IJRAME
INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING
WWW.IJRAME.COM
ISSN (ONLINE): 2321-3051
Vol.6 Issue.9,
September 2018
Pg: -64-81

Comparison of Non-Metallic Multi Materials Sand Casting Parameter

Sonu S. Bansod[1], Lokesh Singh[2], Sushil Kumar Maurya[3]
[1]Department of Mechanical Engineering & GD Rungta College of Engg and Technology,Bhilai, India
[2]Assistant Professor and head of Department of Mechanical Engineering & GD Rungta College of Engg and Technology, Bhilai, India
[3]Department of Mechanical Engineering & Modern Institute of Technology & Research Centre, Alwar , India
[1]bansod47@gmail.com; [2]lokeshsingh25@gmail.com; [3]mauryasushil86@gmail.com

***Abstract*: Casting is one of the most ancient techniques/method used for manufacturing parts. It is usually applied to manufacture near net shape components Today, there has been several casting techniques developed, each with its own characteristics, applications, advantages and disadvantages. During selection of any casting process, it should be kept in mind, no one method of casting process which produce or provide defect free casting, some defect is always present. So we use those process they give optimum result. The traditional method of metal casting is the sand casting. The traditional method of metal casting is the sand casting. Sand casting, which uses sand as the mold material, it is also the least expensive method as compared to other casting techniques.The purpose of this work is to review of sand casting process based on available knowledge, experience of experts & perform experimentally setup of sand casting processes by using non metallic multi-material & measure the various parameter of sand casting such as mold filling time, volume flow rate, solidification time, mold constant, density of mixture ,specific volume & weight & many more parameter related to casting & finally compare all values .our cast shape which is truncated rectangular base pyramid or we simply called pyramidal frustum of rectangle base shape volume.**

Keywords: Sand Casting, Mould filling time, volume flow rate, solidification time, mold constant.

I INTRODUCTION

Metal casting is one of the most ancient techniques/method used for manufacturing metal parts [1] .It is usually applied to manufacture near net shape components around 6.5million kg of casting are produced every year [2]. There has been several casting techniques developed, each with its own characteristics, applications, advantages and disadvantages. The traditional method of metal casting is the sand casting. This method is still important, as more than 70% of metal casting is performed using sand casting. Sand casting, which uses sand as the mold material, is also the least expensive method as compared to other casting techniques. There are many parameter and factor which affect the sand casting process. Some factors is Mould filling time, volume flow rate, solidification time, mold constant, density of mixture ,specific volume & weight. All factor or parameter play a vital role in the sand casting process. The first parameter is Mould filling time is the time required to fill the mould cavity of a particular volume. It depends on materials used in casting & volume of cavity. if cavity is more the time required for filling is also more. We can say that mould filling time is directly depends on fluidity of material say density material. The mold filling time denoted as t_f. it measured generally in seconds. It also measured in minutes for large cavity or large shape, size of casting.

IJRAME

INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING
WWW.IJRAME.COM
ISSN (ONLINE): 2321-3051

Vol.6 Issue.9,
September 2018
Pg: -64-81

The second parameter is volume flow rate, which is defined as volume per unit time that means the volume of fluid which passes per unit time it is also called volume flow rate, rate of fluid flow or volume velocity or volumetric flow rate. The SI unit is m^3/s (cubic meters per second). Another unit used is sccm (standard cubic centimeters per minute)[3]. We used unit of volume flow rate for calculation in cm^3/sec because our casting size is small. Which is depend on Volume of mold cavity & Mold filling time .And we measure in volume in cm^3 and mould filling time in second.There are different type of flow rates are present such as mass flow rate, volumetric flow rate. First understand the term flow rate, If any pipe, inside it any liquid is present. This liquid flow from particular cross section, flow at particular time or in another word, the amount of liquid that is pushed through your system in a given amount of time called flow rate. There are many devices such as flow meter are present now, to measure flow rate.

The third parameter is solidification time. Solidification is a very crucial factor for any casting process. Generally directional solidification will help to achieve a good quality casting product. Different rate of pouring temperature will also affect the solidification rate of casting and so quality of casting[4].One of the very important parameters to assess the properties of materials produced by casting process is the solidification time [5]. Solidification time can be measure by directly by using device such as watch & thermometer or we can also calculated by using formula. The formula of solidification time is called Chvorinov's rule or also called Chvorinov's principle. Chvorinov's rule"For calculation of the total time of casting solidification made also possible to determine chilling effect of foundry moulds (coefficient of heat accumulation of the mould, bf) [6].

The fourth parameter is mould constant (solidification constant). 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 [7]. Or we can say that,The word Chvorinov´s means solidification constants or also called solidification factor or mold constant. if we used Chvorinov's rule. We need many parameter such as relative casting thickness (modulus), bulk density of material, latent crystallization temperature, specific heat of material, metal casting temperature, casting solidification time that why, we calculating solidification time by used device & observation & to minimize the error during measurement we calculating more than one times than after we calculating average of solidification time. Solidification time depends on what type of shape to be cast. if you wanted to calculated using by formula or we can be conclude is depend on ratio of V/SA.

The next parameter is density and specific volume. Density and specific volume are properties of material which has to be cast & weight of casting depend on which material used & shape of casting to be produced. They all play a vital role in the sand casting process. The first understand the term density. Density is mass per unit volume. It depends on materials used in casting. it denoted as ρ. It SI unit is kg/m^3.but we used for calculation in gram per cm^3 because our shape size is small. The second parameter is specific volume, which is defined as volume per unit mass. It is inversely proportional to density. The SI unit is m^3/kg .but we used unit in cm^3/g.

The last parameter is weight. The most common definition of weight found in introductory physics textbooks defines weight as the force exerted on a body by gravity [8,9].This is often expressed in the formula $W = mg$, where W is the weight, m the mass of the object, and g gravitational acceleration. Dimensional quantity of weight is MT^{-2}. It unit is kg m s^{-2}, N. Weight as a vector, since force is a vector quantity. However, some textbooks also take weight to be a scalar by defining:"The weight W of a body is equal to the magnitude F_g of the gravitational force on the body."[8]

II LITERATURE REVIEW

In this section we deals with what actually done & their view by different author related to casting, different casting process, casting defects, optimization of parameter & many more parameter related to casting.

Choudhari et. al. worked on the shrinkage defects minimized approach by an intelligent method and simulation using casting software. he used Traditional casting approach for developing a new part involves manual method design of the 2D drawings of the cast part. This is followed by fabrication of tools, conducting trial runs and inspection. The simulations results were compared with the experimental trial and the comparison was found to be in good agreement. **Vekariya et. al.** shown the capability of generalization and prediction of pattern characteristics such as linear shrinkage, surface roughness and penetration of the wax patterns in IC process within the range of experimental data. The maximum deviations between experimental and fuzzy predicted values are minimal. **Hossain et al**. they investigate the physical and mechanical properties wax materials using uniaxial compressive strength test. This study explores the potential of diametral stress-strain behavior of natural beeswax and synthetic paraffin wax samples by the uniaxial compressive test to measure their strength. **N. Ukrainczyk et al.** worked on Thermophysical properties of Five Commercial Paraffin waxes produced by major Croatian oil company, INA d.d. Rijeka. An experimental investigation has been conducted, Based on results he obtained, the investigated paraffin waxes were evaluated in regard to their applicability as phase change material for latent heat thermal energy storage. The temperatures and enthalpies of melting and solidification (latent heat capacity) and specific heat capacities of solid and liquid paraffin waxes were measured by differential scanning calorimetry (DSC). The thermal diffusivity of paraffin waxes was determined utilizing transient method. The densities and the coefficient of thermal expansion were measured using Archimedes methods. **Gang Pu et al**. he enhancing the performance of paraffin wax based materials for barrier coating applications. he enhances stiffness, strength and ductility of the formed Nanocomposite The thermal stability of wax/clay nanocomposites were investigated using dilatometry. **Banchhor et. al.** analyzed the various process and product design parameter in the green sand casting. **Torresola** worked on solidification properties of certain waxes And paraffins wax. And finding the solidification properties of the microcrystalline wax such as enthalpy, specific heat, latent heat, thermal conductivity of the wax by using Calorimetric experiments. He also designed an apparatus to measure the temperature history of microcrystalline wax under one-dimensional transient solidification as well as give a theoretical investigation of solidification of materials that, like wax, release latent heat over a temperature range. he also performed molten droplet deposition experiments with octacosane, a paraffin with properties similar to those of wax except for its distinct melting point. **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). **Joshi et al.** they work on Solidification Time by Varying Pouring Temperature in Investment Casting Process.he concluded that by increasing pouring temperature there no significance change in solidification time. **Galili et. al.** worked on the importance of weightlessness and tides in teaching gravitation. In this he provide information & better understanding of weight, weightlessness, and tidal effects & there an integrated unit to emphasize the common and contrasting aspects of the effects of gravitation. By using the dichotomy of two weight definitions, the gravitational introduced by Newton and the operational following Einstein.

IJRAME

INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING
WWW.IJRAME.COM
ISSN (ONLINE): 2321-3051

Vol.6 Issue.9,
September 2018
Pg: -64-81

III MATERIALS & METHODOLOGY

3.1 Materials -We used two main materials & one optional material for colouring.Our Casting materials:
Wax (1st main material)
Hot Melt Adhesive (HMA) (2nd main material)
Wax crayons (additional /optional material)

		
Paraffin'sWax	Hot Melt Adhesive (HMA)	Wax crayons

Fig 1 casting materials

3.1.1 Paraffin's wax

Paraffin wax is a synthetic waxy material coming from petroleum Refinery [10]. Paraffin's are a family of saturated hydrocarbons with general formula C_nH_{2n-2} [11]. In the melt, paraffin wax has a low viscosity and a surface tension of approximately 25 mJ/m2.Paraffin wax is used in a variety of products and applications [12]. wax is composed of multiple hydrocarbons with different fusion points. Therefore, solidification of wax occurs differently from that of single-component substances that have a distinct melting point [13]. Their Physical Properties shown in table 1.

3.1.2Hot-melt adhesive (HMA)

Hot melt adhesives are thermoplastic polymer systems applied in a molten state. They must flow smoothly onto both surfaces and then rapidly cool to a tough, adherent solid at room temperature. Thus, viscosity as a function of temperature is a key to proper hot melt performance. It is also called Thermoplastic adhesive or hot glue. The performance of hot melt adhesive are characterized by DSC and Viscometer [14].

Applications of HMA in many areas are Packaging, Graphic Arts, Nonwovens/Hygiene, Tapes and Labels, Product Assembly, Automotive, Textiles. Their Physical Properties shown in table 2.

Properties of Paraffin's Wax & Hot melt adhesive

Table 1 Physical Properties of Paraffin's Wax [15]

S. No.	Properties	Value
1.	Colour	White
2.	Melting point between about	46 and 68 °C (115 and 154 °F)
3.	Boiling point	>370 °C (698 °F)
4.	Density around	900 kg/m^3 or 0.9 g/cm^3
5.	Heat of combustion	42MJ/kg.
6.	Specific heat capacity	2.14–2.9 J g^{-1} K^{-1} (joules per gram Kelvin)

IJRAME

INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING
WWW.IJRAME.COM
ISSN (ONLINE): 2321-3051

Vol.6 Issue.9,
September 2018
Pg: -64-81

7.	Heat of fusion	200–220 J g^{-1}
8.	Electrical insulator with a resistivity	between 1013 and 1017 ohm meter
9.	Modulus of elasticity (E)	2800

Table 2 Physical Properties of Hot melt adhesive [16]

S. No.	Properties	Value
1.	Color (solid)	Clear
2.	Density (g/cm^3)	0.93-0.95
3.	Flashpoint (°F)	514-536
4.	Application Temperature	350-385°F (177-196°C)
5.	Viscosity (CPS)	5,000-6,000 @ 375°F
6.	Open Time (seconds)	40-45
7.	Delivery Time	55-60 seconds
8.	Heat Resistance	140°F/ 60°C
9.	Ball & Ring Melt Point	190°F/ 88°C
10.	Shear Strength	390 psi
11.	Store	Below 120°F (49°C).
12.	Modulus of elasticity (E)	10 MPa

3.2 EQUIPMENT/DEVICE/TOOLS USED IN CASTING

When we perform casting some basic equipment required for casting setup & for parameter measurement. Those equipment/device/tools shown below:

		
Weighing machine -for measurement of weight in proportion	Flask (molding box)-for actual casting is perform. in this we filled sand mould & cavity make.	Mobile-for picture click of each steps ,time measurement by stopwatch.
		
Pattern-by the help of this we create cavity.it is a	Thermometer-for measurement of temperature of liquid casting	Crucible-in this container. We melt our casting materials

IJRAME

INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING
WWW.IJRAME.COM
ISSN (ONLINE): 2321-3051

Vol.6 Issue.9,
September 2018
Pg: -64-81

solid type of pattern.	material.	which are wax &hot melt adhesive.

Fig 2 Equipment/device/tools used in casting

3.3 METHOD

How & which technique or method used for the process of casting discuss here. It is mainly divided into three sections:

Before casting perform
During casting perform
After casting perform shown in fig 3, fig 4 & fig 5 respectively.

The ramming time is 5-8min required for our experiment setup. The moisture content in green sand should always be maintained at 3.3% to 3.6%. It is continuously checked and Maintained during the experiments which provided good results. The number of mould that can be filled by each ladle manually, is mainly depend on ladle capacity and the weight of the molten material .Our the crucible capacity is 2-2.5kg.The crucible travel Time is 5-10 sec, which is time required /taken to the distance between the furnace/stove and the mould box. Hence the traveling time of the molten material is reduced and the molten temperature is maintained effectively. The pouring time also is controlled and interrupted pouring is avoided. Sand mixing time is 25-30min.

1. Before castings perform prepare the sand mould.

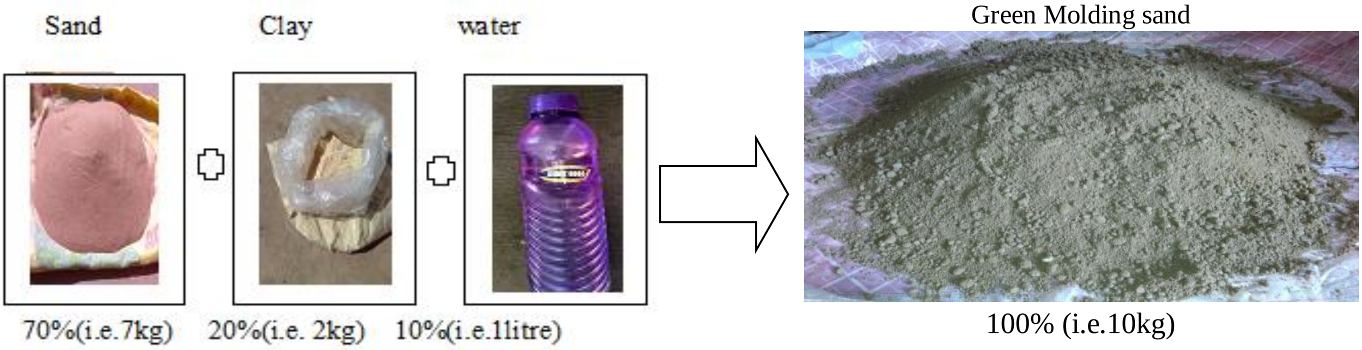

Fig 3 Sand mold preparations

INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING
WWW.IJRAME.COM
ISSN (ONLINE): 2321-3051

Vol.6 Issue.9,
September 2018
Pg: -64-81

2. During casting, after preparation of sand mould, casting is performed. In this section includes

Step1. Making cavity on green mold sand.

Step2. After pouring the molten material into the mold cavity.

Step3. After solidification of molten material

Step4. Removal of cast product

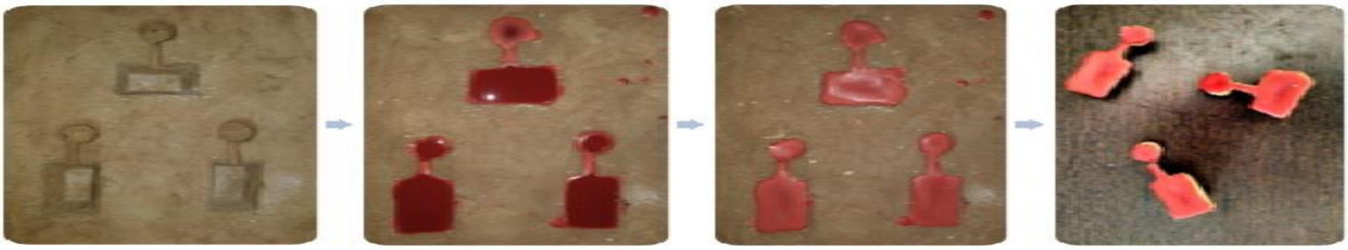

Fig 4 Before pouring molten material to cast product in sand casting

3. After casting: after casting complete. Click the picture of casting & measure dimensions of casting & other related parameter.

Fig 5 All Set of Cast Product Made from Mixing of Wax & Hot Melt Adhesive in weight%

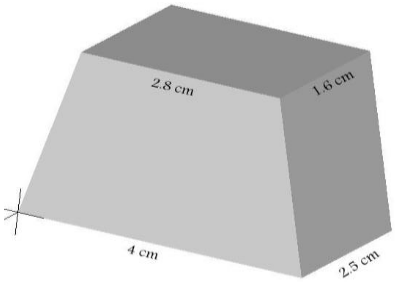

Fig 6 Dimensions of casting

IJRAME

INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING
WWW.IJRAME.COM
ISSN (ONLINE): 2321-3051

Vol.6 Issue.9,
September 2018
Pg: -64-81

IV CALCULATION

All measurement is taken & extracted from while performing with two non-metallic materials (i.e. wax and hot melt adhesive) in sand casting process by using stop watch & thermometer. Manual accuracy is not accurate. that why we calculated at 3 times & then find the average of particular reading.

We calculate some parameters:

4.1. Mold filling time
4.2. Volume flow rate
4.3. Solidification time
4.4. Mold constant
4.5. Density of mixture
4.6. Specific volume of mixture
4.7. Weight of mixture of casting.

4.1. Here we firstly calculate mold filling then secondly calculate volume flow rate

Table 3 Calculate mold filling time for our 21 sets of percentage weight of mixture ,each Wt% of mixture for 3 times.

S. No.	Percentage Amount (in %)		Mould Filling Time (T_1) in Sec	Mould Filling Time(T_2) in Sec	Mould Filling Time(T_3) in sec	Average Mould Filling Time, $(T_f)avg = \frac{T1+T2+T3}{3}$ (in sec)
	Wax	HMA				
1	100	0	2.1	2	2.2	2.1
2	95	5	2.3	2.2	2.2	2.23
3	90	10	2.4	2.3	2.4	2.3666
4	85	15	2.5	2.4	2.4	2.4393
5	80	20	2.5	2.6	2.7	2.6
6	75	25	3.7	3.5	3.4	3.5333
7	70	30	5	4.5	4.9	4.8
8	65	35	9.9	10.3	10.1	10.1
9	60	40	10.5	10.8	11.1	10.8
10	55	45	11.2	10.8	10.7	10.9
11	50	50	12	11	11.5	11.5
12	45	55	16	15	15.3	15.433
13	40	60	22	21.4	21.6	21.664
14	35	65	54	53.7	54.9	54.2
15	30	70	108.6	109.2	110	109.26
16	25	75	118	116	117	117
17	20	80	125	123.6	118	123.63
18	15	85	132.5	134	133	133.1666
19	10	90	145.4	146.6	147.2	146.4
20	5	95	174.4	176.1	175.7	175.4
21	0	100	182.3	181.9	180.6	181.6

IJRAME

INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING
WWW.IJRAME.COM
ISSN (ONLINE): 2321-3051

Vol.6 Issue.9,
September 2018
Pg: -64-81

Mould taking time or time required to fill a mould cavity of given volume or t_f

$$T_f = \frac{\text{Volume of Mould Cavity (V)}}{\text{Volume rate of flow(Q)}} = \frac{V}{Q} = \frac{V}{Ag \times vg}$$

V = Volume of mould cavity

Q = Volume rate of flow or metal flow rate or Volume flow rate

A_g = cross sectional area of ingate (say gate) or c/s area of the down sprue

v_g = Velocity of molten metal at ingate or v_3 or velocity of molten metal at sprue

4.2. Volume flow rate

Table 4 Calculate Volume Flow Rate for our 21 sets of percentage weight of mixture ,each Wt% of mixture for 3 times.

S.No.	Percentage Amount (in %)		Volume Flow Rate $(Q_1) = \frac{V}{T1}$ (in cm^3/sec)	Volume Flow Rate $(Q_2) = \frac{V}{T2}$ (in cm^3/sec)	Volume Flow Rate $(Q_3) = \frac{V}{T3}$ (in cm^3/sec)	Average Volume Flow Rate $(Q_{average}) = \frac{Q1+Q2+Q1}{3}$ (in cm^3/sec)
	Wax	HMA				
1	100	0	9.0738	9.3275	8.6613	9.0875
2	95	5	8.2847	8.6613	8.6613	8.5357
3	90	10	7.9395	8.2847	7.9395	8.0545
4	85	15	7.622	7.9395	7.9395	7.8336
5	80	20	7.622	7.3288	7.0574	7.3360
6	75	25	5.15	5.4442	5.6044	5.3995
7	70	30	3.811	4.2344	3.8887	3.9780
8	65	35	1.9247	1.85	1.8866	1.8871
9	60	40	1.8147	1.7643	1.7166	1.7652
10	55	45	1.7013	1.7643	1.7808	1.7488
11	50	50	1.5879	1.7322	1.6590	1.659
12	45	55	1.1909	1.2703	1.2454	1.2355
13	40	60	0.8861	0.8904	0.8821	0.8795
14	35	65	0.3528	0.3548	0.3470	0.3515
15	30	70	0.1754	0.1744	0.1732	0.1743
16	25	75	0.1614	0.1642	0.1628	0.1628
17	20	80	0.1524	0.1541	0.1614	0.1559
18	15	85	0.1438	0.1422	0.1432	0.1430
19	10	90	0.1310	0.1299	0.1294	0.1301
20	5	95	0.1094	0.1082	0.1084	0.1086
21	0	100	0.1045	0.1047	0.1055	0.1049

IJRAME

INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING
WWW.IJRAME.COM
ISSN (ONLINE): 2321-3051

Vol.6 Issue.9,
September 2018
Pg: -64-81

4.3. Solidification time

The time required to completely solidify the casting is called solidification time .which is calculated by using formula & observation. Here we examine the solidification time by observation with the help of thermometer & stop watch, because solidification time formula needs mould constant(C) and finding, then the average value of solidification time by using average formula.

$$\text{Average} = \frac{\text{Sum of observation}}{\text{Total no. of observation}}$$

Table 5 Calculate Solidification time for our 21 sets of percentage weight of mixture, each Wt% of mixture for 3 times

S. No.	Percentage Amount (in %)		Solidification Time (In min)			Average Solidification Time
	Wax	HMA	1st time (t_{s1})	2nd time (t_{s2})	3rd times (t_{s2})	($t_{average}$) = $\frac{ts1+ts2+ts3}{3}$ In min
1	100	0	39:49	40:6	39:54	40:27=2427sec
2	95	5	39.48	39.53	39:45	39:48
3	90	10	39:44	39.45	39.45	39:44
4	85	15	39:42	39:40	39:32	39.38
5	80	20	39.27	39:33	39.30	39.30
6	75	25	39:17	39:11	39:10	39:12
7	70	30	38:54	38:51	38:53	38:52
8	65	35	38:48	38:46	38:47	38:47
9	60	40	38:36	38:40	38:35	38.37
10	55	45	38:22	38.24	38.20	38.22
11	50	50	38:10	37:56	37:58	38:14
12	45	55	38:02	37:46	37:55	38:07
13	40	60	37:49	37:53	37:50	37:50
14	35	65	37:45	37:43	37:46	37:44
15	30	70	37:39	37:33	37:36	37:36
16	25	75	37:28	37:24	37:23	37:25
17	20	80	37:17	37:10	37:15	37:14
18	15	85	37:05	37	36:55	37
19	10	90	36:47	36:45	36:44	36:45
20	5	95	36:33	36:39	36:35	36.35
21	0	100	36:11	35:56	35:57	36:14

4.4. Mold constant

Here we measure mold constant by using composition relation & by using formula both.

Table 6 Calculate mold constant for our 21 sets of percentage weight of mixture ,each Wt% of mixture for 3 times

S. No .	Percentage Amount (in %)		By relation & observation Mold constant(C) = mold constant of wax (214.80)×wt% + mold constant of HMA (192.3)×wt%(in min/cm)	Mold constant by formula (C) = $\frac{ts}{[\frac{V}{SA}]2}$ In min/cm^2
	Wax	HMA		
1	100	0	214.802	214.802
2	95	5	211.350	211.350
3	90	10	210.97	210.97
4	85	15	210.44	210.44

IJRAME

INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING
WWW.IJRAME.COM
ISSN (ONLINE): 2321-3051

Vol.6 Issue.9,
September 2018
Pg: -64-81

5	80	20	209.757	209.757
6	75	25	208.16	208.16
7	70	30	206.35	206.35
8	65	35	205.93	205.93
9	60	40	205.06	205.06
10	55	45	203.70	203.70
11	50	50	203.01	203.01
12	45	55	202.40	202.40
13	40	60	200.88	200.88
14	35	65	200.35	200.35
15	30	70	199.66	199.66
16	25	75	198.65	198.65
17	20	80	197.70	197.70
18	15	85	196.48	196.48
19	10	90	195.15	195.15
20	5	95	194.25	194.25
21	0	100	192.39	192.39

4.5. Density of mixture

Table 7 Calculate mold filling time for our 21 sets of percentage weight of mixture ,each Wt% of mixture for 3 times.

S. No.	Percentage Amount (in %)		Density after mixing hot melt adhesive on wax = actual density of wax before mixing(0.9) x wt % + density of hot melt adhesive before mixing(0.94) (in g/cm^3)	Specific Volume, υ (in cm^3/g) = $\frac{1}{\rho(\text{density})}$
	Wax	HMA		
1	100	0	$0.9 \text{ x } \frac{100}{100} + 0.94 \text{ x } \frac{0}{100} = 0.9$	1.11
2	95	5	$0.9 \text{ x } \frac{95}{100} + 0.94 \text{ x } \frac{5}{100} = 0.902$	1.1086
3	90	10	$0.9 \text{ x } \frac{90}{100} + 0.94 \text{ x } \frac{10}{100} = 0.904$	1.1061
4	85	15	$0.9 \text{ x } \frac{85}{100} + 0.94 \text{ x } \frac{15}{100} = 0.906$	1.1037
5	80	20	$0.9 \text{ x } \frac{80}{100} + 0.94 \text{ x } \frac{20}{100} = 0.908$	1.1013
6	75	25	$0.9 \text{ x } \frac{75}{100} + 0.94 \text{ x } \frac{25}{100} = 0.910$	1.0989
7	70	30	$0.9 \text{ x } \frac{70}{100} + 0.94 \text{ x } \frac{30}{100} = 0.912$	1.0964
8	65	35	$0.9 \text{ x } \frac{65}{100} + 0.94 \text{ x } \frac{35}{100} = 0.914$	1.094
9	60	40	$0.9 \text{ x } \frac{60}{100} + 0.94 \text{ x } \frac{40}{100} = 0.916$	1.0917
10	55	45	$0.9 \text{ x } \frac{55}{100} + 0.94 \text{ x } \frac{45}{100} = 0.918$	1.0893
11	50	50	$0.9 \text{ x } \frac{50}{100} + 0.94 \text{ x } \frac{50}{100} = 0.920$	1.0869
12	45	55	$0.9 \text{ x } \frac{45}{100} + 0.94 \text{ x } \frac{55}{100} = 0.922$	1.0845
13	40	60	$0.9 \text{ x } \frac{40}{100} + 0.94 \text{ x } \frac{60}{100} = 0.924$	1.0822

IJRAME

INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING
WWW.IJRAME.COM
ISSN (ONLINE): 2321-3051

Vol.6 Issue.9,
September 2018
Pg: -64-81

14	35	65	$0.9 \times \frac{35}{100} + 0.94 \times \frac{65}{100} = 0.926$	1.0799
15	30	70	$0.9 \times \frac{30}{100} + 0.94 \times \frac{70}{100} = 0.928$	1.0775
16	25	75	$0.9 \times \frac{25}{100} + 0.94 \times \frac{75}{100} = 0.930$	1.0752
17	20	80	$0.9 \times \frac{20}{100} + 0.94 \times \frac{80}{100} = 0.932$	1.0729
18	15	85	$0.9 \times \frac{15}{100} + 0.94 \times \frac{85}{100} = 0.934$	1.0706
19	10	90	$0.9 \times \frac{10}{100} + 0.94 \times \frac{90}{100} = 0.936$	1.0683
20	5	95	$0.9 \times \frac{5}{100} + 0.94 \times \frac{95}{100} = 0.938$	1.066
21	0	100	$0.9 \times \frac{0}{100} + 0.94 \times \frac{100}{100} = 0.940$	1.0638

4.7. Weight of mixture of casting.

Table 8 Shows Calculation of Average weight of cast product w.r.t Wt%

S. No.	Percentage Amount (in %)		Net wt of 3 piece cast (in gram)	Average wt (in gram)
	Wax	HMA		
1	100	0	49	16.33
2	95	5	49.2	16.4
3	90	10	49.4	16.46
4	85	15	49.6	16.533
5	80	20	49.8	16.6
6	75	25	50	16.66
7	70	30	50.2	16.73
8	65	35	50.4	16.8
9	60	40	50.6	16.86
10	55	45	50.8	16.93
11	50	50	51	17
12	45	55	51.2	17.06
13	40	60	51.4	17.13
14	35	65	51.6	17.2
15	30	70	51.8	17.26
16	25	75	52	17.33
17	20	80	52.2	17.4
18	15	85	52.4	17.46
19	10	90	52.6	17.533
20	5	95	52.8	17.6
21	0	100	53	17.66

V RESULTS & DISCUSSIONS

Due to the addition of hot melt adhesive on wax, which changes the properties of wax & Enhanced, strength and ductility of wax at room temperature.

All the observation, measurement, calculation, weighing of material should be very carefully done by me, on the basis of available resources, constraint of machine & equipment for test some more parameter & atmospheric condition. Finally get the average values of mold filling time, average volume flow rate, average solidification time, average weight of mixture of casting.

IJRAME

INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING
WWW.IJRAME.COM
ISSN (ONLINE): 2321-3051

Vol.6 Issue.9,
September 2018
Pg: -64-81

How to change mold filling time, volume flow rate, solidification time, mold constant, density of mixture, specific volume & weight of casting with respect to mixture of two non-metallic materials, shown in fig 5.1,fig 5.2, fig 5.3, fig5.4, fig5.5,fig 5.6,fig 5.7 respectively and all curve or graph shows weight % of wax - HMA & in which horizontal axis(x) represent percentage amount of wax and hot melt adhesive(in Wt %) ,and vertical axis represent those term which want to be calculated.
All the graph for paraffin wax and hot glue adhesive at room Temperature (27℃ $i.e. 300K$) are mixed with percentage amount. We take paraffin wax as our main material (i.e.100%) which is equal to 40 gram. then in this wax we increases the percentage amount of hot melt adhesive(HMA) by 5% which is equal to 2 gram, gradually increased the amount of hot melt adhesive as well as decreases the amount of wax, one after one. Initially, when we pour liquid material by help of pouring container of diameter (funnel) 0.6cm on mold cavity volume is 19.055cm^3, then average mold filling time ($T_{f\ avg}$) of paraffin's wax (i.e.100% = 40 gram) is 2.1 seconds then another material (HMA) is mixed in the wax.

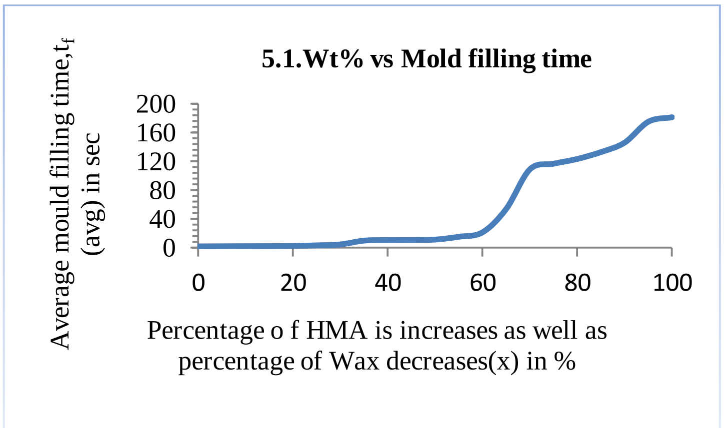

Fig 7 Graph between weight% of non-metallic mixture vs mold filling time

Above graph shows by increases the amount of Hot melt adhesive on paraffin wax ,the Average mould filling time is increase with increases the amount of HMA and as well as decreases the amount of paraffin wax.
Finally the average mold filling time of HMA is 181.6 seconds that means filling time polynomially increases. These graphs shows mould filling time depend on wt% by equation:
$(T_f)_{avg}$ = -7E-08x^5+ 4E-06x^4+0.001x^3-0.079x^2 +1.360x – 1.138
Where $(T_f)_{avg}$ = Average mould filling time (in seconds)
x = wt% of mixture of wax & HMA (in %).

IJRAME

INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING
WWW.IJRAME.COM
ISSN (ONLINE): 2321-3051

Vol.6 Issue.9,
September 2018
Pg: -64-81

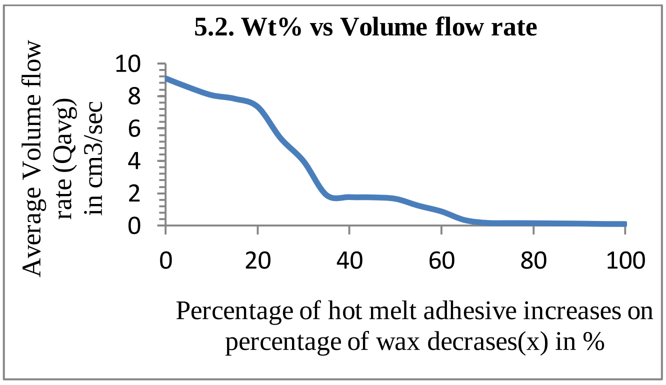

Fig 8 Graph between weight% of non-metallic mixture vs volume flow rate

Above graph shows after increases the amount of Hot melt adhesive on paraffin wax, the Average Volume flow rate is decreases with increases the amount of HMA and as well as decreases the amount of paraffin wax by polynomial. Finally the average Volume flow rate of HMA is 0.1049 centimeter cube per seconds (i.e.cm^3/sec). Thus we can say that volume flow rate (Q) depend on wt% (x) by equation:

Q_{avg} = -7E-07x^4+ 0.000x^3-0.007x^2- 0.039x+9.185

Where

Q_{avg} = Average volume flow rate

x = wt% of mixture of wax & HMA (in %).

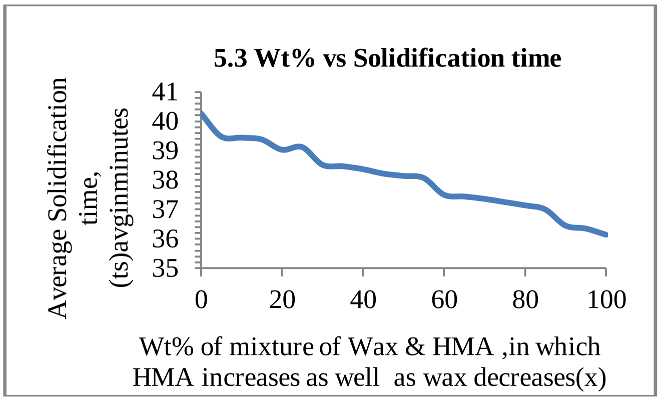

Fig 9 Graph between wt% of non-metallic mixture vs Solidification time

Above graph shows Gradually incre ased the amount of hot melt adhesive as well as decreases the amount of wax, one after one. Average Solidification time is decreases with increases the amount of HMA on wax and as well as decreases the amount of paraffin wax by polynomially. Finally the average Solidification time of HMA is 36.14 min (i.e.2174seconds). Thus range or

IJRAME

INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING
WWW.IJRAME.COM
ISSN (ONLINE): 2321-3051

Vol.6 Issue.9,
September 2018
Pg: -64-81

difference of solidification time is 4 min 13 second (i.e.253 sec). Thus we can say that solidification time (t_s) depends on wt% (x) by equation:

$(ts)_{avg}$ = 2E -08x^4-8E-06x^3+ 0.000x^2-0.064x+ 40.07

Where $(ts)_{avg}$ = Average solidification time

x = weight percentage composition of wax and hot melt adhesive (in %)

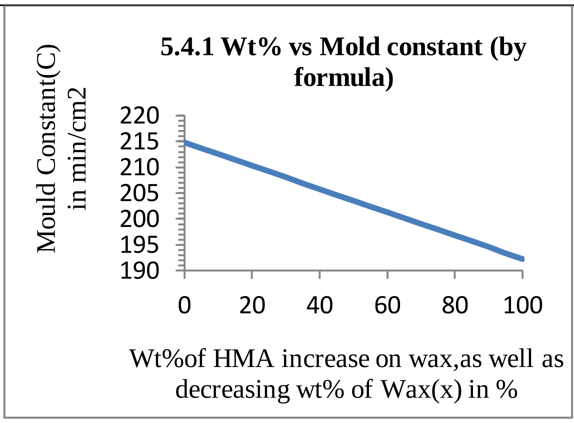

Fig 10 wt% vs Mold constant by using formula

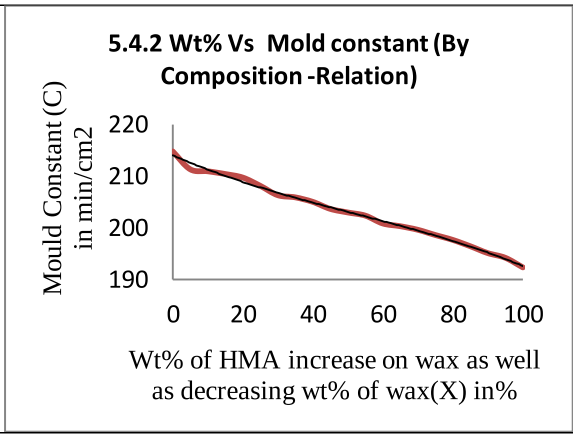

Fig 11 wt% vs Mold constant by using relation

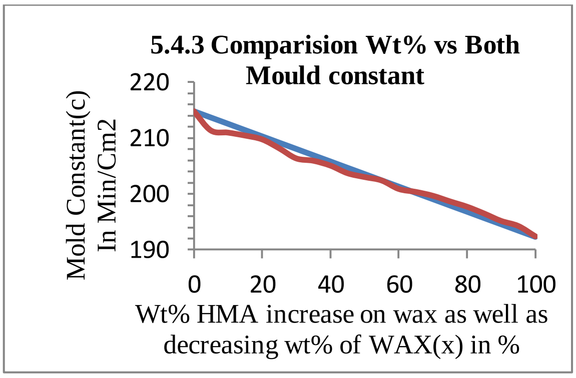

Fig 12 Comparisons of both mould constant(C), which is calculated by using formula & observational relation of weight% of mixture

C = -0.225x + 214.8 (by formula)

C = -1E-05x^3+ 0.002x^2-0.297x + 214.0 (by composition relation)

Where C = mould constant (in min / cm^2)

IJRAME

INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING
WWW.IJRAME.COM
ISSN (ONLINE): 2321-3051

Vol.6 Issue.9,
September 2018
Pg: -64-81

x = weight percentage composition of wax and hot melt adhesive (in %)

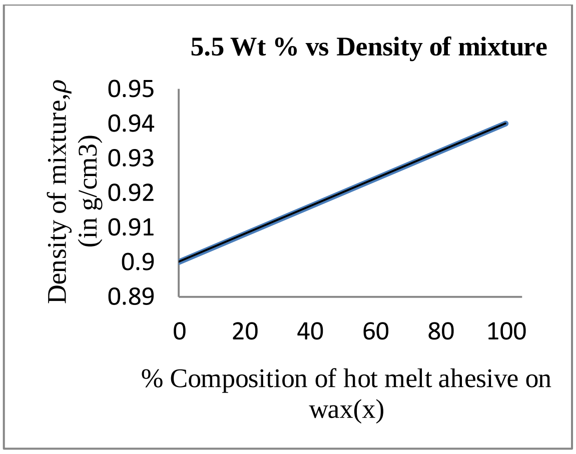

Fig 13 Shows the percentage-density of mixture curve or graph

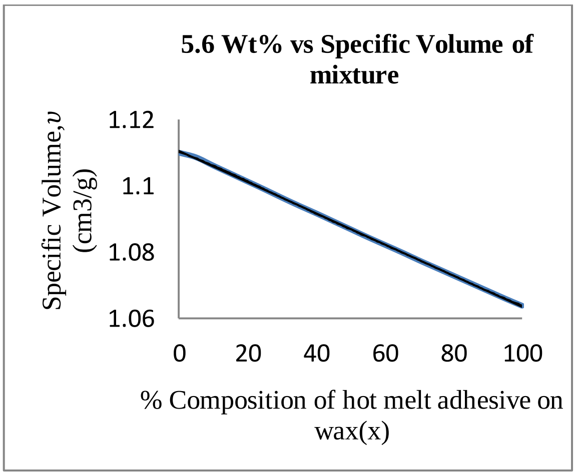

Fig 14 Graph between weight % of mixture vs. specific Volume of mixture

IJRAME
INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING
WWW.IJRAME.COM
ISSN (ONLINE): 2321-3051
Vol.6 Issue.9,
September 2018
Pg: -64-81

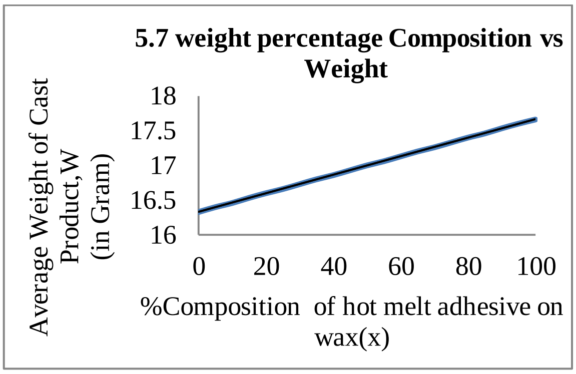

Fig 15 Graph between weight % of wax & hot melt adhesive vs weight of mixture of casting

VI CONCLUSIONS

The following conclusions are drawn out of the experiments conducted on wax and hot melt adhesive (HMA) selection of optimum process parameters. Here we can see that by varying the pouring temperature & Weight percentage of mixture .we gets different value of mold filling time their range value are shown in below:

Table 9 Shows conclusion for casting parameter with their range value & final generalized equation

Factor related to sand casting		Result (in Range Value)	Conclusion
Average Mold Filling Time of mixture		2.1-181.6 sec	It increases polynomially
		Equation: $(T_f)_{avg}$ = -7E-08x^5+ 4E-06x^4+0.001x^3-0.079x^2 +1.360x – 1.138	
Average Volume Flow Rate of mixture		9.0875-0.1049 cm^3/sec	It decreases polynomially
		Equation: Q_{avg} = -7E-07x^4+ 0.000x^3-0.007x^2- 0.039x+9.185	
Average Solidification Time of mixture		40min27sec-36min14sec	It decreases polynomially
		Equation: $(ts)_{avg}$ = 2E -08x^4-8E-06x^3+ 0.000x^2-0.064x+ 40.07	
Mold Constant of mixture	By formula	214.802-192.39 Min/cm^2	It decreases linearly
		Equation: C = -0.225x + 214.8	
	By relation & observation	214.80-192.3 Min/cm^2	It decreases polynomially
		Equation: C = -1E-05x^3+ 0.002x^2-0.297x + 214.0	
Density of Mixture of casting		0.9-0.94 g/cm^3	It increases linearly
		Equation : ρ = 0.000x + 0.9	
Specific Volume of mixture		1.11-1.0638 Cm^3/g	It decreases linearly
		Equation: υ = -0.000x + 1.110	
Average Weight of mixture Casting		16.33-17.66 Gram	It increases linearly
		Equation: w = 0.013x +16.33	

IJRAME

INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING
WWW.IJRAME.COM
ISSN (ONLINE): 2321-3051

Vol.6 Issue.9,
September 2018
Pg: -64-81

REFERENCES

[1] C.M.Choudhari, B.E.Narkhede And S.K.Mahaajan, Methoding And Simulation Of Lm 6 Sand Casting For Defect Minimization With Experimental Validation, Global Congress On Manufacturing And Management , Vol 12, Pp.1145- 1154, 2013

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

[3] https://en.wikipedia.org/wiki/Volumetricflowrate

[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] Katsina Christopher BALA, Reyazul Haque KHAN; Experimental Determination Of The Effect Of Mould Thickness On The Solidification Time Of Aluminium Alloy (Al-Mn-Ni -Si) Casting In Rectangular Metallic Moulds; (IJERT) Vol. 2 Issue 3, March – 2013;pg1-6

[6] 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

[7] N. Chvorinov, Theorie der Erstarrung von Gussstücken.Giesserei, 27, 1940, Heft 10, pp. 177 – 188, Heft 11, pp.201 – 208, Heft 12, pp. 222 – 225.

[8] https://en.wikipedia.org/wiki/Weight

[9] I. Galili and Y. Lehavi; The importance of weightlessness and tides in teaching gravitation; *American Journal of Physics teacher*;Vol. 71, No. 11, 2003;pg- 1127 -1135.

[10] M. Enamul Hossain, Chefi Ketata, 2009; Experimental Study Of Physical And Mechanical Properties Of Natural And Synthetic Waxes Using Uniaxial Compressive Strength Test; International Conference on Modeling, Simulation and Applied Optimization Sharjah, U.A.E January 20-22;pg1-5

[11] N. Ukrainczyk, S. Kurajica, and J. Šipušiæ; 2010; Thermophysical Comparison of Five Commercial Paraffin Waxes as Latent Heat Storage Materials; Biochem. Eng. Q. 24 (2) 129–137

[12] Gang Pu, Jinfeng Wang, Steven J. Severtson; 2007; Properties of Paraffin Wax/Montmorillonite Nanocomposite Coatings; NSTI-Nanotech ; Vol. 2, 2007;pg112-115

[13] JAVIER TORRESOLA; solidification properties of certain waxes And paraffins;pg 1-51

[14] Mohammad Khairushany Abd Rashid *et al*, 2017 Australian Journal of Basic and Applied Sciences, 11(3) Special 2017, Pages: 182-186

[15] Raghwendra Banchhor, S.K. Ganguly ; Optimization In Green Sand Casting Process For Efficient, Economical And Quality Casting; Banchhor Et Al.,International Journal Of Advanced Engineering Technology E-Issn 0976-3945, Int J Adv Engg Tech/Vol.V/Issue I/Jan.-March,2014/25-29

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