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Mold Constant for Casting of Non Metals Hma and Shellac

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ABSTRACT

Casting is a well known process for producing metallic or non metallic products in small scale up to mass quantity. Casting process is widely adopted to produce objects vary in shape form simple to complex in nature. It is a simple accurate and fast process with minimum scrap generation. As we have studied in the field of manufacture casting especially is generally comes in context with metal that is it generally meant to metal. Also most of the research and work have been carried in casting taking metals. Few of scholars have done their research related to casting of non metals. Casting of non-metallic multi-materials is rare to find. This paper work is on sand casting of non-metallic multi-materials i.e. hot melt glue and shellac. The aim of this work is to critically review all the aspect related to sand casting of hot melt glue and shellac and to measure and analyze all parameters related to this sand casting process. This paper is for finding mold constant with respect to weight percentage of casting of two non-metallic multi-materials hot melt adhesive and shellac.

Keywords : Casting, non-metallic multi-material, mold constant.

I. INTRODUCTION

Metal casting is one of the earliest manufacturing techniques known to mankind and a very direct, fast and economical method of producing metal parts [1]. Castings range in weight from less than an ounce to single parts weighing several hundred tons. Various types of product shapes and dimensions in different sizes can be produced with the help of casting now days. Due to its versatility and economic nature metal casting has been one of the important near net shape manufacturing technology [2]. The traditional and most common method used is sand casting. It has still more importance and near about 70 percent of the cast product were produced using this method only. There are various parameters related to sand casting process like mould filling time and solidification time, mould constant, volume flow rate, casting yield. Mould constant is among the crucial aspect of casting process [3].

The mold constant can be calculated using Chvorinov's rule i.e.

$T_s = \gamma^2 C$

γ = casting modulus which is ratio of volume and surface area of the casting

C= mold constant given by Chvorinov.

Then,

$$C = \frac{T_s}{\gamma 2}, \quad \gamma = \frac{\text{volume of casting}}{\text{surface area of casting}}$$

Chvorinov's rule "For calculation of the solidification time made possible to determine chilling effect of foundry moulds [5]. The constant used in the solidification time is called solidification constant. The term of solidification constant was introduced in foundry specialized literature by N. Chvorinov. Or we can say that the word Chvorinov ´s means solidification constants or also called solidification factor or mold constant. The casting with large surface area and small volume will cool more rapidly than a casting with small surface area and a large volume [6].

II. LITERATURE REVIEW

In this chapter we will discuss about previous works done by different author in the field of casting. We will have some brief of their views about the different casting process, casting defects, casting parameters and other aspects related to casting. Some of the literatures we have studied are as follow. **B. Ramesh Chandra et. al.** worked on casting simulation software. He emphasized on casting tools which facilitates foundry engineers to use better simulation software. Casting simulation provides facility to visualize mold filling and casting solidification. **Sumaiya Shahria, Md. Tariquzzaman, Md. Habibur Rahman, Md. Al Amin, Md. Abdur Rahman et. al.** the aim of their research is to reduce the defect of aluminum casting by finding the optimum proportion of water and bentonite clay added to recycled mold. In the industries of aluminum casting, the foundry engineers find the quality of the sand mold as important aspect to achieve high quality with minimum defect aluminum castings. **Bhushan Shankar kamble et. al.** project aimed at analysis of various casting defects in medium scale foundry industry. A defect in castings cannot just happen itself. They occur because of mall practice in manufacturing cycle that does not get properly controlled and something done wrong. **R.G.CRAIG, J.D.EICK, and F.A.PEYTON et. al.** their analysis was aimed at evaluating the strength and properties of wax at various temp and its various applications. In this study, the strength properties of modulus of elasticity, proportional, and compressive strength were measured on three principal natural waxes used to com- pound casting waxes and on several commercial dental casting waxes at temperatures from 230 to 40'C. **Gang Pu, Jinfeng Wang, Steven J. Severtson et. al.** they have analyzed the properties of paraffin wax. Study aimed at enhancing the performance of paraffin wax based materials for barrier coating applications. Nanocomposites produced by ultrasonic processing with paraffin wax matrices and reinforced with organically modified montmorillonite clay have resulted to perform significantly improved mechanical properties. **Bam, S. A., Akaaza, J.N. & Iorstsor et. al.** their study was about the application of expandable polystyrene foam (EPS) as pattern material in sand casting. The EPS foam and the traditional wood were used separately and shaped to give the University logo and both used as pattern martial in sand casting. **Abd Rashid et. al.** worked on packaging industry prefers to use hot melt adhesive based on polyolefin due to the fact that polyolefin provides ease of processing, low off-taste, low smell and heat-seal ability. he shows Ethylene Vinyl Acetate (EVA)-based hot melt adhesive with the same properties of polyolefin-based hot melt adhesive (HMA) since Eva offers lower cost than polyolefin. **Sonu S. Bansod et .al.** worked on sand casting of non metallic multi materials. the purpose of

his work is to review critical factor of casting & perform experimental setup of sand casting processes using two non metallic material & comparing the various casting processes parameters with sand casting by economical consideration parameter (i.e. cost, quality, performance, production time, surface finish, output etc.

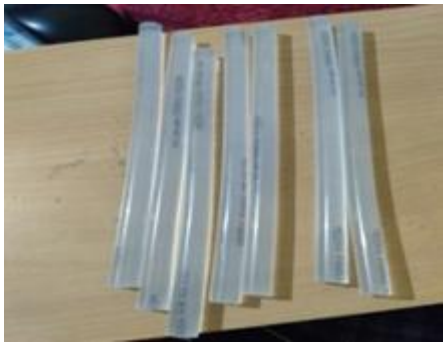
III. METHODS AND MATERIAL

3.1 Casting Materials

We have used two main materials which are non metals

First material is Hot Melt Adhesive & the second material is shellac (lac).

Hot Melt Adhesive



Shellac

3.1.1 Hot Melt Adhesive Hot melt adhesives are generally 100% solids made of thermoplastic polymers base. They are solid at room temperature and are softens on heating become liquid and hence can be processed. After application they remain wet until solidifies. Upon solidification, they become rigid and act as an adhesive. These adhesives can be used to create bonded joints that are thermally separable and can also be re-joined. HMA is also known hot melt glue or thermoplastic glue. Basically there are two main varieties of industrial hot melt adhesives: ethylene-vinyl acetate (EVA) and polyolefin, or metallocene. EVA is a copolymer adhesive; mostly used in the paper, packaging, and assembly industries, as they make joint to a variety of cellulosic materials and have a long range of formulation [7].

3.1.2 Shellac A resinous substance is excreta of the female of the lac insect, Laccifer lacca, native to India. The insects mainly deposits lac on the twigs and gentle new branches of several varieties of soapberry and acacia trees. The color of shellac varies from a pale yellow to a deep red. Shellac is soluble in alcohol and is used to produce the high gloss on French polished furniture. Shellac can be divided in to parts by the use of ether. The part which is soluble in ether is called soft resin which is sticky and viscous. The portion which is insoluble in ether is called the hard resin which has higher softening and melting point [8].

Properties of HMA and Shellac:

Table 1 Physical Properties of Hot Melt Adhesive [9]

S. No.	Properties	Value
1.	Appearance and color	Solid and white
2.	Melting point	Between 105 and 115oC (221 and 239 oF)
3.	Flash point	514-536oF
4.	Density	Around 930 kg/m3 or 0.93 g/cm3
5.	Shear strength	390 psi

6.	Modulus of Elasticity	10 Mpa
7.	Application temp	177-196oC
8.	Open Time	40-45 sec
9.	Delivery Time	55-60 sec
10.	Viscosity(cps)	5,000-6,000 @ 375°F

Table 2 Properties of Shellac [10]

S.No.	Properties	Values
1.	color	Dark orange or chocolaty
2.	solubility	Insoluble in water, turpentine, spirit. Soluble in ethanol, acetone.
3.	Melting Point	115-120^{o}C
4.	density	1.035 to 1.14 kg/m^{3}
5.	Refractive Index	1.516
6.	Young Modulus	3.81 to 5.81Gpa

3.2 Equipments used in the casting

The equipment used in the experiment is as follow

Mold box made of cardboard

Gas stove for melting

Thermometer for temp measurement

Crucible for melting

Weight machine

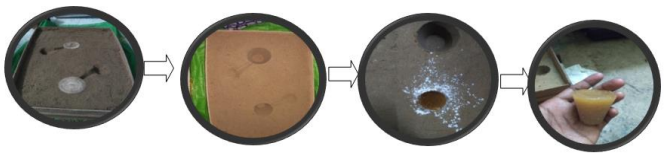
Mobile for taking photos

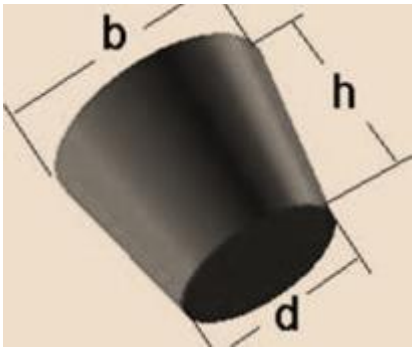
3.3 Methodology

How we applied the method in the experiment is as follow:

First of all we have made molding box with the help of cardboard. we used pattern made of wood which is a truncated conic pyramid. After that we make green sand mold with the use of sand water and clay. Sand clay and water taken in proportions 7:2:1, that mean if sand is 70% the clay is taken 20% and water will in 10%. We made mold with total of 10kg with proper ramming which takes aroung10 minutes. Then

casting process is followed. Both materials in proportions.





Pattern

melted together and being casted. Furnace is made near to the mold to maintain pouring temp certain. Amount of shellac is increased progressively a being casted. First 100% hot melt adhesive is casted the shellac increased by 10% in each further step. The changes in the parameters of the casting are being measured and analyzed further.

Where,

h= 5.2cm

b= 2.5cm

d= 1cm

IV. CALCULATIONS

We will calculate mold constant for our experiment using Chvorinov's formula.

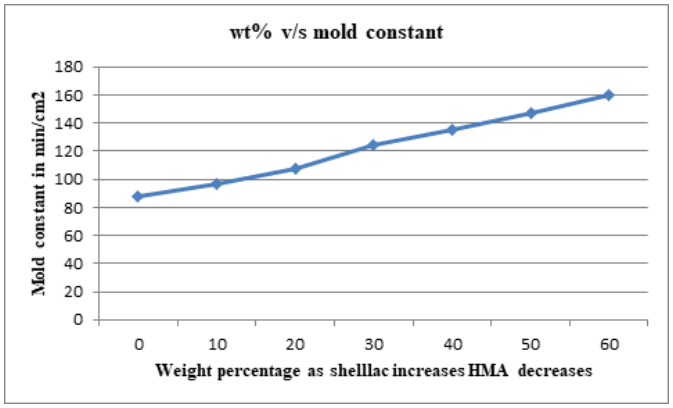
Table 1 : Average mold constant for various castings of respective weight proportions

S.No.	Proportions of Materials	Avg. solidification time In min	Mold constant $C=\frac{T_s}{(\frac{Vol}{SA})2}$ In min/cm^2
1.	100% + 0%	35.5	87.93
2.	90% + 10%	39	96.72
3.	80% + 20%	43.5	107.88
4.	70% +30%	50	124.00
5.	60% + 40%	54.5	135.16
6.	50% + 50%	59.5	147.56
7.	40% + 60%	64.5	159.96

V. RESULTS AND DISCUSSION

With the experiment we found that with addition of shellac in hot melt adhesive properties of hot melt adhesive get affected. It enhances strength and make more rigid at room temperature. We have all done all the experiment carefully with available resources and taken measurements of the various parameters. On this way we have calculated average mold constant for our experiment.

We have plotted the graph for mold constant against weight percentage of hot melt adhesive and shellac for our experiment which is as follow.



We conducted the entire experiment at room temperature as 27°C (300°K). The mixture of two materials i.e. hot melt adhesive and shellac being taken in 60gm weight. Our main material was hot melt adhesive and the quantity of shellac being altered. We have taken a fixed value of 10% alteration. In the first set of casting the entire material was HMA as 100%. In each successive experiment amount of shellac in increase by amount of 10% as HMA decreases by the same amount. In this way the mixture being casted and is observed. As we see as the amount of shellac being increased along with decrease in amount of hot melt glue the mold constant being increases simultaneously. In the first case the mold constant was 87.93 and it becomes 159.96 in the last experiment. So mold constant is increases polynomially with increase in amount of shellac in hot melt adhesive.

The relation between w% of materials and mold constant in equation form given by graph is as follow:

$C = 8E\text{-}06x^4 - 0.001x^3 + 0.051x^2 + 0.394x + 88.04$

Where, C= mold constant and x= w% of materials. Here 8E-06= 0.000008.

VI.CONCLUSION

This paper has represented mold constant for sand casting of two non-metallic multi-materials. By altering the mixture proportions the mold constant of process get affected. The following result can be drawn out from our experiment.

Parameter of sand casting	Result(Range value)	conclusion
Mold Constant	87.93-159.96 min/cm^2	Increases polynomially
	$C = 8E\text{-}06x^4 - 0.001x^3 + 0.051x^2 + 0.394x + 88.04$	

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