International Journal of Scientific Research in Mechanical and Materials Engineering
© 2021 IJSRMME | ISSN : 2457-0435

Mold Filling Time and Solidification Time for Casting of Non-Metals Hma and Shellac

P. Shiv Kumar Soni[1], Lokesh Singh[2]
[1]Department of Mechanical Engineering & RSR Rungta college of Engg and Technology, Bhilai, India
[2]Assistant Professor and head of Department of Mechanical Engineering& RSR Rungta College of Engg and Technology, Bhilai, India

Article Info
Volume 5, Issue 3
Page Number : 47-54

Publication Issue :
May-June-2021

Article History
Accepted : 05 May 2021
Published : 20 May 2021

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 like mould filling time and solidification time of cast product which is truncate conic pyramid.

Keywords : Casting, non-metallic multi-material, mould filling time, solidification time

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 filling time and solidification time are two crucial factors in a sand casting process [3].

For a specific sprue and pouring ladle the mould filling time depends upon the property of the casting material. Mould filling time is depends upon the viscosity of the material which in turn depends upon the density of the material. Material with higher density and viscosity results in higher mould filling time whereas materials with lower viscosity and density results in lesser mould filling time.

Solidification time is another important aspect in sand casting process. Solidification time is affected by the pouring temperature maintained during the casting also the ambient condition under which casting is being carried out [4]. Pouring temperature and ambient temperature greatly affect solidification time. Higher pouring and ambient temperature makes solidification time higher compared to case when casting carried at lower pouring and ambient temperature. These all aspects in combine affect the quality of casting. Solidification time can be measured with the use of stop watch or can be calculated with the help of formula called Chvorinov's principle [5].

Here,
Solidification time $T_s = \gamma^2 C$
γ = casting modulus which is ratio of volume and surface area of the casting
C= mold constant given by Chvorinov.

To calculate solidification time with chvorinov formula we need many parameters such as relative casting thickness (modulus), material bulk density, latent crystallization temperature, specific heat of material, casting temperature of material etc. So measured solidification time with the help of stop watch and taken more than one measurements to minimize error.

As we calculate casting modulus for different shapes we found that for cylinder (diameter = height) and sphere of same diameter casting modulus results same i.e. d/6.Casting modulus depends upon shape and surface of casting. So for larger surface area casting modulus will be fewer results lower solidification time and small surface area results larger solidification time [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

ain 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]

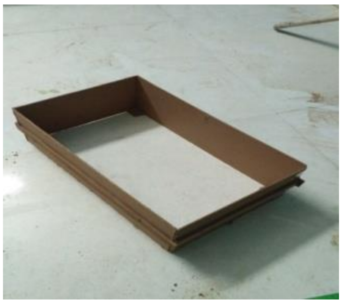
S. No	Properties	Value
1.	Appearance and color	Solid and white
2.	Melting point	Between 105 and 115°C (221 and 239 °F)
3.	Flash point	514-536°F
4.	Density	Around 930 kg/m³ or 0.93 g/cm³
5.	Shear strength	390 psi
6.	Modulus of Elasticity	10 Mpa
7.	Application temp	177-196°C
8.	Open Time	40-45 sec
9.	Delivery 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°C
4.	density	1.035 to 1.14 kg/m³
5.	Refractive Index	1.516
6.	Young Modulus	3.81 to 5.81Gpa

3.2 Equipments used in the casting

Mold box made of cardboard



Gas stove for melting

Thermometer for temp measurement

Crucible for melting

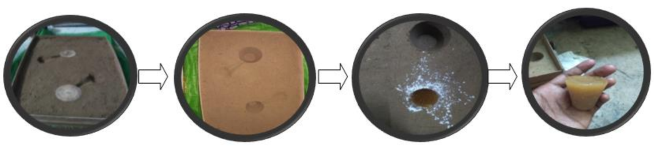
Weight machine

Mobile for taking photos

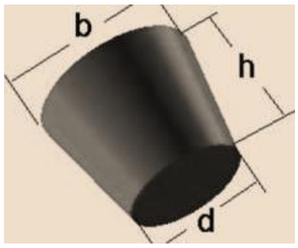
3.3 Methodology

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 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.



Pattern

Where,
h= 5.2cm
b= 2.5cm
d= 1cm

IV. CALCULATIONS

We will calculate two parameters which is mould filling time and solidification time.

1. Mould filling time: measured with use of stopwatch.
2. Solidification time: measured with the stopwatch.

since there are two experiment performed for each proportions of casting material so both mould filling time and solidification time where taken average of both the readings.

Table 1: Avg. Mould filling time for various casting of respective proportion

S.No.	Proportions of materials (HMA+Shellac)	Mould filing time T_1 in Sec.	Mould filing time T_2 in Sec.	Avg. mould filling time T
1.	100% + 0%	41	43	42
2.	90% +10%	44	47	45.5
3.	80% + 20%	50	48	49
4.	70% + 30%	59	58	58.5
5.	60% + 40%	60	61	60.5

6.	50% + 50%	62	64	63
7.	60% + 40%	65	67	66

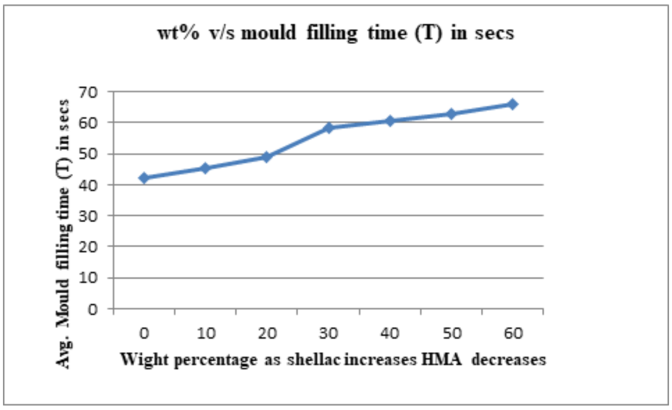
Table 2: Avg. Solidification time for various casting of respective proportion

S. No.	Proportions of Materials In	Solidification Time T_{s1} In min	Solidification Time T_{s2} In min	Avg. Solidification Time T_{avg} in min
1.	100% + 0%	36	35	35.5
2.	90% + 10%	38	40	39
3.	80% + 20%	44	43	43.5
4.	70% + 30%	48	52	50
5.	60% + 40%	54	55	54.5
6.	50% + 50%	58	61	59.5
7.	40% + 60%	65	64	64.5

V. RESULT 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 avg. solidification time and avg. mold filling time for our experiment.

We have plotted graph for mold filling time and solidification time against wt% of hot melt adhesive and shellac which is as follow:



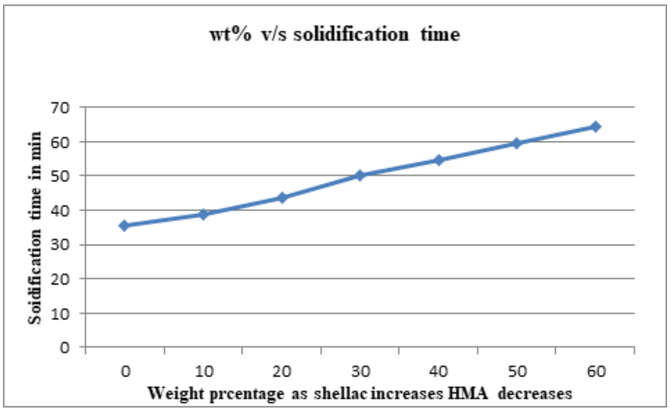
We conducted the entire experiment at room temperature as 27°C (300°K). The mixture of two materials i.e. hot melt adhesive and shellac being taken in 60gm weight. We have taken a fixed value of 10% alteration. In the first set of casting the entire material was HMA as 100%. In each successive experiment amount of shellac in increase by amount of 10% as HMA decreases by the same amount. In the initial experiment the avg. mold filling time was 42 seconds with increase in amount of shellac it finally become 63 seconds that means mould filling time increases polynomially with respect to weight percentage.

The graph gives the equation for mould filling time and weight percentage as

$T_{f,\,avg} = 9E\text{-}06x^4 - 0.001x^3 + 0.051x^2 - 0.172x + 42.21$

Where, $T_{f,\,avg}$= Avg mould filling time in sec. And x= weight % of HMA and shellac.

We have also plotted graph for solidification time against wt% of hot melt adhesive and shellac which is as follow:



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 solidification time being increases simultaneously. In the initial experiment the resulting cast product was taken 35.5 min to solidify completely whereas in the last final case it takes around 64.5 min to solidify. That means the solidification time increases polynomially when amount of shellac in the hot melt adhesive being increased.

The relation in equation form between weight% of materials and solidification time given by graph as:

$T_{s\,avg} = 3E\text{-}06x^4 - 0.000x^3 + 0.020x^2 + 0.157x + 35.54$

Where, $T_{s\,avg}$= avg. solidification time in minutes and x= wt% of materials

VI.CONCLUSION

This paper has represented the mold filling time and solidification time for two non-metallic multi-material of sand casting process. By varying the pouring temperature and mixture proportion solidification time and mold filling time get affected. The following conclusion can be drawn out on this experiment done with hot met adhesive and shellac:

Parameter of sand casting	Result(range value)	conclusion
Mold filing time	42sec-66sec $T_{f,\,avg} = 9E\text{-}06x^4 - 0.001x^3 + 0.051x^2 - 0.172x + 42.21$	Increases polynomially
Solidification time	35.5min-64.5min $T_{s\,avg} = 3E\text{-}06x^4 - 0.000x^3 + 0.020x^2 + 0.157x + 35.54$	Increases polynomially

VII. REFERENCES

[1]. Ganesh G. Patil, Dr. K. H. Inamdar, Optimization of Casting Process Parameters using Taguchi Method, International Journal of Engineering Development and Research(IJERD), Vol. 2, No. 2, pp. 157 – 164 (2014).

[2]. Renish M Vekariya1 And Rakesh P Ravani1; Investment Casting Process Using Fuzzy Logic Modeling; Int. J. Mech. Eng. & Rob. Res.(IJMERR) 2013 ;Vol. 2,;pg 232-241.

[3]. Raghwendra Banchhor, S. K. Ganguly, OPTIMIZATION IN GREEN SAND CASTING PROCESS FOR EFFICIENT, ECONOMICAL AND QUALITY CASTING, International Journal of Advanced Engineering Technology, Vol.5, No. 6, pp. 25-29(2014).

[4]. Yogesh A. joshi , H.D.Patel;An Estimation of Solidification Time by Varying Pouring Temperature in Investment Casting Process;IJSRD -International Journal for Scientific Research & Development| Vol. 2, Issue 04, 2014;pg 118-120.

[5]. P. Jelínek, T. Elbel; Chvorinov's rule and determinationof coefficient of heat accumulation of moulds with non-quartz base sands;ISSN (1897-3310)Volume 10Issue 4/2010;pg77 –82.

[6]. P.N.Rao, "Manufacturing Technology", Tata McGraw-Hill Education, New Delhi, 2008.

[7]. Beeley, P.R., Smart, R.F., 1995. Investment Casting (Material Science). London: Maney Material Science, ISBN-13.

[8]. K.Wehlte, The Materials and Techniques of Painting, Van Nostrand Reinhold Co., New York, 1975.G.S.Brady, Materials Handbook, McGraw-Hill Book Co., New York, 1971 Comment: p. 705.

[9]. http://www.3M.com/Adhesives.

[10]. Wikipedia: http://en.wikipedia.org/wiki/Shellac (Accessed Feb. 10, 2006)

Cite this article as :

P. Shiv Kumar Soni, Lokesh Singh, "Mold Filling Time and Solidification Time for Casting of Non-Metals Hma and Shellac",International Journal of Scientific Research in Mechanical and Materials Engineering (IJSRMME), ISSN : 2457-0435, Volume 5 Issue 3, pp. 47-54, May-June 2021.
URL : https://ijsrmme.com/IJSRMME21535