Wear of Reciprocating Screw for Injection Moulding Machine: A Review

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Abstract: ***Injection moulding machine is the most commonly used manufacturing process for the fabrication of plastic parts.The plastic being melted in injection molding machine and then injected into the mould. The barrel contains reciprocating screw for injecting the material into the mould and the material is also melted into the barrel. This paper presents the review of the causes of the wear of the screw and the barrel and their suggested solution.***

Keywords: Reciprocating, wear, Screw, Injection moulding machine.

1. Introduction

In the process of injection moulding machine material is melted by heat and pressure. The material enters the grooves of the screw .the screw completes the shot volume and returns to reverse position problem occurred in the reciprocating screw is of wearing of threads due to the effect of high melting temperature and pressure of mould materials. At the same time literature review shows that the injection moulding machine encounters various problems while its operations. Some scholars who works on injection moulding machine problems are:

1. P. Boey et. al. presents that Glass-filled polymers are known to produce considerable wear on the barrels and screws of injection moulding machines. A few model tests simulating the tribological conditions in the injection moulding machine have been developed for finding the appropriate coatings and treatments to combat the wear. This paper presented a new wear tester that has been developed to simulate more closely the wear that occurs inside the barrel of an injection moulding machine. The concept of the tester is similar to that of the ASTM rubber wheel abrasion tester with some additions to ensure the requirements of closely simulating the condition of wear. This paper presented a tester to assess the wear of untreated, chrome plated and nitrided steel by glass-filled nylon as a function of temperature and to analyze the wear mechanisms occurring under the studied test conditions, the best performance were achieved by nitrided steel. The wear rate of untreated steel and chrome-plated steel increases as the temperature rises but the wear rate of the nitrided steel is effectively constant.

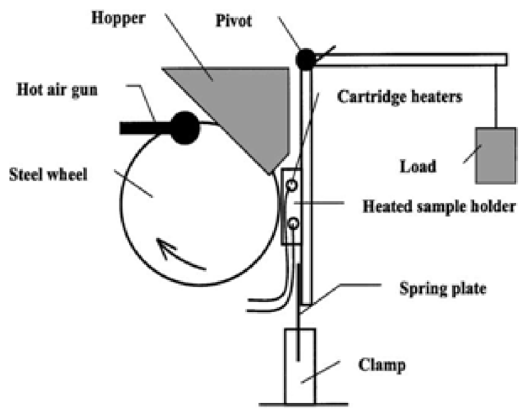

Figure 1: Schematic of the wear tester.

The wear test is based on the ASTM rubber wheel abrasion test, but the rubber wheel is replaced by a steel wheel of the same grade used in the barrel of an injection moulding machine (Fig. 2). The rim of the steel wheel is heated to the required temperature by hot air guns (accurate to ±10◦C). The sample is placed in a holder connected to a pivot loading system that can press it against the rim of the steel wheel. The sample holder is heated independently of the steel wheel by cartridge heaters. The sample temperature is controlled to ±2◦C.

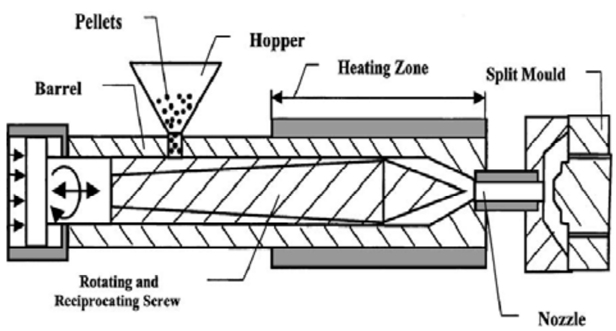

Figure 2: Schematic diagram of an Injection Moulding Machine

2. Ke Yao et. al. proposed that Injection molding barrel temperatures have slow responses. During the transitions between the machine's idle state and the operation state, significant temperature variations exist in the temperature zones. This leads to inhomogeneous melt temperatures and inconsistent product quality.

This paper introduces this industrial problem and then presents a combined strategy using a feedback controller and an iterative learning feed forward (ILFF) controller to resolve the problem. The proposed strategy is implemented and tested on an industrial-sized reciprocating-screw injection molding machine. Experiments show that the combined control strategy has superior performance compared with that of the traditional feedback controller. The transitions between the machine idle state and operation state result in large barrel temperature variations in the injection molding process. A combined strategy of feedback (GPC) control and ILFF control has been designed to solve this problem. Experimental results on an industrial-grade machine clearly show the effectiveness of the proposed strategy. The developed control strategy can maintain the barrel temperatures tightly around the set-point during normal operation, machine idle and the transitions. The key to the success of the strategy is the learning of the impact of the disturbance on the control by taking advantage of the repetitive nature of the process. The strategy can be used under different conditions as the disturbance impact can be learned iteratively.

3. P. Boey et. al. demonstrated that Glass-filled polymers are known to produce considerable wear on the screws and barrels of injection-moulding machines and several coatings and surface treatments have been used to combat this ranging from chromium plating to high velocity oxy fuel (HVOF) WC/Co. The tester concept is similar to that of the ASTM rubber wheel abrasion test except that the rubber wheel is replaced by a grooved steel wheel heated to a fixed temperature (up to 250 ◦C) by hot air and the sand is replaced by pelletised plastic.

This paper shows that plastic is captured by the wheel and dragged past the sample, which is also heated to the same temperature. The sample is pressed against the plastic coated wheel with a small load and a wear scar is produced at the contact point by a combination of abrasive wear from the glass filler and sliding wear from the plastic. A specially designed feeder system allows the controlled supply of polymer feedstock for operating times of a few hours. In the case of glass-filled nylon, the best surface treatment was a diamond-like carbon coating, but hybrid surface treatments involving the nitrogen ion implantation of nitrided steel also showed excellent wear performance.

Paper suggests that hybrid surface engineering techniques involving ion implantation of nitrided steel generate much better performance in the test when compared to simple nitrided steel However; DLC coatings have shown the best performance to date and have great potential for industrial application.

4. A B M Saifullah, et. al. sates that Injection moulding is one of the most versatile and important operation for mass production of plastic parts. In this process, cooling system design is very important as it largely determines the cycle time. A good cooling system design can reduce cycle time and achieve dimensional stability of the part.

This paper describes a new square sectioned conformal cooling channel system for injection moulding dies. Both simulation and experimental verification have been done with these new cooling channels system. Comparative analysis has been done for an industrial part, a plastic bowel, with conventional cooling channels using the Mold flow simulation software. Experimental verification has been done for a test plastic part with mini injection moulding machine. Comparative results are presented based on temperature distribution on mould surface and cooling time or freezing time of the plastic part. The results provide a uniform temperature distribution with reduced freezing time and hence reduction in cycle time for the plastic part.

The paper propose that cooling process is one of the most important sub processes in injection moulding because it normally accounts for approximately half of the total cycle time and affects directly the shrinkage, bending and warpage of the moulded plastic product.

The results of Mold flow Plastic Inside MPI simulation and experimental verification show that using square shape conformal cooling channels gives up to 35% reduction in cooling time and 20% of the total cycle time can be obtained, thus greatly improving the production rate and the production quality of injection moulded parts.

5. R. Dubay shows that parameters in plastic injection moulding are highly nonlinear and interacting. Good control of plastic melt temperature for injection moulding is very important in reducing operator setup time, assuring consistent product quality, and preventing thermal degradation of the melt.

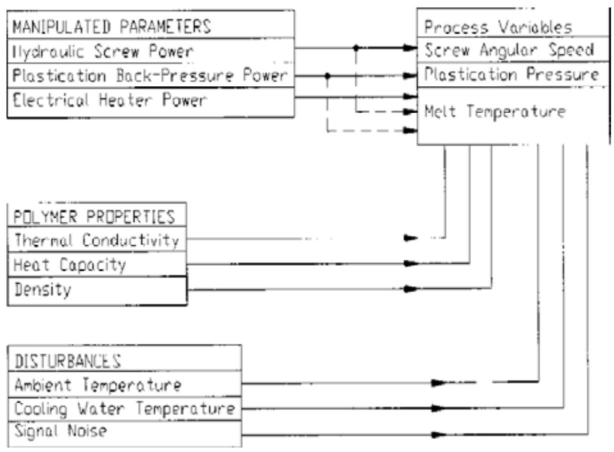

Figure 3: Interaction of process variables in injection moulding.

In this paper Step response testing was performed on the barrel heating zones on an industrial injection moulding machine ~IMM! The open loop responses indicated a high degree of process coupling between the heating zones. From these experimental step responses, a multiple-input–multiple-output model predictive control strategy was developed and practically implemented. The requirement of negligible overshoot is important to the plastics industry for preventing material overheating and wastage, and reducing machine operator setup time. A generic learning and self-optimizing MPC methodology was developed and implemented on the IMM to control melt temperature for any polymer to be moulded on any machine having different electrical heater capacities. The control performance was tested for varying set point trajectories typical of normal machine operations. The results showed that the predictive controller provided good control of melt temperature for all zones with negligible oscillations, and, therefore, eliminated material degradation and extended machine setup time.

Paper suggests that self-optimizing MPC structure is better suited for plastic injection moulding since it provides the ability for formulating the dynamic matrix **p***b* for any plastic material, IMM, and operating region. The self-optimizing terminology is based on the ability for the operator of the machine to develop a predictive controller for a specific material without having in-depth knowledge of the control methodology. This technique is a key ingredient for developing controllers on industrial IMM's that can redefine its parameters when different plastic materials and machine types are used, thereby providing a learning framework for controller adaptability and adjustment.

6. **Sorin ILIE et. al.** proposed the practical experiments to determinate the influence of the roughness at the contact surface between two thermoplastics polyurethanes. Thirst polyurethanes it is a soft plastic material and the second is very rigid or hard polyurethane. The adhesion between these two materials it is very important for the bi-components injection molding parts. These parts obtained with bi-components molding injection technologies are very complex because they combine multi characteristic of the different plastics material like thermoplastics polyurethanes.

Paper proposes an influence of the roughness of the contact surface for the injection molding bi-components parts. Because all the other parameters of the bi- component injection molding machine was constant only one variable can be the cause of different values of the tensile force at bonding break. Increase the roughness of the contact surface between two polyurethanes thermoplastic for an injection molding bi-components part the adhesion between the two components also increase. But this value of the bonding between the two components has a limit value and she is depending of the roughness of the contact surface and also the local injection condition. The local molding condition are very important because depending of this values we can influence the thickness of the interfusion layer.

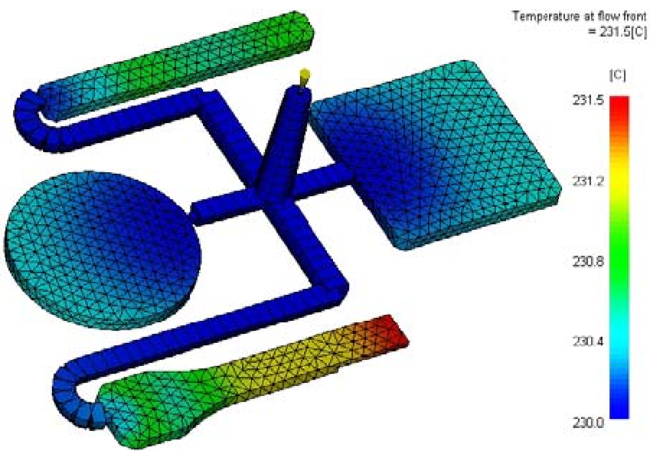

Figure 4: The results of flow front temperatures after CAE simulation

Table 1: The values sets for the bi-component injection machine used for the experimental trials

Name of the injection parameters	*Values for the first component*	*Values for the second component*
Melt temperature [°C]	220	240
Mold temperature	45	45
Injection time [s]	2,50	0,58
Switch over pressure [bars]	150	100
Holding pressure [bars]	200	200
Holding time [s]	20	16
Cooling time [s]	18	12

7. Y. Bereaux et. al. suggested a model to predict the throughput of a single-screw extruder or the metering time of an injection moulding machine for a given screw geometry, set of processing conditions and polymeric material is important both for practical and designing purposes. The model is based on viewing the entire screw simply as a pump, conveying a solid and a molten fraction. The evolution of the solid fraction is the essence of the plastication process, but under a particular hypothesis on solid bed acceleration, its influence on the throughput is nil. This allows getting a good estimate on the throughput and pressure development along the screw. Calculations are compared to a large set of experiments available from the literature. Consistent agreement with these published results is obtained, both for throughput and pressure along the screw. The effect of the plasticating process on the throughput is non-existent if the plastication length is short, and more visible if the plastication length takes a good part of the screw length (for instance, at higher screw rotation frequency). This diminishes the throughput value and widens the pressure peak.

The model also shows that the screw geometry is the most important parameter, followed by polymer rheology and processing conditions. Melting properties and length seem to intervene to a lesser extent. Finally, the model is used for screw design, highlighting the influence of the compression zone on throughput.

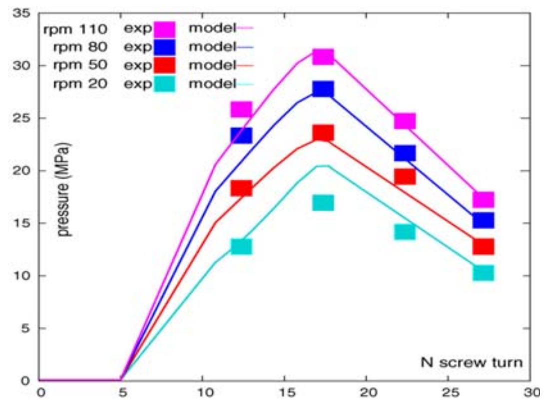

Figure 5: Pressure along a 45mm diameter screw processing LDPE. Model predictions plotted against experimental data from (Wilczynski, 1999).

8. Somjate Patcharaphun et. al. In sandwich injection molding, two polymeric materials are sequentially injected into a mold to form a multilayer product with a skin and core structure. Different properties of these polymers and their distribution in the cavity greatly affect the applications of the mouldings. In an ideal situation, the core material should be entirely encapsulated in the skin material. When the flow front of the core material overtakes that of the skin material, breakthrough occurs, resulting in a defective part. The focus of this study is to determine the effect of molding parameters on the skin/core material distribution. The commercial simulation package (Mould flow) has been extensively compared with experiments. Both simulated and measured results suggest that in order to obtain the optimum encapsulated skin/core structure in the sandwich injection molded parts, it is necessary to select a proper core volume fraction and suitable Processing parameters. A good agreement between simulations and experimental results indicates that the Mould flow program can be used as a valuable tool for the prediction of melt-flow behavior during the sandwich injection process.

Paper suggest that the important parameters for controlling the breakthrough phenomenon are the core volume fraction and the core injection flow rate, while the skin injection flow rate does not have any significant influence on the thickness fraction of the core material. The penetration length of the core melts increases with a decrease in skin or an increase in core melt temperatures. These phenomena are associated with the heat transfer between the cold mold wall and the polymer melt

2. Acknowledgement

Our thanks to the scholars who have worked on the problems related to injection moulding machine.

3. Conclusion

Injection moulding is a very important process, the paper shows that temperatures and pressure parameters of an injection moulding machine plays a vital role in product configuration. In this way we can say that problems caused by these parameters has an effect on the life of reciprocating screw for injection moulding machine and directly affects the quality of the components manufactured by Injection moulding machine.

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