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Non-Metallic Multi Materials Casting for Density, Specific Volume & Weight

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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 and analyze or identify the various perspectives 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 density of mixture, specific volume of mixture ,weight of mixture of casting & parameter related to our cast shape which is truncated rectangular base pyramid or we simply called pyramidal frustum of rectangle base shape volume.**

Keywords: Casting, mould cavity, density, specific volume & weight.

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]. The most common materials used for casting are grey iron, ductile iron, aluminum alloys and copper alloys. 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. The three parameter is density of material, specific volume of material & weight of casting, which affects quality & process of casting. 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. and 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 [3, 4].

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."[3]

II LITERATURE REVIEW

In this chapter 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. **Galili et. al.** worked onThe 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. **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) since Eva offers lower cost than polyolefin. Hot melt

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adhesive with lower viscosity would have more flexibility to flow out, indicating that it had better wetting properties when applied to the substrate.

III MATERIALS & METHODOLOGY

3.1 CASTING MATERIALS

We used two main materials & one optional material for dyeing purpose
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 [5]. Paraffin's are a family of saturated hydrocarbons with general formula C_nH_{2n-2} [6]. 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 [7]. 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 [8].

3.1.2 Hot-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 [9]. 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

While performing casting, the properties of material is also important for understand their characteristics feature

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Table 1 Physical Properties of Paraffin's Wax [10]

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)
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 [11]

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.

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Pattern-by the help of this we create cavity.it is a solid type of pattern.	Thermometer-for measurement of temperature of liquid casting material.	Crucible-in this container. We melt our casting materials 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.

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. It is divided into three sections: Before casting perform, During casting perform & After casting perform.

1. Before castings perform prepare the sand mould.

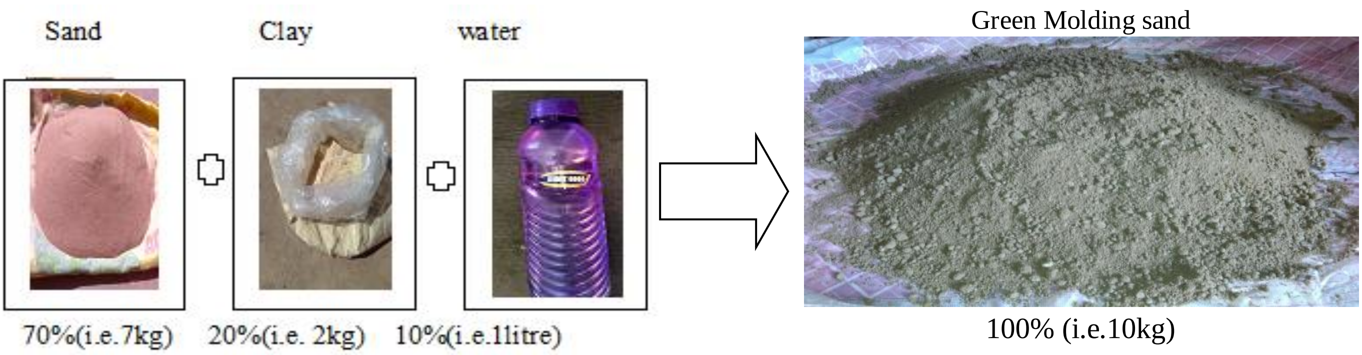

Fig 3 Sand mold preparations

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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

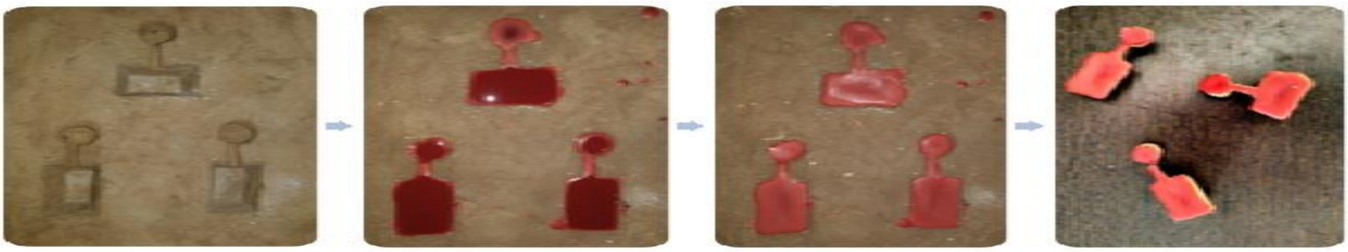

Fig 4 Before pouring molten material to cast product in sand casting

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%

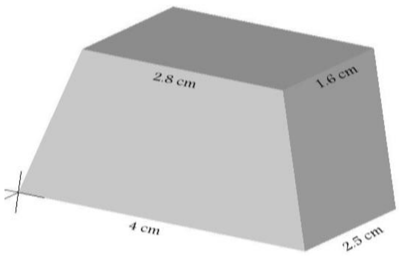

Fig 6 Dimensions of casting

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IV CALCULATION

We calculate three parameters:
4.1. Density of mixture of casting.
4.2. Specific volume of mixture of casting.
4.3. Weight of casting of mixture of casting.
Here we firstly calculate density of mixture then secondly calculate specific volume of mixture, then finally calculate the weight of mixture of casting.
Now measuring 4.1 density of mixture of casting & 4.2 measuring specific volume of casting

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

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. manual accuracy is not accurate.that why we calculated at 3 times & then find the average value of density of mixture of casting.

4.3 measuring average weight of casting

Table 4 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 & DISCUSSION

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.

How to change density, specific volume and weight of the casting with respect to mixture of two non-metallic materials, shown in below figure 4.1, figure 4.2 and figure 4.3 respectively.

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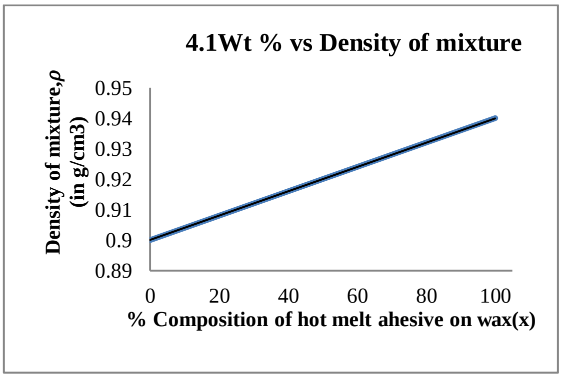

Fig 7 Shows the percentage-density of mixture curve or graph,

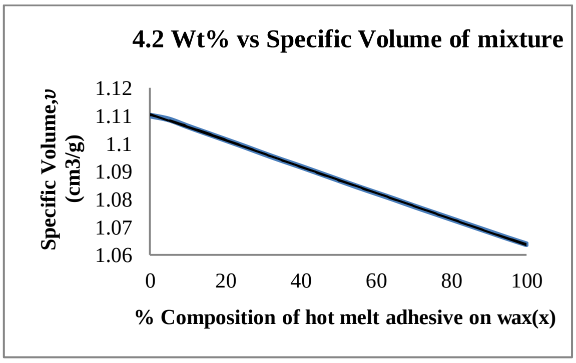

Fig 8 Graph between weight % of mixture vs. specific Volume of mixture

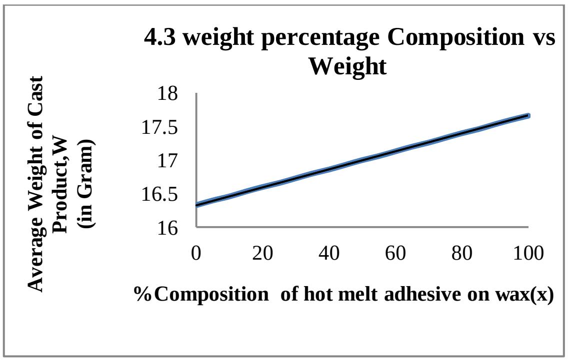

Fig 9 Graph between weight % of wax & hot melt adhesive vs weight of mixture of casting.

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 density, specific volume & average weight of casting their range value are shown in below:

Table 5 Shows conclusion for casting parameter with their range value & final generalized equation

S.No.	Factor related to sand casting	Result (in Range Value)	Conclusion
1.	Density of Mixture of casting	0.9-0.94g/cm^3	It increases linearly
		Equation : ρ = 0.000x + 0.9	
2.	Specific Volume of mixture	1.11-1.0638 Cm^3/g	It decreases linearly
		Equation: υ = -0.000x + 1.110	
3.	Average Weight of mixture Casting	16.33-17.66 Gram	It increases linearly
		Equation: w = 0.013x +16.33	

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