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Optimum Performance of Heat Pipes in Mould Cooling

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ABSTRACT
Conventional water jacket method is used to cool the various products manufactured by molding processes. Injection moulding and die casting moulds are the basic casting methods which are cooled with conventional water jacket method. Cooling of mould is essential in order to obtain the good quality of moulded part. Further the factor which is also absolutely essential is the rate of production. Conventional water jacket method is not suitable to obtain the good results and possess many disadvantages. Hence heat pipes are used in conventional water jacket method to cool the molding processes. In this paper, the experiment is performed and observations are taken with conventional water jacket method and heat pipe system and results are shown. It is observed that the liquid cooling with heat pipe system is more effective than liquid cooling with conventional water jacket method.

***Keywords*: Conventional water jacket, heat pipe, moulds cooling.**

1. Introduction

Plastics are available in two types i.e. thermosetting plastics and thermoplastic materials. Thermosetting plastics are also known as heat setting materials and are formed in to shape under heat and pressure and results in a permanently hard product. Thermoplastic materials are also known as cold setting materials and they do not become hard with the application of heat and pressure and no chemical change occurs. They remain soft at elevated temperature and become hard on cooling. Both types of plastics moulded with the various moulding processes. Moulding is most common method employed for the fabrication of plastics. Plastics are moulded into any desired shape with the application of heat and pressure [3].
Injection moulding and die casting moulds are basic methods of casting. These processes are cooled by conventional water jacket method to obtain the good quality of moulded part. But this system is not suitable to obtain the good results and having many disadvantages. Hence the cooling with conventional water jacket is not optimum. Hence to obtain the good results and optimum performance, application of heat pipes are done in conventional water jacket method. Heat pipes transfer heat faster and hence the cycle time is reduced and the production rate is increased. Thus with the application of heat pipes in conventional water jacket method, the various disadvantages associated with conventional water jacket method are eliminated and the moulding processes become optimum. Hence by utilization of heat pipes in conventional water jacket method, the optimum performance of heat pipes is achieved. In plastic injection moulding the function of the cooling system is to provide thermal regulation in the injection molding process. When the hot plastic melt enters into the mould impression, it cools down and solidifies by dissipating heat through the cooling system [4].Injection mould cooling influences both technology and economy of production cycle. Main requirement given on to cooling system of injection moulds is quick and homogenous heat removal from injection part [5].

2. Experimental Set-Up

2.1 Components of Experimental Set-up
It consists of

- Heat Pipe
- Ceramic Band Heater
- Cooling water jackets
- Thermometers
- Mould cavity

2.1.1 Heat Pipe

Heat pipe is a heat transfer device with an extremely high effective thermal conductivity. Heat pipes are evacuated vessels which are partially back filled with a small quantity of working fluid. They are used to transfer heat from a heat source to a heat sink with minimal temperature gradient. As heat is input at the evaporator; fluid is vaporized creating a pressure gradient in the pipe. This pressure gradient forces the vapour to flow along the pipe to the cooler section where it condenses giving up its latent heat of vaporization. The working fluid is then returned to the evaporator by capillary forces developed in the porous wick structure. Heat pipe working fluids range from helium and nitrogen for cryogenic temperatures and to liquid metals like sodium and potassium for high temperature applications. Some of the, more common heat pipe fluids used for electronic cooling applications are ammonia, water, acetone and methanol. Heat pipe is a very good thermal conductor [6]. Among the various cooling techniques, heat pipe technology is emerging as a cost effective thermal design solution due to its excellent heat transport efficiency and capability [7]. Cooling of electronics is one of the major

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fields of application for the heat pipes, especially in notebook computers and telecommunications applications [8].

2.1.2 Ceramic Band Heater

To maintain the good quality, the temperature of the moulding must be appropriately set and precisely controlled [9].

2.1.3 Mould cavity

Various products are moulded in mould cavity.

2.1.4 Water Jacket Set-up

The cooling system is one of the most important systems in a plastic injection mould to affect the quality and productivity of the molded part [10].

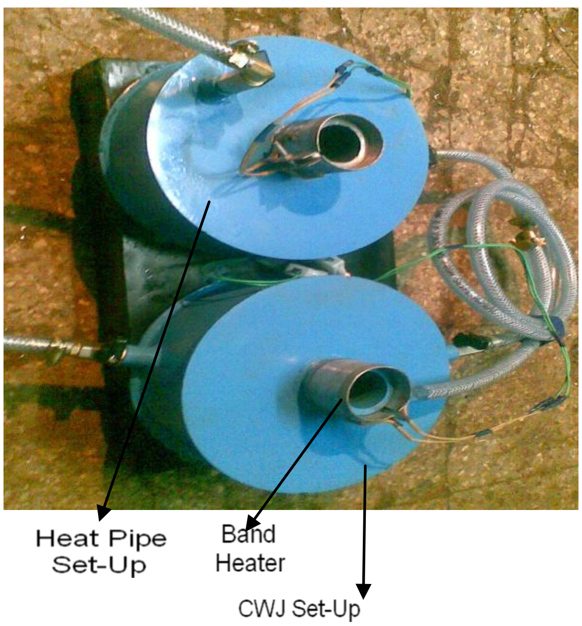

Fig 1: Experimental set-up

2.1.5 Heat Pipe Set-up

The performance of heat pipe depends upon various factors such as its diameter, length; application (how and where the heat pipe is used) and its orientation [11].The various orientations performed for heat pipe are as follows

1. Horizontal orientation
2. Inclined orientation
3. Vertical orientation

Out of these orientations heat pipe gives better thermal performance in horizontal orientation.

3. Experimental Results

We have taken various readings for both the set-up as follows.

Table 1: Observation table for cold water jacket set-up

Sr. no.	Volume in Beaker (ml)	Time (sec)	Mass flow rate kg/sec	T1 (^{0}C)	T2 (^{0}C)	ΔT (^{0}C)
1.	100	266	0.0036	24	34	10
2.	100	240	0.0040	24	33.2	9.2
3.	100	190	0.0051	24	32.3	8.3

Total Heat Transfer= Q= U*A*ΔT

Where U= Overall heat transfer coefficient

= 340 to 455 w/m^{2}k

A = Heat Transfer Area

= π*D*L

= π *0.048*0.075

= 0.011m^2

Q = 340*0.011*10

Qcwj = 37.4 Watt

Table 2: Observation table for heat pipe set-up

Sr. no.	Volume in Beaker (ml)	Time (sec)	Mass flow rate kg/sec	T1 (^{0}C)	T2 (^{0}C)	ΔT (^{0}C)
1.	100	266	0.0036	24	44	20
2.	100	240	0.0040	24	43.2	19.2
3.	100	190	0.0051	24	42	18

Total Heat Transfer= Q = U*A*ΔT

Where U= Overall heat transfer coefficient

= 340 to 455 w/m^{2}k

A1= Heat transfer area

= (π*D*L)-2(π/4)* d^2

= (π *0.048*0.075)-2(π/4)*(0.022)^2

A1=0.0105m^2

Q1=340*0.010*20

= 71.4 watt

A2=Heat transfer area for evaporator of Heat pipe

$= 2(\pi*D*Levap)$

$= 2(\pi*0.012*0.025)$

$A2 = 0.001884\ m^2$

$Q2 = 340*0.001884*20$

$= 12.81$ watt

Total heat transfer through heat pipe system

$Qhp = Q1+Q2$

$Qhp = 71.4+12.81 = 84.21$ watt

3.1 Effectiveness of heat pipe system over cooling water jacket system

$\varepsilon = mcp\Delta T$ with Heat pipe / $mcp\Delta T$ with CWJ

$\varepsilon = Qhp / Qcwj$

$\varepsilon = 84.21/37.40$

$\varepsilon = 2.25$

Thus liquid cooling with heat pipe system is 2.25 times effective than liquid cooling with water jacket method.

4. Conclusion

With the application of heat pipes in conventional water jacket methods in mould cooling, it is observed and can be stated that the liquid cooling with heat pipe system is more efficient and effective than liquid cooling with water jacket cooling method.Thus heat pipes are proved to be the basic need in conventional water jacket methods in mould cooling processes for optimum performance.

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