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OPTIMIZATION OF HEAT TRANSFER RATE IN WAX TANK FOR WAX INJECTION MOLDING MACHINE

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Abstract- ***Investment casting is basically a metal shaping technique. It is a foundry practice by which high precision castings are manufactured. This is a specialized foundry technology and is considered a high - tech area. This process has gained popularity on the basis of the superior quality of the castings produced. Making of wax pattern is important process for investment casting. Wax pattern is made by wax injection molding machine. For making wax pattern the one important issue is temperature of wax. The temperature of wax is maintained between 60c for obtain the best result. Temperature of wax in wax injection molding machine is maintain uniform in wax tank. The band heater and cooling band are placed around the wax tank for maintain the uniform temperature of wax. The stirrer also available for rotating the wax in wax tank. So the locations of heater band, diameter of wax tank, speed of stirrer are important factor for optimum heat transfer rate in wax tank. So optimization of this parameter is done by taguchi metthod. This purpose cad software for modeling and analysis and Minitab software for DOE are used.***

I. INTRODUCTION

Investment casting has gain popularity in high tech area on the basis of superior quality and higher accuracy. In investment casting important step is to make the wax pattern. Wax pattern are made in wax injection molding machine. For the good quality of wax pattern the temp of wax is important issue. For the best quality of wax pattern temperature of wax is maintain 60 centigrade. For this wax tank is used in wax injection molding machine. In wax tank band heater and cooling band are used to maintain the uniform temperature. Stirrer is also mounted in wax tank for rotate the wax in wax tank. Design and dimension are taken from MODE TECH MACHINE PVT LTD at vatava GIDC Ahmadabad, Gujarat. In this research work my objective is to optimize the heat transfer rate in wax tank for uniform temperature of wax. For optimization of heat transfer rate various parameter like heater position, diameter of tank and stirrer speed are important. So optimization of heat transfer is done by using taguchi method. Taguchi method is reducing the number is experiment. Here three level and three parameter is used in taguchi. Also used the Minitab software for taguchi method. For this model of wax tank is made in solid works then convert this model in STEP file and imported in ANSYS for CFD analysis. In this paper present the CFD analysis of wax tank and comparing this result to practical reading. For taking practical reading temperature sensor and thermocouple is used.

II. Taguchi method

The Taguchi method involves reducing the variation in a process through robust design of experiments. The overall objective of the method is to produce high quality product at low cost to the manufacturer. The Taguchi method was developed by Dr. Genichi Taguchi of Japan who maintained that variation. Therefore, poor quality in a process affects not only the manufacturer but also society. He developed a method for designing experiments to investigate how different parameters affect the mean and variance of a process performance characteristic that defines how well the process is functioning. The experimental design proposed by Taguchi involves using orthogonal arrays to organize the parameters affecting the process and the levels at which they should be varied; it allows for the collection of the necessary data to determine which factors most affect product quality with a minimum amount of experimentation, thus saving time and resources. Analysis of variance on the collected data from the Taguchi design of experiments can be used to select new parameter values to optimize the performance characteristic.

In this article, the specific steps involved in the application of the Taguchi method will be described and examples of using the Taguchi method to design experiments will be given.

In this project work three parameter and three level are used. So L_9 array is used which is shown below.

Table:1 Taguchi Array

Analysis	Diameter (mm)	Heater position	Speed (rpm)
1	380	A	15
2	380	B	20
3	380	C	25
4	415	A	20
5	415	B	25
6	415	C	15
7	350	A	25
8	350	B	15
9	350	C	20

III. PROCEDURE

For good quality of wax pattern the temperature of wax is remain uniform in wax tank at 60 c. For taking the practical reading thermocouple sensor are used which are placed at the

inner surface of inner tank. These sensors are giving the temperature at outside surface of tank. For measuring the inner temperature of wax one another thermocouple sensor is use. From the practical reading observe that the temperature at outside surface is height and at the middle of tank is lowest. The practical reading is plotted in bellow table.

Table 2
Practical reading of wax tank

MAXIMUM TEMPERATURE	333 K
MINIMUM TEMPERATURE	329K

Here ANSYS workbench is used for CFD analysis of wax tank. For CFD analysis following step are perform. In step 1 wax tank modal make in solidworks are converted in to STEP file and this step file are imported in ANSYS. In step 2 the meshing of this wax tank model is done. In meshing CFD mesh type is selected and fine meshing is done by using ten node tetrahedral elements. The reason for selecting this element is that is gives the good meshing on curvature parts. In step 3 various domains is define. Domain 1 is for stirrer, domain 2 is wax, domain3 is inner tank, domain 4 is for heater and domain 5 is for glass wool. out of all domain the domain 2 is fluid while other domain are solid. Now next step is define the interface between each domain here four interfaces are taken. First interface between domain 1 and domain 2, second interface is taken between domain 2 and domain 3, third interface is taken between domain 3 and domain 4, fourth interface is taken between domain 4 and domain 5.Now specify the boundary condition for CFD analysis. In boundary condition the stirrer speed is given 20 rpm. Next initialize the all domain temperature at 25 c. here specify the heater input temperature at 65 c. After giving boundary condition solve it for result. Here 100 iteration is run for accurate result. After solution go to the post processor for getting result. The result from Ansys is plotted below.

Table 3
ANSYS result

MAXIMUM TEMPERATURE	333 K
MINIMUM TEMPERATURE	328K

Fig 1 show the wax tank model in solidworks. In fig red color indicate the band heater which is placed on inner tank. Around the heater glass wool is placed as insulator and finely outer cover around the glass wool. In ANSYS analysis the outer cover is neglected. In below Fig wax domain is not showing. The wax domain is consider in ANSYS analysis for giving the wax property.

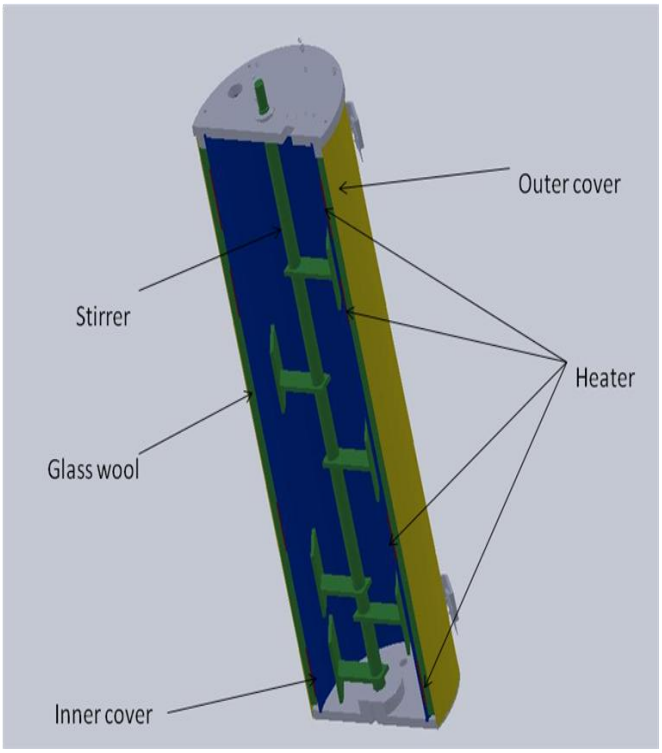

Fig 1: Wax Tank drawing in solid works

Fig 2 indicates the meshing model of the wax tank. Meshing detail of the wax tank is shown table below.

Table 4
Meshing detail of wax tank

DOMAIN	NODES	ELEMENT
DOMAIN 1	15815	69849
DOMAIN 2	59140	318434
DOMAIN 3	8190	4092
DOMAIN 4	15392	7200
DOMAIN 5	13351	48106
ALL DOMAIN	111888	447681

In fig 3 ANSYS CFX analyses is shown. From we can say that the maximum temperature is 333K and minimum temperature is 328 K. Fig 4 indicate velocity streamline of wax we can say that the maximum velocity is at the stirrer blade which shown by red portion in fig.

From practical reading and Ansys result we can say that ANSYS is give the close reading to the practical. So here ANSYS is used for the perform nine analysis as shown in taguchi array. From this analysis we can decide which modal of wax tank is best for maintain the uniform temperature of the wax in wax tank.

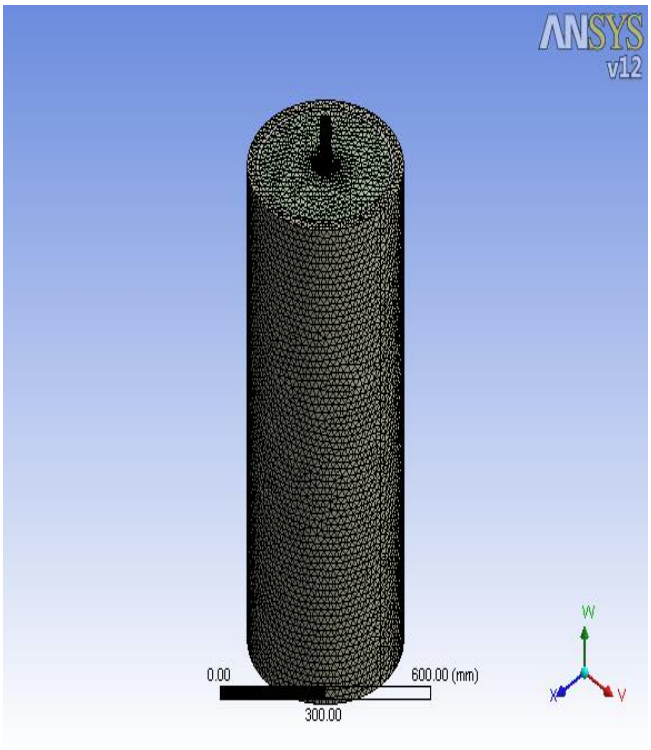

Fig 2: Meshing modal of tank

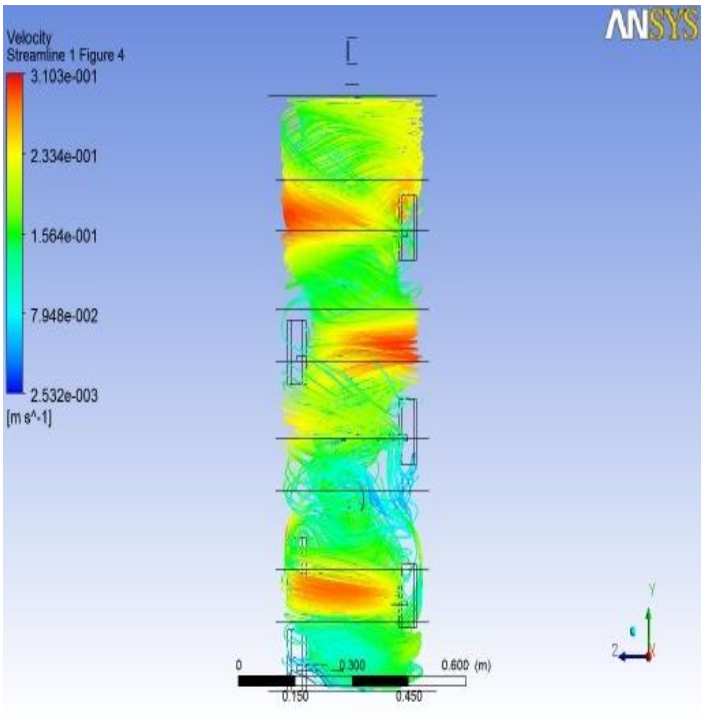

Fig 4: velocity streamline of wax in wax tank.

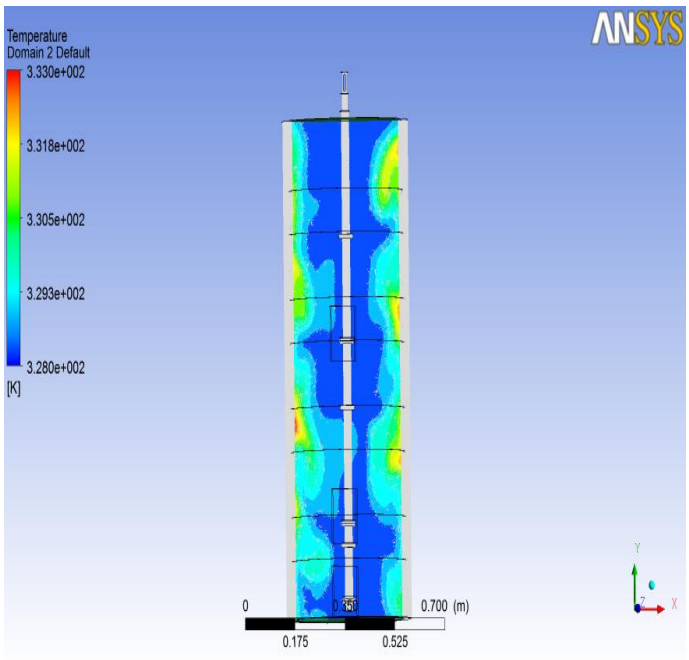

Fig 3: Temperature contour of wax in ANSYS.

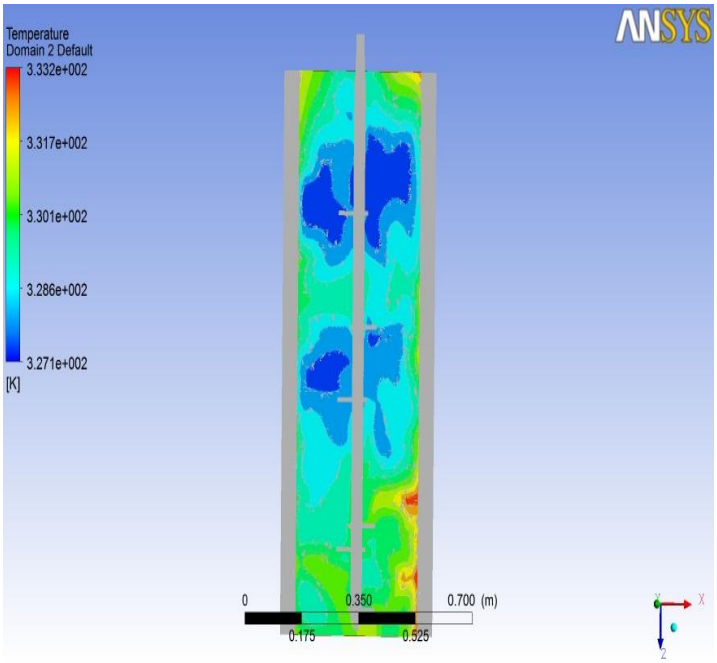

Fig 5: Analysis 1

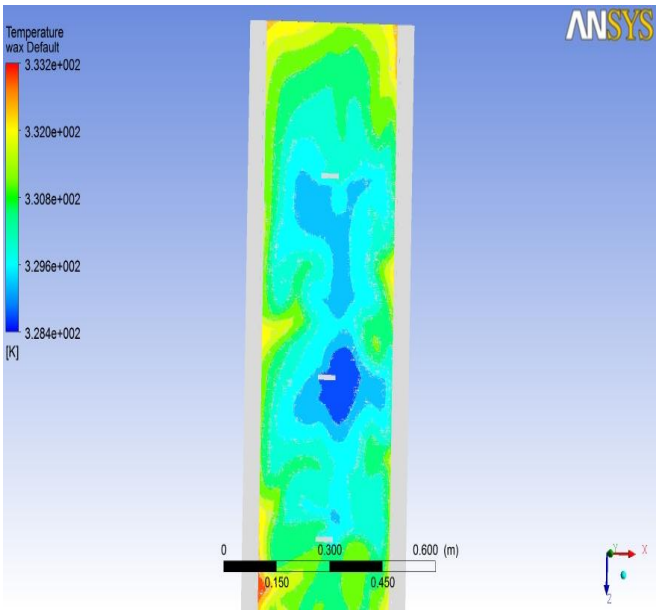

Fig 6: Analysis 2

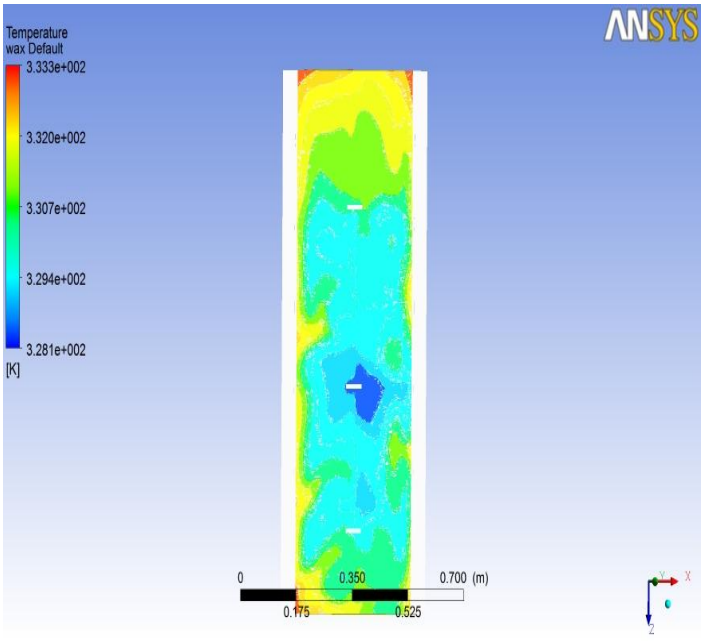

Fig 7: Analysis 3

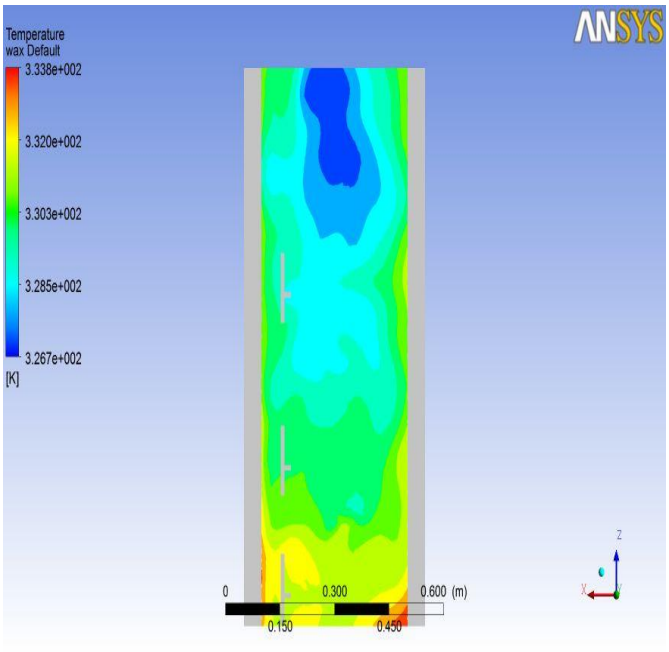

Fig 8: Analysis 4

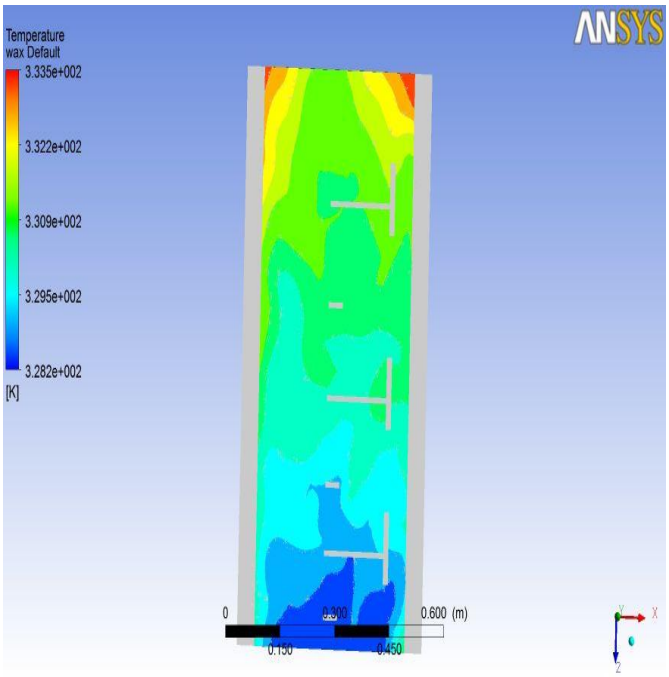

Fig 9: Analysis 5

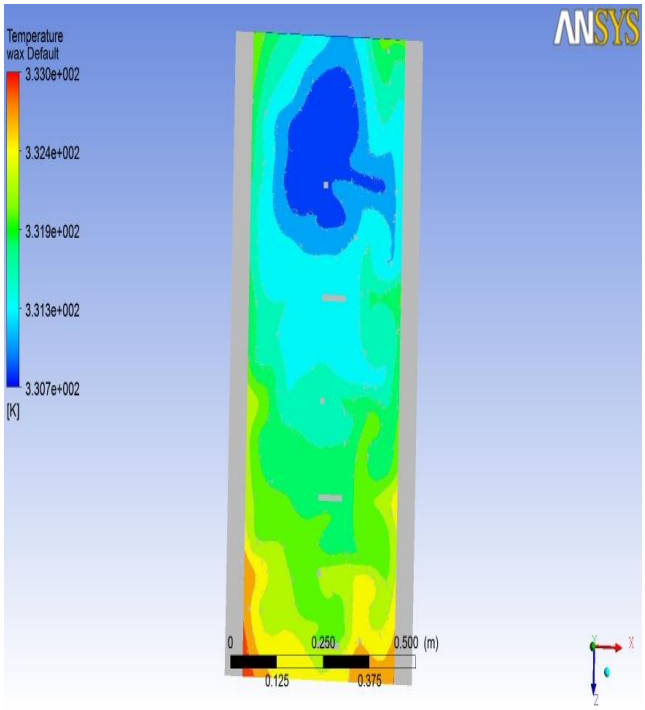

Fig 10: Analysis 6

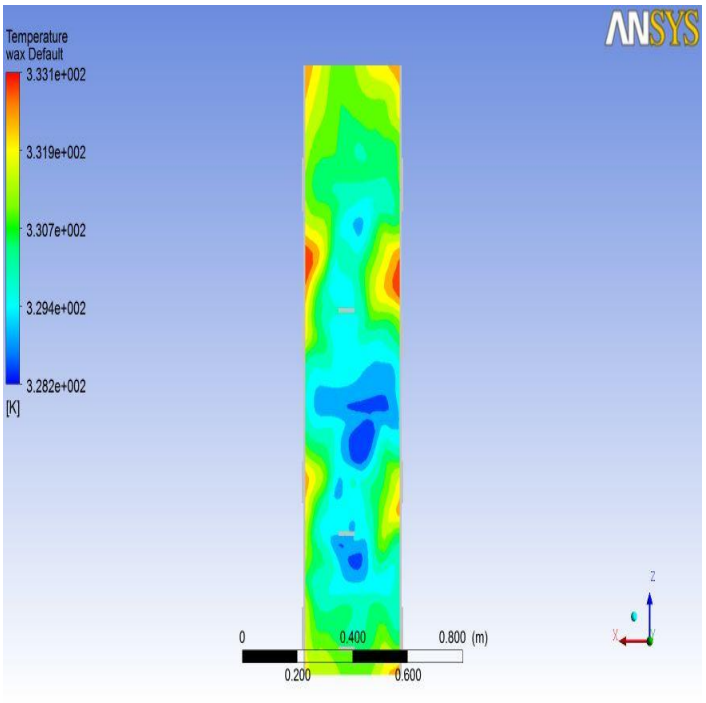

Fig 12: Analysis 8

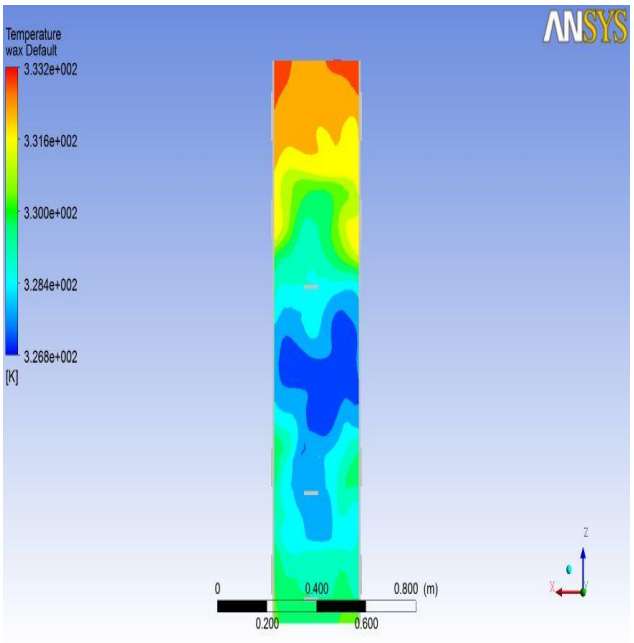

Fig 11: Analysis 7

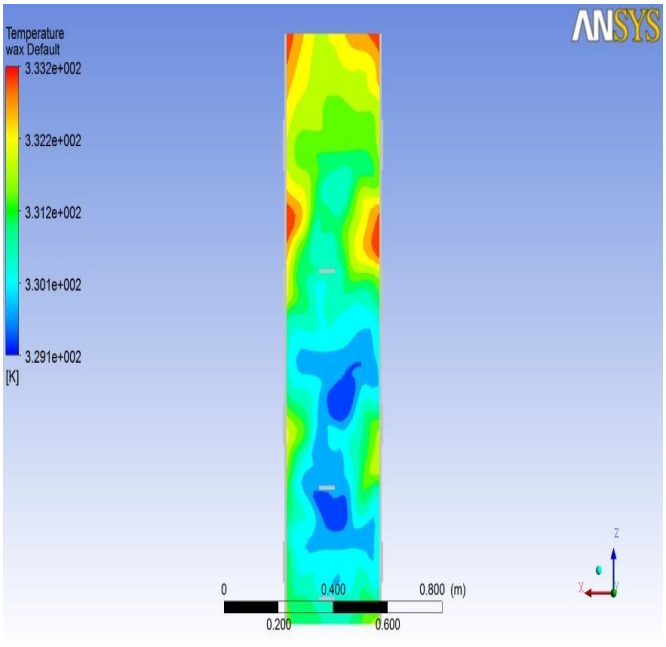

Fig 13: Analysis 9

Result of nine analyses are shown table below.

Table 5: Analysis Result

Analysis	Diameter (mm)	Speed (rpm)	Heater position	Temperature Difference (k)
1	380	15	A	6.1
2	380	20	B	4.8
3	380	25	C	5.2
4	415	15	B	7.1
5	415	20	C	5.3
6	415	25	A	2.3
7	350	15	C	6.4
8	350	20	A	4.9
9	350	25	B	4.1

IV. CONCLUSION

Temperature of wax in wax pattern is important factor for the best quality of wax pattern. For best quality of pattern the temperature is at 60 c uniform in wax tank. From table 5 we can say that analysis 6 is give the best result for maintain uniform temperature because the temperature difference is only 2.3 k. so the best modal is 415mm diameter, 25 rpm speed and heater position A.

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