# Magnetic mould casting: technical review and methodology

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**Abstract**- Casting is a manufacturing process, which is used directly or indirectly in almost every industry. It is a primary manufacturing process and has its effect on the properties of the resultant product. In this era there is a demand to innovate processes, which can reduce lead-time, reduce cost of production without compromising with the quality of the products and reduce ill effects on environment. Magnetic mould casting is an innovative process having a great potential to replace conventional casting methods due to various advantages associated with it. The setup of MMC includes winding of copper wire such that it behaves like a solenoid with hollow cavity in which actual casting process is to be carried out. The setup was prepared with copper wire of 19 gauge and winding is done until required magnetic field is created. The prepared setup and trial runs shows that there is a scope of creation of similar setup at large scale so that MMC can be used at industrial level to utilize its advantages of reduced cost, reduced lead-time, reduced effect on environment and imparting improved properties to the resultant product.

**Index Terms**- Magnetic moulding, Magnetic mould casting, Experimental procedure of magnetic moulding, steel shot mould.

## 1 INTRODUCTION

CASTING is a manufacturing process that can be performed in a number of ways. The type of process employed for casting has an effect over properties like surface finish, microstructure, hardness, toughness, etc. of the resultant product. In modern days industries there are many factors, which affects the decision of selecting the type of casting process to be used. This includes properties of cast product, cost incurred in manufacturing, lead-time, and environmental effects of the process.

Magnetic mould casting (MMC) is an application of electromagnetism to the process of casting. Steel shots constitute the mould that is formed by application of magnetic field on them. The application of magnetic field that induces magnetic bonds between steel shots which gives strength to mould. This reduces the time elapsed in ramming process. Also, breaking of mould becomes easier by using magnetic field, as it is required to switch off the supply to turn down the magnetic field and mould breaks.

MMC process employs a one-piece mould and an EPS (expandable polystyrene) pattern, which gives an advantage of cast products being free of defects associated with joint line (Geffroy et. al.). Also the products have better dimensional tolerances than the products obtained from conventional methods. The amount of machining required is less thus reducing the time and cost involved in finishing a product for use.

The mechanical properties like tensile strength, impact strength and hardness of the products cast from MMC have higher values as compared to sand casting products (P. Gnanavel). The reason behind this improved might be the higher solidification rate of steel mould as its thermal conductivity is more than the sand mould (Geffroy et. al.).

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A major concern related to casting is environmental pollution. In casting, foundry waste is released, which is directly related to type of molding technique, type of furnace and type of metal used. In sand casting sand once used gets burnt and is of no use, thus adding up to foundry waste whereas in MMC steel shots can be reused and magnetic field had not any effect on the worker's health. Therefore MMC is an ecofriendly process as waste generation is minimum and due to reusability of mould material.

This process is still in its research phase. There is no evidence of its use in any industry till now but it can be used as a replacement of conventional methods of casting as this process has certain advantages over them.

## 2 EXPERIMENTAL SETUP

- Dimensions of mould box:
  Hollow cylinder of Diameter = 200mm and Height = 250mm is made by winding copper wire over hollow core of steel. Steel is used as core so as to confine the magnetic field inside the solenoid since steel has high magnetic permeability.
- Copper wire of 19 wire gauge is used to sustain the current for required time period of experiment without damage due to heating.
- Iron container- It is made up of pure iron sheet of 1mm thickness rolled into the shape of cylinder of 180mm outer diameter and 250mm height and closed at one end.
- Power supply- Constant DC power supply is provided with the help of single-phase 0-250V autotransformer and a bridge rectifier of 230V and 10 A rating is used.

- The numbers of turns were decided by checking the magnetic field value at different values of turn and winding was stopped when required field value was obtained. Hall effect sensor is used for the detection of magnetic field produced inside the mould box. The mould box is designed to produce magnetic field from 0-0.5 Tesla

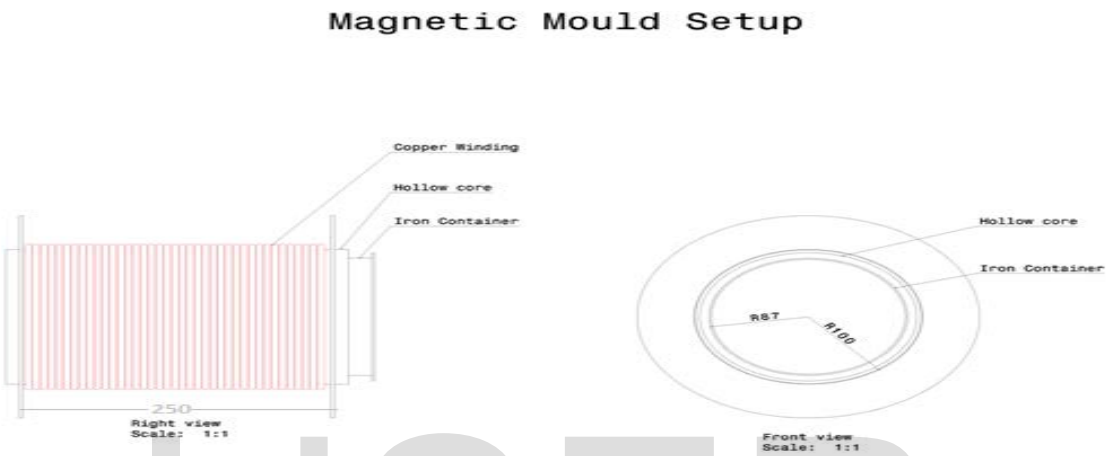


Fig. 1 CAD model of magnetic mould.

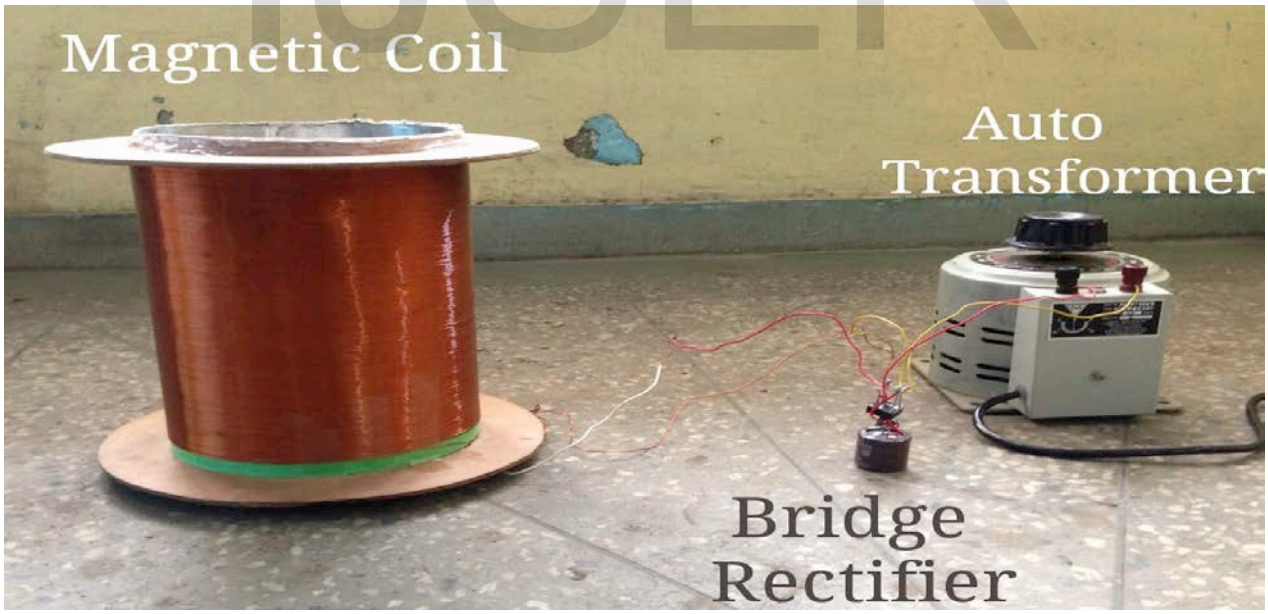


Fig. 2 Fabricated setup.

## 3 EXPERIMENTAL PROCEDURE

Initially parameters for MMC are decided. First step is to select a design of magnetic setup and to define parameters like gauge of copper wire, intensity of field required, size of steel shots, composition of steel shots, size of expendable polystyrene pattern and refractory coating on its surface. The following steps are followed to perform magnetic mould casting:

**1. Preparation of magnetic setup:**

A hollow cylindrical box of aluminium is used to wind the coils over it. Copper wire of 19 gauge is used. 6.5 kg of copper coil is used for coiling. An iron box is inserted into the mould box to form the core for magnetic field.

For supply to the copper coil, a power rectifier in series to auto transformer is connected. Ac supply is given to autotransformer through which voltage is varied. Output of autotransformer is connected to power rectifier, which converts ac to dc, and this dc output supply is given to copper coils.

**2. EPS pattern and refractory coating:**

EPS sheet is cut into the required pattern shape. This pattern is going to vaporize during the casting process. Refractory coating of pattern plays a vital role in MMC, it forms a physical and thermal barrier between pattern and magnetic mould, this coating prevents the diffusion of melt into the steel shot mould (Pierre-marrie Geoffrey et. al.).

Fire clay is used for refractory coating of pattern. Its chemical composition is 30% aluminium oxide, 60 % silica and rest is MgO, CaO and iron oxides. It can withstand a temperature of 1600'C. The pattern is dipped into the fire clay water based slurry, which is a refractory coating. A constant thickness of slurry over the pattern is maintained. The pattern is then allowed to dry at room temperature.

**3. Formation of magnetic mould:**

Steel shots are filled in the mould box and then EPS pattern is kept in center and steel shots are kept pouring. Steel shots are poured up to the level of pouring basin. After the settling of pattern in surrounding steel shots supply is switched on and magnetic field is applied on steel shots. These steel shots gets bind to each other due to magnetic force and thus a mould comprising of steel shots around the pattern is formed. Increasing field intensity, which can be increased by increasing the voltage, increase strength of mould. Voltage can be increased by using autotransformer up to a certain limit only because higher value of voltage may lead to burning of coils.

**4. Casting:**

Aluminium that is having application in various industries like automobile, consumer goods, defense, construction etc. is cast by MMC. Aluminium melt is prepared by using a furnace. This melt is then poured into magnetic mould. While pouring EPS pattern got vaporized and the melt took the place of this pattern, after 8 min 30 sec the magnetic field is turned off by switching off voltage supply and mould collapses suddenly. The cast is then taken out and allowed to cool down to room temperature.

The small casting from MMC is successfully prepared.

## 4 CONCLUSION

A magnetic mould casting setup was successfully prepared. Small castings of aluminium were prepared with ease and it was observed that the surface finish of the product is really good and this characteristic can be used to cast complex shapes as the amount of machining required is less with good surface finish. With the use of this process advantage of permanent mould casting and lost foam casting can be utilized and thus complex and quick casting can be produced. Because of the use of magnetic mould as a permanent mould in this process, MMC would be ecofriendly process as compared to sand casting.

## 5 REFERENCES

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