, No. 2, p. 022079). IOP Publishing.
12. Saidov, A. S., Saparov, D. V., Usmonov, S. N., Kutlimratov, A., Abdiev, J. M., Kalanov, M., ... & Akhmedov, A. M. (2021). Investigation of the Crystallographic Perfection and Photoluminescence Spectrum of the Epitaxial Films of (Si2) 1-x (GaP) x \left(0≤x≤1\right) Solid Solution, Grown on Si and GaP Substrates with the Crystallographic Orientation (111). *Advances in Condensed Matter Physics*, *2021*, 1-8.
13. Saidov, A. S., Usmonov, S. N., Karshiev, A. B., & Abdiev, J. M. (2022, December). Influence of the varizonal Si1-xGex solid solution composition on the thermovoltaic effect in n–Si–p–Si (1-x) Gex structure. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1112, No. 1, p. 012040). IOP Publishing.