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Development of Salt Core Use as an Alternative in Aluminum Alloy Castings

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Abstract

For creating complex geometric shapes in the cast part, salt was used to produce core instead of sand which is thermo-chemical or chemical process using resin as a binder. In salt core casting, the efficiency will be increased by reducing the core gas-induced errors in the part. The harmful effect on the environment will be reduced with the absence of odor and smoke from the core gas. Using water in salt core breaking instead of mechanical impact and vibration during sand core breaking will bring benefits such as eliminating the noise source and using less energy. By eliminating the dust generated during sand core breaking, its harmful effects on the environment will be reduced. Since the salt core can be dissolved in water and removed from the piece without any residue, there will be no problem of sand remaining in the sand core from time to time.

Keywords: Core gas, sand core, salt core.

1. Introduction

The geometries of casting parts used in the automotive industry are quite complex. In casting molds of complex parts, steel cores (sliders) are often not sufficient in terms of both castability and casting quality[1,2]. Sand cores are generally used in the production of parts with complex structures and internal cavities, where steel cores cannot be used. Sand cores are produced by cold-box (polyurethanes as binders) or hot box (alkali silicates) method [2]. The use of salt cores instead of sand cores has been known and developed since the end of the 20th century, especially in the field of gravity and low pressure die casting work continues [3-9]. Better mechanical properties, easy removal from the part by dissolving in water without using any chemicals and reduction of waste after casting have made the development studies of using salt cores instead of sand in aluminum alloy castings important [10]. In the literature review, there are studies on the strength of salt cores [11]. The use of salt cores in high pressure casting has also been observed to have positive effects on the solubility and environment of these cores [12].

There are various methods of producing salt cores. It is one of the methods of producing salt in core molds made of metal, wood by turning it into a slurry with fast-hardening mixers [4]. In addition, salt cores are produced by injection casting method using melted salt (from the liquid phase) [13]. The important advantage of being produced from the liquid phase is that it gives a high level of mechanical and thermal stability [13]. Its high strength allowed it to be used in injection molding. In addition to high strength, it has advantages such as very smooth surface quality, no gas escape in the casting, no casting faults due to this, easily dissolving from the part with pressurized water and removing it without residue. In terms of the casting mold used, easy cleaning without residue and not causing any wear such as sand are among its advantages. The fact that it does not have any negative effects on human health or the environment, and that it is recyclable, is also one of the advantages of salt cores over sand cores. The first automatic salt core production facility in the world is Bühler's technology center in Uzwil. It was established as a pilot plant for small series production parts [13].

2. Materials and Methods

The trials were carried out with the pump body part, which was poured into a gravity mold by tilting (Figure 1). Due to the structure of the part, it is a part that is difficult to discharge sand core and evacuation of core gas in the current process.

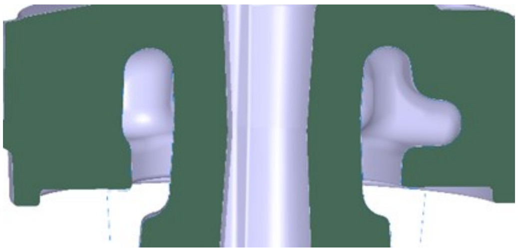

Figure 1. Sectional view of the pump body.

The internal cavities of this casting part are formed with sand cores in the current mass production. In order to use high pressure casting method for the production of salt cores to be used instead of sand cores, an injection mold with one chamber was designed for the salt core. The runner and air evacuation pockets were made using injection filling calculations according to the core geometry. Since the existing tilting casting mold will be used, the reference and fixation points, namely the core heads, are designed to have the same geometry in the salt core. Cooling channels are opened in the upper and lower holders of the mold.

There are also steel cores on both sides of the mold. Injection mold manufacturing was done according to the design (Figure 2.1, Figure 2.2).

Imported raw materials and casting facilities provided by the company within the scope of the cooperation agreement were used in the trials. The melting point of the salt (NaCl) used is ~ 800 °C, its density is ~ 2.165 kg/m3. Its appearance is crystalline solid and white in color.

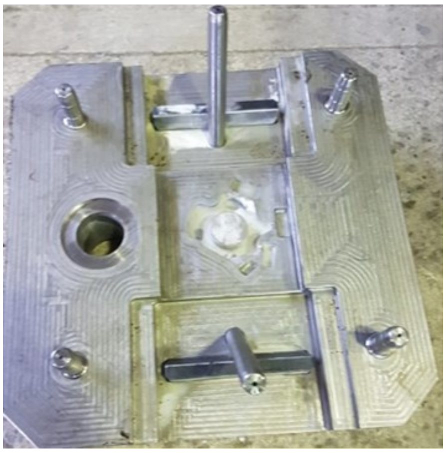

Figure 2.1. Injection mold movable side manufactured for salt core

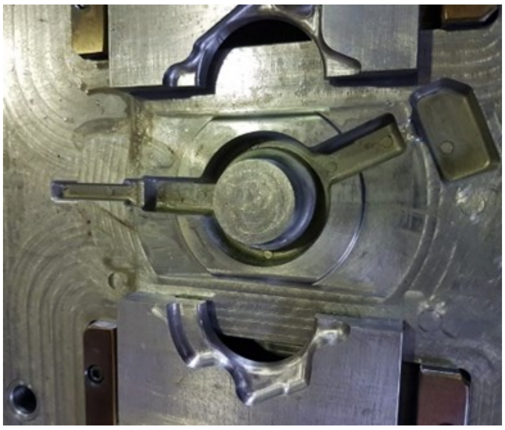

Figure 2.2. Injection mold fixed side manufactured for salt core.

The salt was melted in the crucible, and the molten salt was poured into the steel mold, which was poured with a piston, on the casting bench, as in the casting process (Figure 3).

Figure 3. Salt core injection molding

Initially, a standard general value was given as the shrinkage margin. Salt core laser scanning was done with Faro Edge Scan Arm HD and compared with 3D data model (Figure 4). According to the core scans and the measurement results after the first trial core casting, it was observed that the shrinkage varies in the thick and thin parts of the inner and outer figures of the core, as in metal injection molding. Since the shape and thickness of the core affects the shrinkage, different values of scales are given on the core geometry and the core geometry is created. In the second trial, results were obtained with appropriate measurement values.

In the experiment, it was seen that the cooling in the mold was also very important. It has been observed that temperature change affects the surface quality, scale and core strength of the core.

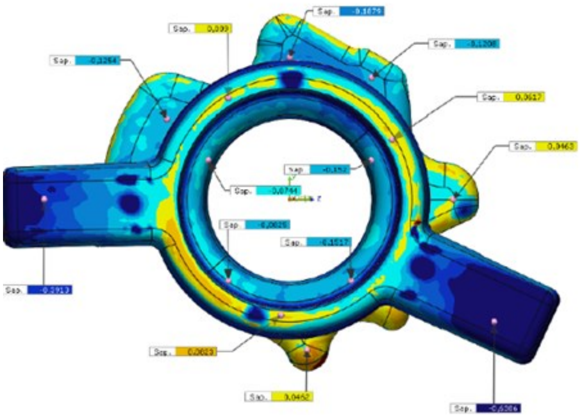

Figure 4. Salt core laser scanning compared with 3D data model.

The temperature change in solidification should not be sudden. As a result of unsuitable temperature change, it formed a fracture due to sudden shrinkage (Figure 5). Shrinkage was more in the thick mass regions.

Figure 5. Salt core exterior surface crack.

Initially, the existing cooling channels in the lower and upper holders of the mold were used. During the trials, cracks occurred in the inner diameter figure of the core (Figure 6).

Figure 6. Salt core inner diameter surface crack visible with eye control.

In order to achieve a more balanced cooling, cooling was added to the core area, which was inserted in the mold, and a separate cooling line was operated (Figure 7). Cracks formed in the inner diameter region were healed by the addition of cooling.

Figure 7. Mold inner diameter core insertion

Surface roughness of salt core and sand core compared. In the salt core, the outer most surfaces solidify rapidly and form a surface film layer, and the roughness value of the core surface was found to be smoother than that of the sand core (Figure 8). Although the grain size of the sand core small, the casting part surface the roughness of the casting is rough compared to the salt core (Figure 8.1).

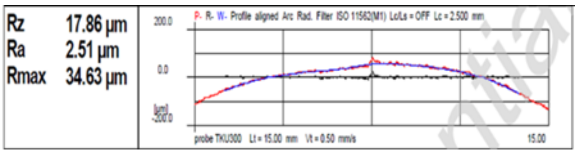

Figure 8. Roughness value measure from the casting part with a salt core.

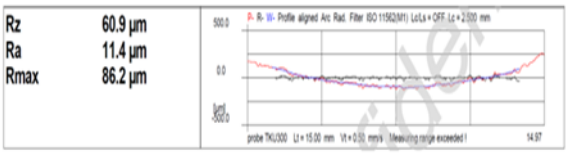

Figure 8.1. Roughness value measure from the casting part with a 60 AFS sand core.

The solidification of the salt core did not reach the inner regions at the same rate. The inner surfaces solidify later as a result of the film layer formed outside (Figure 9).

In addition, the color of the core varies according to the temperature and the residence time in the mold. The salt core produced at low temperature and in a short time is light in color (Figure 10.1).The salt core produced at high temperature and long time is dark in color (Figure 10.2).

Figure 9. Inside view of salt core.

Figure 10.1. Salt core produced in low temperature and short time.

Figure 10.2. Salt core produced in high temperature and long time.

Instead of sand, a salt core was placed in the existing tilting casting mold and a casting tilt was carried out in the same way as the casting conditions in the standard series casting machine (Figure 11.1). The aluminum alloy is robotically filled into the casting ladle (Figure 11.2).

Figure 11.1. Tilt casting machine.

Figure 11.2. Tilt casting ladle.

Figure 11.3. The tilt casting machine rotates 180 degrees.

The tilt casting machine rotates 180 degrees and fills the aluminum alloy steel mold (Figure 11.3). Trial casting cycle time with salt core is equal to casting using sand core used in series conditions.

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Figure 12. The casting part with salt core that comes out of the casting mold.

After solidification, the casting machine returns to the flat position. The mold opens when casting machine is in flat position.

The casting part came out of the mold, it was left in a water-filled couldron.

The salt was dissolved in the core in a short time and was removed from the part without leaving any residue (Figure 13).The salt that settles to the bottom of the boiler can be used for recycling.

Figure 13. The salt that starts to dissolve, the core and the cast part.

The cast part was cut to see its inner surfaces. No salt core residue was found in the indentation areas on the inner surfaces. The salt core dissolved was completely (Figure 14).

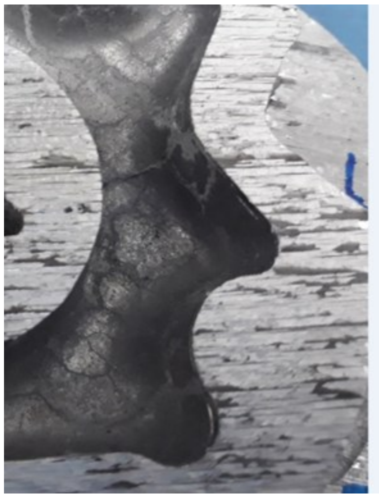

Figure 14. Casting part cross section.

For the cast part, measurements were made and appropriate results were seen. Visually, traces were seen on the surfaces coming out of the salt core on the cast part. The part was cut and polished, traces were examined, it was seen that it did not cause leaks and similar errors as it did not go inside (Figure 15, Figure 16).

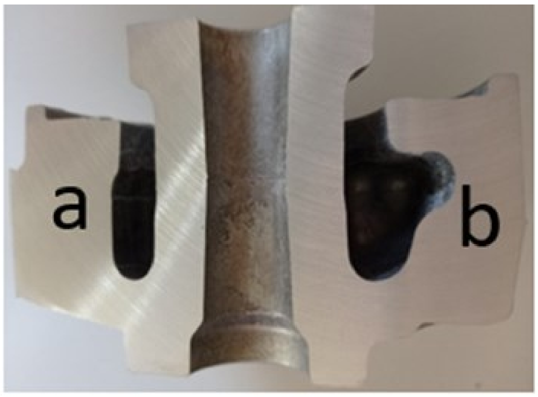

Figure 15. Polished cast part cross-section.

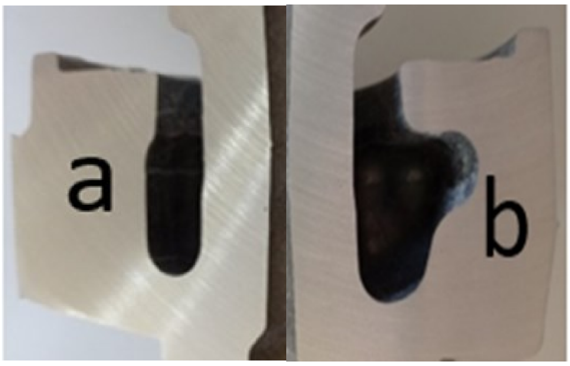

Figure 16. Cast part zoomed images.

3. Results and Discussion

Core gas formed due to resin burning in casting with sand core match was not seen in casting with salt core. During the part casting with sand core resins stack in the steel mold. Resin blocks air filters. Core gas cannot be removed from the mold by blocking the air filters. Therefore the mold is cleaned periodically. Since there is no resin in salt core casting, core gas is not released. After casting, the mold was inspected and no resin stack and air filter blocks were observed.

The use of salt cores instead of sand cores resulted in a reduction in the waste rate by eliminating / minimizing the errors that may occur in the part due to core gas, energy savings resulting from processes such as recycling and recycling and less emission gains.
During the casting process, the harmful effects on the environment are minimized by minimizing the emission of core gas and smoke.

Since the salt core can be removed from the cast part without residue, there has been no sand residue and related problems in the production with sand cores, where the sand does not completely remove from the part.

In the core breaking process, it is one of the advantages of dissolving salt in water with low/zero noise level, which does not require mechanical energy, instead of mechanical methods that require energy consumption and high noise. The sound level, which is 92dB in the pulsed method used to remove the sand from the core, has disappeared since the salt core is dissolved with water.

It is observed that salt cores can remain intact for a long time in humid environments.

Disadvantages are the difficulty in determining the shrinkage value and the increase in the cycle time due to the longer salt solidification time compared to the sand core. In order for the solidification to be homogeneous and to prevent cracks on the core surface, the cooling system and cooling parameters optimization in the mold, used for the core production are the aspects that need attention and improvement.

4. Conclusion

It has been seen that the appropriate results obtained and what has been learned about the salt core process can be a reference to the use of salt cores by injection casting or low pressure die casting method from now on.

Experimental studies examining the mechanical and thermal properties of salt core and comparison with sand core can be done in the next studies.

The possibilities of recycling salt collected in the cauldron and using local alternative supplier can be developed for cost reduction studies.

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Author's Contributions

Tülay Hançerlioğlu: Drafted and wrote the manuscript, performed the experiment and result analysis.

Ethics

There are no ethical issues after the publicion of this manuscript.

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