IMPROVEMENT IN CONVENTIONAL WATER JACKET METHOD IN MOULD COOLING USING HEAT PIPE

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Abstract:
Die casting moulds and injection moulding are cooled by conventional water jacket method. Cooling of mould is very essential for the purpose of quality of parts and cycle time. The conventional water jackets methods used are having many disadvantages, due to which the effect of mould cooling is not optimum. Hence a technique which can overcome all the disadvantages and become optimum emerged. The main aim of this proposed work is to improve conventional water jackets methods in mould cooling by the application of heat pipe. Heat pipe plays an very important role in such situations, and shows effective results, there by improving the conventional water jacket method in mould cooling. It transfers heat many times faster than pure copper.

Keywords: Conventional water jacket, mould cooling, heat pipe.

1. Introduction

Plastics are the synthetic organic materials which can be moulded into any desired shape when subjected to heat and pressure. They are a group of materials when heated can be formed into a variety of useful articles by moulding and casting. Plastics have been increasingly accepted for modern engineering application because of the fact that plastics are attractive materials and offer many advantages in weight, cost, moisture, strength, and chemical resistance. Moulding is the most common method used in the fabrication of plastics. Moulding processes are based on the fact that when the plastic is heated, it will soften to a viscous liquid that can be forced into a mould, where it solidifies of desired shape. Injection moulding and die casting are the most common methods in the manufacturing of plastics
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2. Methods of casting

2.1 Die Casting: - Die casting is the art of rapidly producing accurately dimensioned parts by forcing molten metal under pressure into split metal dies which resemble a common type of permanent mould. Within a fraction of second, the fluid alloy fills the entire die. Because of the low temperature, the casting solidifies quickly permitting the die halves to be separated and the casting ejected. The advantages of die casting practice lies in the possibility of obtaining castings of sufficient exactness and in the facility for casting thinner sections that cannot be produced by any other casting methods. With the help of die casting, very high rate of production is achieved.

2.2 Injection Moulding: - Injection moulding is the most widely used method of producing parts of thermoplastic as well as thermosetting resins. The process resembles the hot chamber die casting of metals. The die, split to allow removal of the solidified product is kept shut, with an appropriate press force and ejectors are provided for removing the moulded component.

Injection moulding and die casting moulds are cooled by conventional water jacket method. In plastic injection mould, cooling system plays a very important role for the purpose of quality and productivity of the moulded part [1]. In plastic injection moulding the function of the cooling system is to provide thermal regulation in the injection moulding process. When the hot plastic melt enters into the mould impression, it cools down and solidifies by dissipating heat through the cooling system [2].

2.3 Conventional Method

The conventional water jacket method is used for cooling the moulding processes. The conventional water jacket method is used in conjunction with baffles, blades and offers various disadvantages.

Limitations of Conventional Method

The conventional water jacket method used for cooling the moulding processes is having many disadvantages. They are as follows.

1. Heat transfer with water jacket takes place with laminar flow, which is very low as compared to heat transfer to turbulent flow.
2. Hot spots are produced due to inability of water jacket to cool the in accessible areas of mould
3. Increased cycle time due to slow cooling.
4. Rejection of parts due to defects such as Sink marks, pulling and spotting that takes place due to insufficient cooling.
5. Increased maintenance and operating cost as there is a tendency of scale formation, calcium deposits and clogging of ports in water jacket cooling system.

Hence there is a need of a technique which can overcome all these disadvantages emerged. The solution for above problem is with the application of heat pipe in conventional water jacket method in mould cooling.

3. Proposed Method

In this method it is suggested to use heat pipe in conventional water jacket method.

3.1 Heat pipe

Heat pipe is a heat transfer device specifically designed for optimal performance in plastic injection moulds and dies for the die casting industries .The heat pipe consist of vacuum tight copper tube containing a wick and a non toxic working fluid .The two ends of heat pipe perform distinct functions, one end is evaporator and other end is a condenser. In heat pipe thermal energy is gathered at the evaporator end vaporizing the working fluid. The vapour then travels through the heat pipe to the condenser end. At the condenser end the vapour condenses back into a liquid giving up its latent heat in the process. To complete the cycle the condensed liquid then travels along the wick, via capillary action back to the evaporator section. This process repeats itself continuously, transferring heat many times faster than pure copper.

Fig3. 1: Heat Pipe.

Heat pipe is a device which works as an excellent heat conductor enables very intensive heat transfer from the area with higher temperature to the area with lower temperature [3]. Among the various cooling techniques, heat pipe technology is emerging as a cost effective thermal design solution due to excellent heat transport efficiency and capability [4]. Cooling of electronics is one of the major fields of applications for the heat pipes especially in notebook computers and telecommunications applications [5].

3.2 Heat pipe orientation

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 [6].
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:

Fig 3.2 shows, heat pipe in horizontal orientation. The thermal performance of heat pipe is best in this orientation. Hence it is better to use heat pipes in this position in mould cooling.

Fig 3.2: Heat pipe in horizontal orientation

Fig.3.3 shows, heat pipes in inclined orientation. The thermal performance of heat pipes is less in this orientation than above orientation.

Fig 3.3: Heat pipe in inclined Orientation

Fig 3.4 shows heat pipes in vertical orientation. The thermal performance of heat pipes is less in this orientation than the above two orientations.

3.3 Heat Pipes in Moulds

Heat pipe is available in a variety of standard lengths and diameters, heat pipes are used in cores, core slides, cavities and other areas of mould or die requiring cooling or controlled temperatures. In moulds, heat pipes are available-le in two temperature ranges.

(i) For Injection Moulds: - Heat pipes having temperature range from $+5^0$C to $+200^0$C. The main application of these types of heat pipes are in injection moulding, compression and transfer moulding.

(ii) For Die Casting Dies: - Heat pipes having temperature range from $+5\ ^0$C to $+350^0$C. The main application of these types of heat pipes are in die casting.

Fig 3.4: Heat pipe in vertical orientation

The basic consideration of a suitable working fluid in the operating vapours temperature range is very important during the performance. Table 3.1 shows the different working fluids with their melting point and boiling point. It also gives suitable temperature range for different working fluids. To maintain the good quality, the temperature of the moulding must be appropriately set and precisely controlled.

Table3.1

Medium	Melting pt. (° c)	Boiling pt. at atm. pressure (° c)	Useful range
Helium	- 271	- 261	271 to -269
Nitrogen	- 210	- 196	-203 to -160
Ammonia	- 78	- 33	-60 to 100
Acetone	- 95	57	0 to 120
Methanol	- 98	64	10 to 130
Flutec PP2	- 50	76	10 to 160
Ethanol	- 112	78	0 to 130
Water	0	100	30 to 200
Toluene	- 95	110	50 to 200
Mercury	- 39	361	250 to 650
Sodium	98	892	600 to 1200
Lithium	179	1340	1000 to 1800
Silver	960	2212	1800 to 2300

4. Applications

Typical applications of heat pipes in mould cooling include

(1) In small cores like Ball Pen, Barrel and disposable syringes, normal water cooling becomes very difficult. Cooling channels get blocked either due to rust or impurities in water, causing production problems. Heat pipes are best for such cases.

(2) In double wall containers due to thin section of core, normal water-cooling becomes impossible and then one has to continue moulding at very long uneconomical cycles. In such cases heat pipes are suitable to overcome such problems.

(3) In case of very old moulds where water cooling is blocked due to moulds rusting or due to some cracks developed on moulds, circulating water through mould becomes impossible. Heat pipes are suitable to overcome the problems.

(4) On some products like luggage bags, gating is required to be given from core side, this is done to avoid

gate marks on the external face. Ejection system in such moulds is to be provided from the same injection side. Such moulds are known as reverse moulds. These moulds have some problems like gating sink marks, circular flow marks, shining patches around gate etc. heat pipes are used in such cases.

(5) Heat pipes are applicable in all normal moulds to enhance the cooling effect.

5. Benefits

(1) Cool mould faster and reduce cycle time:

The ability of heat pipe to cool moulds is faster and thus reduces cycle time. This occurs due to number of factors, first it permits higher coolant velocity which transfer heat faster, second it transfers heat away from inaccessible area, improving overall cooling rate and reduces cycle time.

(2) Improve Part Quality:

As the heat pipe transfer heat to the coolent, air or mould component it also dissipates heat evenly along its entire length, this isothermal action provides faster and more uniform cooling .Thus eliminating hot spots which cause sink marks, pulling and spotting.

(3) Simplify mould design and lower cost:

With heat pipes, Water line design is greatly simplified since coolant flow into the heated area of the mould is not required. In addition the ability to locate heat conductors in areas inaccessible to other cooling devices can further simplify the overall mould design. In most cases the machining and construction time required for the mould is reduced, lowering mould making costs.

(4) Reduce maintenance and operating costs:

The increased waterline diameter, coolant velocity and heat capacity effectively eliminate scale formation, calcium deposits and the plugging up of small waterlines and ports. In addition, Heat pipes operate in any coolant without corroding.

(5) Upgrade existing moulds and dies:

Heat pipes effectively solve cooling, cycle time or part quality problems in existing moulds. They can be retrofitted as replacements for bubblers or baffles and to provide heat transfer in previously uncooled areas.

6. Conclusion

With the application of heat pipes in conventional water jacket methods in mould cooling, it is found that the various disadvantages associated in conventional water jacket methods in mould cooling are eliminated and the quality of the moulded parts are improved. Further a very high rate of production is achieved. Thus heat pipes are proved to be the most efficient and beneficial tool in mould cooling.

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