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Experimental Study of Flow Behavior in Centrifugal Casting by Cold Modeling

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Abstract: In centrifugal casting process the quality and properties of the casting depends upon the flow of the fluid and other factors like temperature , rotational speed and the properties of the fluid like viscosity, density etc. Since it is very difficult to study the fluid behavior in centrifugal casting due to opaque nature of melt and mold, hence in the current investigation fluid flow behavior is determined by using cold modeling experiment by replacing opaque mold with a transparent one. Effect of viscosity and rotational speed on vortex height, thickness of the fluid and flow behaviour has been observed in vertical centrifugal casting using fluid of different viscosity like SAE 30 , SAE 40,water etc.

Keywords: Centrifugal Casting, Cold Modeling Experiment, Flow Behavior.

I. INTRODUCTION

Centrifugal casting is the casting technique in which the molten metal is poured into a rapidly rotating mold or die. Fluid Flow in the centrifugal Casting determines the quality and properties of the final product. The factors which affects the flow are viscosity and rotational speed of mold. The viscosity of fluid affects the lift of the fluid by resisting the fluid flow. As the viscosity increases lift decreases, but in the vertical casting another factor which affects the lift of the fluid is the force of gravity which tries to pull the fluid in downward direction. Another factor which affects the fluid flow is the rotational speed of the mold. On the one hand, excessive speed of rotation produces a high tensile stress in the outer periphery of the casting which eventually results in longitudinal cracks. As the rotational speed increases lift increases and the change in thickness occurs and at last at a certain speed a complete uniform cylindrical shape of the fluid is observed. Over the years, a rich variety of flow patterns have been observed within a rotating cylinder partially filled with a particle-free liquid that completely coats the cylinder surface.

Rimming flow is the flow of a liquid layer around the inside surface of a rotating horizontal cylinder. It occurs in a variety of industrial applications in which a layer of viscous liquid is required to be speared on a solid surface. When the cylinder is rotating at high speed, a liquid forms a hollow cylinder. Different patterns are observed in the fluid for the rotational speed below critical speed. The effect of the rotation speed on the flow patterns were studied. Since it is difficult to study the melt flow as melt & mould are opaque and casting process is rapid. Hence in the present investigation cold modeling experiment is carried out using transparent mould and fluid of different viscosity to study the effect of viscosity of the fluid, diameter of the mould, and speed variables on the flow pattern.

II. EXPERIMENTAL SETUP

The set up of centrifugal casting consists of a DC motor, attenuator, thermocouple, transparent mold and proximity sensor. The mold is fixed in wooden base which is connected to motor through connecting rod. The wooden based is fixed over a flange via studs. To run DC motor, 220v AC supply is given to motor via transformer for speed control and it will also convert AC input to DC output as shown in Fig.1.

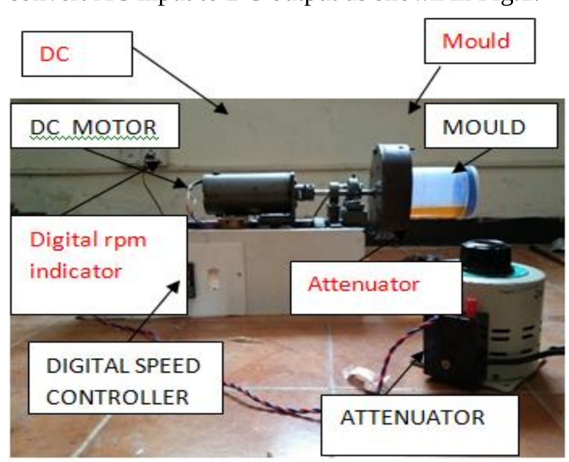

Fig.1. Horizontal experimental setup.

The proximity sensor is placed over the setup to count the number of rotations of mold which is digitally displayed over a display unit which is attached to the setup. Thermocouple is attached to the setup to measure the temperature of the mold. Here another display unit is placed to observe temperature of the mold and cut off temperature can also be set so that if temperature exceeds, the power supply will be cut off. The fluids used are water, SAE 30 and SAE 40. The different fluids are poured into the mould at lower speeds and then the speed is gradually increased till the formation of complete cylinder takes place. This procedure is repeated for the different fluids used and for different thickness as shown in Fig.2. For better visualization K2Cr2O7 is added as a coloring agent to water.

Fig.2. Vertical experimental setup.

TABLE I: Properties of Fluid

Sl. no.	Fluids	Viscosity in $\frac{Ns}{m}$	Density in $\frac{kg}{m^3}$
1	Water	$0.798 \text{ x}10^{-3}$ at $30°C$	1000
2	SAE 30	128 at 30°	875.4
3	SAE 40	121 at $30°C$	856.70
4	Paraffin wax	3.0657 at $100°c$	900

III. RESULTS AND DISCUSSION

Results of this paper is shown in bellow Figs.3 and 4.

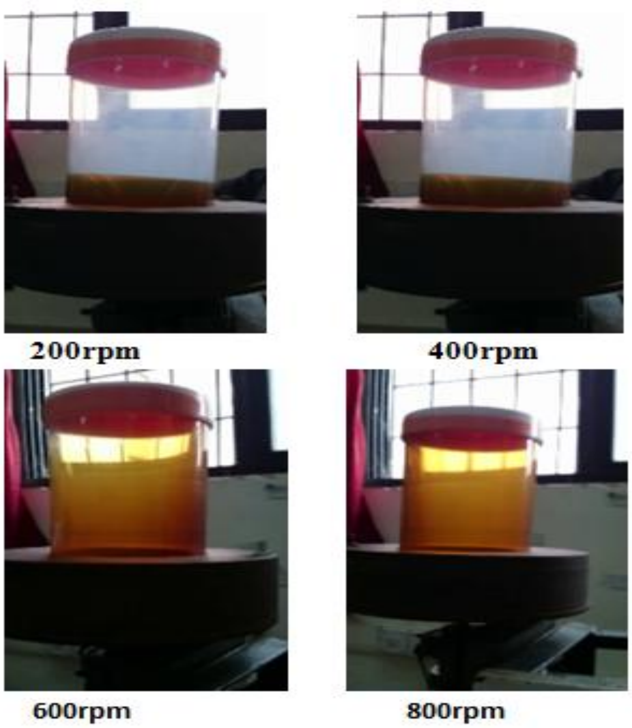

Fig.3. SAE 40 at different rotational speed in vertical centrifugal casting process.

TABLE II: Lift of Fluid at Different Rotational Speed

Sl. No.	Speed in rpm	Lift in mm		
		water	SAE 30	SAE 40
1	0	30	29	29
2	200	58	55	51
3	400	113	106	97
4	600	170	170	160
5	800	170	170	170

TABLE III: Vortex Height at Different Rotational Speed for Fluid of Volume 200ml

Fluid	Vortex height at different rotational speed (mm)			
	200 rpm	400 rpm	600 rpm	800 rpm
Water	150.06	300.18	450.34	600.74
SAE 30	150.62	301.25	451.93	602.58
SAE 40	150.62	301.25	451.93	602.58

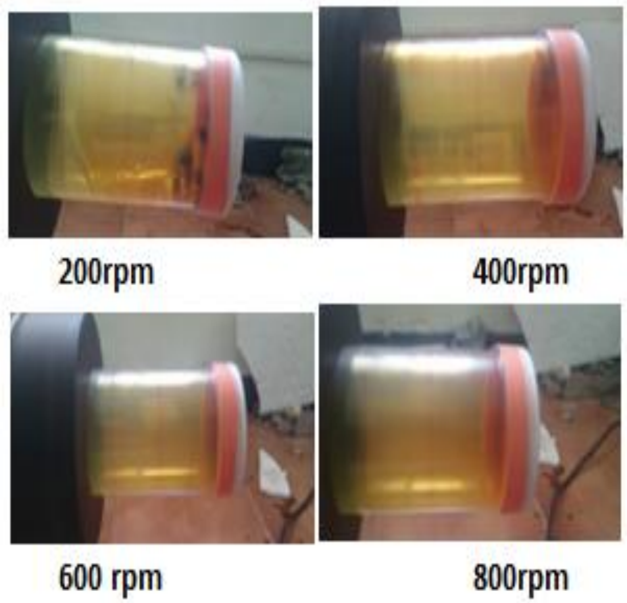

Fig.4. SAE 40 at different rotational speed in horizontal centrifugal casting process.

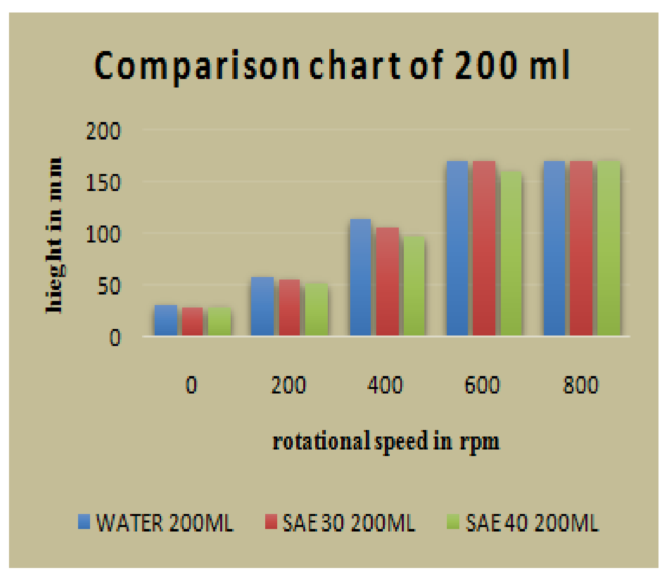

Fig.5. Graph comparing lift of water, SAE 30 and SAE 40 of 200ml at different rotational speed.

TABLE IV: Vortex Height Different Rotational Speed for Fluid of Volume 300ml

Fluid	Vortex height at different rotational speed (mm)			
	200 rpm	400 rpm	600 rpm	800 rpm
Water	144.07	288.14	432.29	576.36
SAE 30	144.63	289.26	433.66	578.59
SAE 40	144.63	289.26	433.66	578.59

The above fig.5 shows the comparison of the fluid flow at different rotational speed. For the fluids having more viscosity lift was less whereas for water having less viscosity reaches maximum height at same rotational speed. In above chart SAE 40 having more viscosity gives the minimum height at same speed. This proves that viscosity of fluid is an important parameter in the lift of the fluid. The fluid of 300ml will reach the maximum height of the mold at low rotational speed. The vortex height is minimum with lesser volume of fluid for same rotational speed.

IV .CONCLUSION

In vertical cold modeling experiment the lift of fluid is directly proportional to the speed of mold. It has been observed that lift decreases with increase in viscosity .At 800rpm in 170mm height mold, uniform hollow cylinder is formed. For fluid of lower viscosity, formation of cylinder is found to be at higher speed, whereas for fluid of higher viscosity formation of cylinder is obtained at lower speed. At lower rotational speed fluid exhibits patterns like slashing of liquid. At higher speed, Ekmann flow and Taylor flow get reduced and form a full cylinder.

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