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Design and Analysis of Salt Core for a Casting of Alluminium Alloys

Core Casting

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Abstract — *casting of light weight alloys like al based on Sand Core are gaining importance in several Industrial and Automobile applications. For replacing the Sand by the Salt to make core for lightweight alloys has been under the research owing of its excellent mechanical properties coupled with easy removal without using any kind of chemicals. Addition of salt core used as core material can reduce the solid waste which is generally generated as the core made up of sand.*

Keywords- *salt, casting applications, solid waste, core, casting, light weight, component.*

I. INTRODUCTION

Salt mixture based cores are used extensively in the manufacturing of cast engine components, blocks, cylinder heads and a wide range of other engineering and consumer products. Specialist precision applications include the formation of internal cooling passages in cast blades and vanes. The most widely used core material is fused silica because of its very low thermal expansion and it can be leached out of the casting, using aqueous or fused potassium or sodium hydroxide. High temperature deformation of silica has proved problematic, as cores have become more complex. Salt cores can produce cavities and holes with a high degree of accuracy and good surface finish. Cores are prepared by a variety of methods.

Salt cores are manufactured using similar methods to sand molds. Some cores are injection molded whilst many are prepared simply by slip casting fast-setting salt mixers slurry or plaster into a core box. The core is then extracted from the mould; whatever the method of manufacture it is then either cured (sand) or fired before use. In the process of slip casting, quick setting slurries are formed in conventional foundry patterns or in standard core boxes made of wood, plastic, plaster, or metal. Setup and equipment costs can be quite modest, particularly when integrated into an existing sand operation.

The use of cores in castings can allow the design engineer a degree of flexibility whilst producing cost-effective components. However, the use of cores may bring with it technical problems and additional costs. For an impeller mould, for example, uniform filling around very thin Salt cores is important to avoid movement or flotation of the core. Although complexity of the casting is enhanced and difficult to machine, features may be incorporated, requiring little or no finish machining; the use of cores is often a compromise in one way or another. Manufacture of a correctly dimensioned core of appropriate strength is only part of the process. It is necessary that the core is stable during the casting process.

The gases generated within the core during casting must be capable of being vented to the outside of the mould, precluding gas porosity and the defect known as a core blow. Complex cores may further be strengthened with metal rods and wires. It is also essential that the core can be removed without adversely affecting the casting. This can be achieved using a suitable reagent that degrades or dissolves the core. Alternatively, it may be possible to use materials that cause breakdown at an appropriate temperature. A core for a light aluminum casting must degrade at lower temperatures, compared with the temperatures that a core must withstand with e.g. steel, which is cast at much higher temperatures.

1.1. Core making process: The core making process may be divided into 6 steps.
1. Die construction – metal, plaster or wood dies
2. Material mixing – time, formulation, test
3. Injection or slip pour – time, temperature, pressure, rate
4. Assembly - (if necessary)
5. Firing – arrangement, time, temperature
6. Inspection - dimensions, removing parting line.

The die usually is a metal (hardened tool steel), also aiding heat transfer if a hot mix is used. The raw materials consist of an aqueous mixture of fine Salt powder with inorganic materials and binders. A vacuum may be applied to remove the air from the core mixture. These materials may be warm or cold when mixed and to remove air from the mixture a vacuum is often applied. An enclosed impeller core box, for example, will usually have a narrow central opening for slurry entry. The mix slurries are prepared by carefully mixing the aggregate and binder, avoiding excessive turbulence. Temperatures of the formulated raw materials, injection pressure, and rate of injection and time of injection are all controlled in the process.

1.2. Core setting

Core setting is the process of placing cores in mould. The cores must be accurate in size and positioned accurately with respect to the mould cavity. Cores are positioned in the mould by core prints. When metal is poured, cores may rise unless they are securely anchored. Advance planning is required so that the cores will be correctly positioned and firmly held when metal is poured.

Small cores are placed in the mould by hand. Larger cores may require a hoist or crane service. A number of cores may be assembled and set in the mould at a time. This usually requires an assembly fixture e.g. for automotive motor-block cores. When transferred to the mould, the core assembly may be bolted together or held together by the fixture. Fixtures or gauges are needed when numbers of cores are assembled at one time since dimensional error may otherwise occur.

II. LITERATURE REVIEW

2.1. Based on Composition

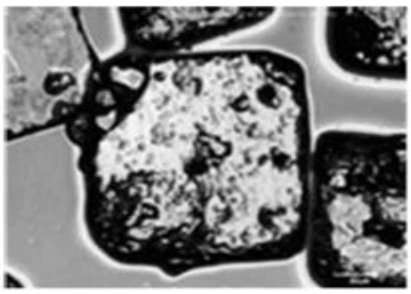
Jun Yaokawa, Daisuke Miura, Koichi Anzai1, Youji Yamada and Hiroshi Yoshii [1] have investigated that the strength of four binary systems NaCl–Na2CO3, KCl–K2CO3, KCl–NaCl and K2CO3–Na2CO3 was investigated in order to develop expendable salt core for high pressure die casting processes. Four point bending test was conducted to determine the strength of specimens made from molten salts by using the permanent mold casting technique. The strength of the system NaCl–Na2CO3 was over 20 MPa at the Na2CO3 composition between 20 mol% and 30 mol%, and between 50 mol% and 70 mol%. The highest strength was about 30 MPa at the composition of NaCl–70 mol%Na2CO3. This strength was 5 times as high as that of commonly used sand cores. The system KCl–K2CO3 also showed 20 MPa in strength. It was observed that there were the primary particles surrounded by the eutectic structure in the solidification structure of the systems NaCl–Na2CO3 and KCl–K2CO3 at the composition where the peak strength was obtained.

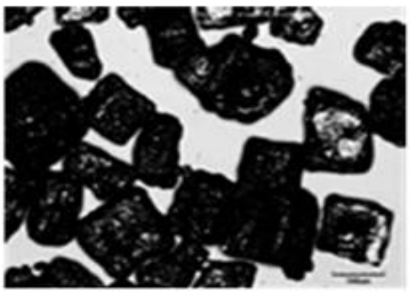
Warwick N. Brown and Peter M. Robinson [2] have worked on Soluble Metal Casting Cores Comprising a Water Soluble Salt and A Synthetic Resin and Found that Water soluble cores uses in the casting of metals, and also methods of making such cores. The cores essentially consist of a water-soluble salt and a synthetic resin.
One form of the core consists of a mixture of a water soluble salt and a liquid synthetic resin binder such as to retain the salt grains in agglomerate. Another form of the core consists of grains of a water soluble salt which are coated with a synthetic resin and subsequently dried to a powder.

Shujing Zhao [3] had first, concentration of polymer, concentration of NaCl, solvent composition, gas-jet pressure and extrudate rate of the solution are five key parameters in the Gas Jet Nanofibers (GJF) process for fabrication of core-shell Nano fibers. Second, the core-shell structure of Nano fibers could be detected by transmission electron microscopy (TEM) only when the fiber diameter was smaller than 300 nm. The presence of NaCl enhanced the contrast between the core liquid and the shell polymer. Third, the solubility of NaCl in the core liquid affects the ionic conductivity of the core and the structure of Nano fibers. Structure of core-shell nanofibers can be broken by NaCl crystals if the solvent remaining in the core is not enough and the amount of NaCl is beyond solubility limit of NaCl in the core liquid. The viscosity of the core solution is reduced slightly with additional NaCl, but remains insensitive to the amount of NaCl up to 0.01 g/ml. This work formed a preliminary study of core-shell Nano fiber fabrication by the GJF method. We focused on the effect of sodium chloride on the core-shell Nano fibers. The research results are also useful for other inorganic salts, like lithium salts. By changing the inorganic salt, this work can be applied to other problems involving electrolytes.

2.2. Based on casting method

Petr Jelinek, Frantisek Miksovsky, Jaroslav Beoo, Eliska Adamkova [4] studied to describe the possibilities of using salt cores for gravity, low-pressure or high-pressure die casting technology. Determinations of the primary, secondary and final residual strengths were carried out in order to evaluate the possibilities of the salt-core utilization. Furthermore, this contribution is focused on developing composite salts with better mechanical properties. The solubility of these cores and a possibility of their reclamation in a closed cycle with positive impacts on the environment were also studied.





Prof. Dr. Philipp Rudolf von Rohr [5] has investigated based on the aluminum automotive components manufactured by die casting have an excellent performance to weight ratio and are therefore an important contributor to the reduction of CO2 emissions by global car fleet. A new technology based on salt cores enables to extend the range of components to be manufactured by die casting also to highly complex parts. In addition, thinner wall thicknesses and enhanced surface quality can be achieved. The lost salt core technology comprises the following process steps:

· Salt formulation
· Casting of salt core
· Die casting of Al (steel mold with salt core inserts)
· Removal of salt core by power washing

III. EXPERIMENTAL DETAILS

Based on the exhaustive literature survey, it is conclude that manual method of the core making methods have a major impact on the research as to ensure that the error can be considered as a manual error. This phase includes the detail of the experiment that is to be carried out for the development of a Salt Core. The material tested has been done and approved for the experimental work by the comparison with standard data of that material.

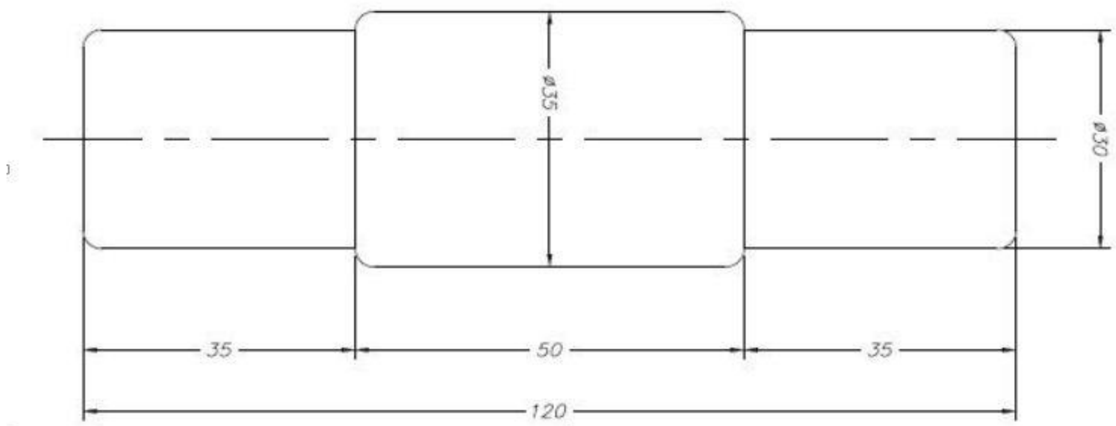
For the detailed analysis of salt core we have made cylindrical shape core for pilot testing. Then casting is performed on the prepared salt core to study the quality characteristics. For the sake of clarity visual basics, photographs of equipment's / instruments that have been used in this work are also presented according to their place of use.

3.1. Selection of materials

Commercial grade Sodium Chloride, Sodium Carbonate and Phenol Formaldehyde Resin were obtained from Zahabi Marketers Pvt. Ltd., India. The Aluminium particulates were obtained from the market.

3.2. Core design

The use of cores in castings can allow the design engineer a degree of flexibility whilst producing cost-effective components. However, the use of cores may bring with it technical problems and additional costs. For Guide Pin Housing, for example, filling around cores is important to avoid movement or flotation of the core. Although complexity of the casting is enhanced and difficult to machine, features may be incorporated, requiring little or no finish machining; the use of cores is often a compromise in one way or another. In the figure shown below the core design for guide pin housing used in shell core shooter machine.



3.3. Core making

Manufacture of a correctly dimensioned core of appropriate core hardness is only part of the process. It is necessary that the core is stable during the casting process. The gases generated within the core during casting must be capable of being vented to the outside of the mould, precluding gas porosity and the defect known as a core blow. Complex cores may further be strengthened with metal rods and wires. It is also essential that the core can be removed without adversely affecting the casting. This can be achieved using a suitable reagent that degrades or dissolves the core. Alternatively, it may be possible to use materials that cause breakdown at an appropriate temperature. A core for a light aluminium casting must degrade at lower temperatures, compared with the temperatures that a core must withstand with e.g. steel, which is cast at much higher temperatures.

So , while core making we have consider this facts and made the core with the help of the mixture of salt and 10% of the resin added as a binder material which has given the best results as shown in the figure

3.4. Core drying

Other than metal cores, all cores may be given a controlled "pre-heat" to reduce the thermal shock of firing that may have a very adverse effect on core properties. The salt core is subjected to a heating at 150°C temperature. This process will also remove any residual moisture content on cores. The time and amount of firing of the core depend entirely on the composition of the core, the type of binder used and the size of core. The binder changes chemically and molecularly from powder to solid by oxygen absorption and polymerization

Suitable heating is very important for the good performance of the core. If a core is heat treated for a small amount of time, it could give off much gas during pouring and solidification. A core heated for a long period may become brittle and collapse under the force of the molten metal or again during casting. Heating of the salt core in the furnace confirms the core to a surface of the "setter" to reduce distortion of the core and improve yields of cores within preselected dimensional tolerances

3.5. Mechanical properties testing

Batches of ten core trial (1-5) were produced for mechanical property testing and one sample for casting purposes. Other core compositions (6-10) have grinded material.

3.5.1 Core Hardness

To determine the capacity of core the hardness test is done with the core hardness tester. According to industrial need if the core is having hardness more than 70 then the core is accepted and from the test we found core hardness for salt core trial 1 and trial 2 are respectively 82 and 92 which is shown in the figure

3.5.2 Compressive Strength

The Compressive Strength test produces the maximum capacity of load pressure that can be sustained by the core. The test pieces were mounted in a computer controlled KELSONS Universal Strength Machine (UTM) shown in Figure.

IV. RESULT AND DISCUSSION

The core composition results and discussions have shown that the use of finer mesh sizes of sand provides better finishing compared to salt core materials which also increases the strength of cores with smooth surfaces. The salt core composition demonstrates that mixed slurries have a standard slurry working life. As discussed, the grinding of binder material used in salt core composition has shown that by grinding the material we can achieve the smooth surface finish but doe to that the binding capacity reduced and the core became brittle and also found reduction in the compressive strength. But though according to hardness test we have found satisfactory results for trial 2.

Test Results:

Types of Core	Hardness	Compressive Strength
SAND	80	13.49
SALT Trial 1	82	9.11
SALT Trial 2	92	7.94

The compressive strength of the core from trials decreased by more than 20% due to changes in the binder particle size. The use of finer particles of binder improved the mix and produced a smooth flowing, easy pouring slurry, with acceptable setting and removal from the casting. Since the use of nitric acid is not environmentally friendly, citric and acetic acid were adopted to leach out the cores. Higher concentrations of citric and acetic acids attacked and leached the core trials in less time. Lower concentrations of acid took a longer time to leach the cores. While casting made with salt core removed easily with the help of manually water injected at very less force.

V. REFERENCES

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