INJECTION MOULD TEMPERATURE CONTROL WITH CAVITY EYE SYSTEM

During the production of injection moulded products one of the most important and - cycle point of view - longest part is the cooling process. Determines the quality of final product and efficiency of the production (cycle time). Usually two methods used to get control of tempering:

1. Measuring the mould temperature (surface or cavity thermocouple, infra sensor etc.)

2. Monitoring the conditions of the medium used for tempering (temperature, pressure, flow)

The benefit of the second method is that there is no need to modify the mould, and after installing the measuring equipment onto the machine, more than one mould can be used at the same injection machine. To control the whole injection cycle including the cooling phase, it is necessary to measure the temperature, pressure and the volume of the tempering liquid. by this way the continuous product quality can be ensured, and possible to reach a higher level of technology which can open doors to manufacture new products with higher requirement (quality, quantity). The Cavity Eye Hungary Kft. - besides the cavity pressure measurement - offers a fully integrated solution with their newly developed Water Flow Monitoring product to monitor and control the tempering process. The internal pressure and tempering control solutions together gives reliable information to ensure the continuous product quality and production process monitoring.

The First and mandatory step to launch the production is to fasten the water hoses to the mould according to the cooling plan. the appropriately and consistently connected water circuits can ensure the heat removal is theoretically identical and constant. In practice many errors can occur in everyday production life due to equipment, maintenance or connecting faults.

TEMPERING DEVICE

It can be easily forgotten that between two seemingly identical tempering device can work like two totally different. Over time, the equipment loses transport capacity therefore the pressure-flow characteristic could show considerable variation. So continuous equipment monitoring helps to make decisions by data not by feelings.

1. Figure: Waterflow measurement solutions: waterflow measurement system built into rotameter on the left - easy and fast integration into existing distributors; Cavity Eye's self-developed 8 channel manifold and waterflow measurement system on the right

MOULD MAINTENANCE

In the mould cooling circuits deposit can appear from the flowing medium (mainly water) and these can reduce the flowing cross-section. It can have insulating effect therefore the amount of extracted heat may decrease. If the flow rate decreases, a laminar flow may develop, which greatly reduces the amount of extracted heat and therefore there may be a significant rise in the mould temperature. Not to mention the sliders, where the circuits have small cross-section, if at least a 2l/min flow cannot be achieved, then the metal surface of the slider may overheat. With regular inspection of the cooling circuits condition in the tool shop - before put the tool onto the machine - lot of time and energy can be saved, the measured data can be stored and

retrieved furthermore the maintenance can be planned. This will help to avoid failed production launch, scrap and customer complaints.

WATER CONNECTION FAILURES

The water circuits are mostly connected directly through tempering device or through distribution (rotameter, manifold). a single mould cooling circuit can be connected to the system in two ways. In the case of a parallel connection the tempering device is not able to detect if a circuit becomes clogged or a hose slips out. With serial connection the tempering unit can detect the fault, but the flow rate drastically decreases and there will be a large temperature difference (in some cases 10-15°C) between the inlet and outlet. This can cause inadequate product because of different cooling rate among the cavities. If the hose length changes or breaks when the mould close, the flow rate may fluctuate. If the inlet and the outlet circuits are reversed, totally different shrinkage and warping may occur on the product. the best solution to avoid is to measure the flow rate, temperature and pressure of the supply and return cooling circuits, thus the tempering errors can be recognised immediately. The system makes it possible to determine the reference and tolerance values for several cooling circuits per mould (technological process). Warning and intervention levels can be defined for the alert system therefore the notifications will reach the right person at the right time. The system can even stop the machine preventing the production of scrap parts.

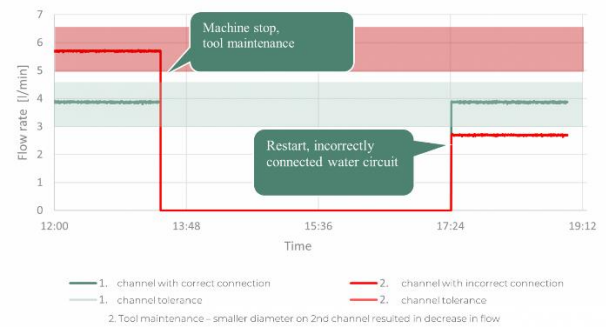
CAVITY EYE FLOW CONTROL SYSTEM

The two most common application of the system are the manifold and the independent pipe solution. Cavity eye's own developed manifold is available with 4 or 8 channel version (Diagram 1.), which usually placed in the mould clamping unit, but if there is not enough space (<50 t injection moulding machines) the measurement is located outside the clamping unit. the pipe solution makes possible to choose the sensor's locations freely. It can be placed around the clamping unit, or onto an existing manifold. The sensors can be put even into the rotameter or directly to the inlet or outlet of tempering device. Depending in the design, the sensors are capable to measure three physical quantities: flow rate [l/min], temperature [°C] and pressure [bar]. From the temperature difference between the supply and return water circuit, with a known flow rate, the extracted energy can be accurately calculated. This makes it possible to monitor the process variations, plan the preventive maintenance and to follow the condition of tempering device. By monitoring the sudden pressure drop a slipped fitting or a broken hose can be quickly detected, and the tempering device can be stopped.

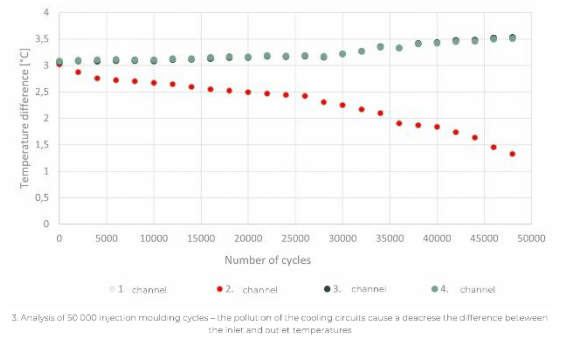
By connecting the Cavity Eye Flow system to the network, the production data can be collected on a central server and can be easily analysed. The data from the cavity pressure and waterflow measurement can be collected at the same place and correlating the data sources together, the process oversight and traceability can be raised to a next level.

INDUSTRIAL TESTS AND EXPERIENCES

When the water circuits are connected to the installed measuring system, a water connection plan should be prepared for each monitored circuit. This way the chance for typical errors (misconnecting the hoses) can be significantly reduced. It is necessary to define the reference values for the flow rate, pressure and temperature. This can be achieved in one step but only after the thermal equilibrium state is reached inside the mould. The data collection is continuous, and a sample is taken in every second. The monitoring system can be switched on and off manually or automatically at production launch.



2. Figure: Mould maintenance – smaller diameter used on the 2nd channel resulted in decrease of flow



3. Figure: Analysis of 50 000 injection moulding cycle - the pollution of the cooling circuits causes to decrease the difference between the inlet and outlet temperature

By analysing the measured data, the tempering errors can be identified. After mould maintenance, it happens often that the hoses are not put to the same position as previously (Diagram 2.) If the pipe diameter or the condition (fastener diameter, pipe length) has changed, it can drastically affect the waterflow. It results a significant change of the cooling process. Similar effect happens if the supply and the drain is reversed or even connected to other position of the mould. It is common for a broken or clogged hose to cause flow loss. If the error occurs periodically (related to cycle time), the blocking of the tube is certainly caused by the mould closing and opening. If the measured values fall outside of tolerance range, the system detects it immediately, and it can prevent the production start. The cooling of a product with short cycle time (4-10 s) is always critical because a significant amount of heat must be transferred quickly. If the production stops even just for a few seconds, the system can detect it and send a notification.

The network-based data collection and analysis allows to monitor the conditions of the cooling circuits in the tool and determine the optimal maintenance intervals. If limescale is formed on the surface of the cooling in the tool, then the efficiency of heat transfer is reduced. Therefore the temperature difference between the supply and return of the given circuit is decreasing, often to 2-10°C. If all circuits are affected by the pollution, then this phenomenon happens to all circuits. If only one circuit is polluted, then the polluted water circuit transfers less heat at the same flow rate so temperature difference decreases. The mould will heat up, so the heat must be dissipated by other circuits. As a result of this the supply and return temperatures of the nearby cooling circles will minimally increase (Diagram 3.). By testing the mould before production, the number of unsuccessful production starts, caused by water circuit failure, can be reduced to zero. For this purpose, Cavity Eye device provides a solution.

SUMMARY

Cooling is a key part of the injection moulding cycle. The more efficient the process is, the more productivity can be reached. The controlled and increased production helps to increase machine utilization. Often a shut-off fitting, a smaller diameter hose or a half-open tap can result in several hours of scrap product because the defect will be revealed after assembly of the product. The complex tempering of the mould can be monitored, and the constant quality of the product can be improved. Adding this system to the cavity pressure measuring, the scrap-free production is guaranteed, and customer complaints can be avoided. Using the system, a higher level of technology can be achieved, for this Cavity Eye provides courses for all users. Official distribution expected to start in mid-October.