There's more to an injection unit than screw size, says **John Goff**. Failing to understand the differences between different injection unit classifications can lead to process setting problems

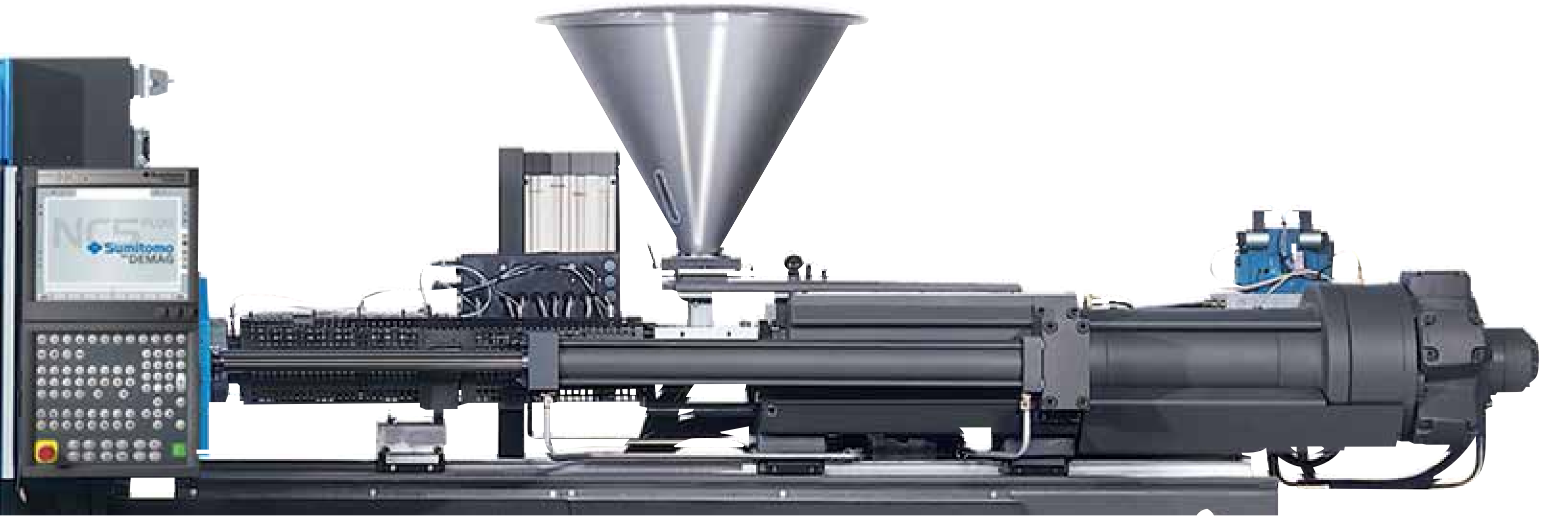

PHOTO: SUMITOMO SHI DEMAG

Understanding injection units

Main image: There's more to injection unit selection than matching screw size

In last month's edition we began to discuss the challenges moulders face when having to move a mould from one machine to another. Over the next few months we will take a closer look at these, beginning with the transfer of a mould tool between two injection moulding machines of the same make and clamping force but with different injection units. This was touched on briefly in an earlier instalment but will be considered more fully in the following article.

For some time now, injection moulding machine manufacturers have offered the industry moulding machines of a specified clamping force with the option to select a particular screw and barrel assembly to accommodate required component weights. Figure 1 shows the typical array of injection units and their associated screw and barrel assemblies that can be selected for one particular moulding machine model of 2,100kN clamping force capability (in this case a 2,100kn Systec 210/580 model from Sumitomo SHI Demag).

Let us consider a scenario where a polypropylene (PP) box and lid assembly is to be manufactured from two four-impression valve gated hotrunner mould tools. Both of the four-impression mould tools are designed to fit and run in a machine of 2,100kN clamping force capacity. The component weight for the box and lid are 19.86g and 9.08g respectively.

The moulding company, when considering the purchase of the two moulding machines, needed to be able to manufacture both lids and boxes in either moulding machine for ease of planning and production call off. However, due to urgent product supply requirements, the moulder decided to buy two 2,100kN clamping force capability machines, each installed with a 40mm diameter screw and barrel assembly having the same shot capacity but each with a different injection unit specification. Machine A possessed an injection unit of 430 classification; Machine B has a classification of 600. Figure 2 shows the injection unit specifications for Machine A and Machine B (Sumitomo SHI Demag 210/580 models equipped with standard motor and pump and no accumulator).

To many processing personnel, the relevance of injection unit specifications is either overlooked or they are unaware of its implications. This is particularly important if the moulding machine is hydraulically actuated (although the same issues are encountered with servo-electric machines, which will be covered in later articles). More often than not, the mould shop staff's main daily duties are to install the mould tool in the

Figure 1: Injection unit and screw combinations for 2,100kn Sumitomo SHI Demag Systec 210/580 model

Injection unit		430			600			840			1450		
Screw diameter	mm	35	40	45	40	45	50	45	50	60	50	60	70
L/D ratio		20	20	20	20	20	20	20	20	20	20	20	20
Specific injection pressure	bar	2644	2025	1600	2423	1914	1550	2402	1946	1351	2426	1905	1400
Maximum shot weight (PS)	g	153	210	266	210	294	383	326	402	579	482	695	946

machine and achieve optimum performance capability and output at the standard cycle in the minimum amount of time. As both designated machines in this case had the same clamping unit specification and shot capacity, then it tends to be taken for granted that they are identical from a process setting and moulding performance viewpoint.

Taking a closer look at the information given in Figure 2, however, it can be seen that there are subtle differences between the injection unit attributes of the two 2,100kN machines. These differences are not deficiencies but are characteristics of the injection units and will have a significant effect on the selection of process parameters and the relevant outcome when transferring either the box or lid mould tools from Machine B to Machine A. In this scenario, we will be considering the box component and related mould tool to be installed into each moulding machine for the same component quality standard, output and performance efficiency to be achieved.

In comparative terms both Machine A and Machine B possess the same clamping force capability, screw diameter and geometry, shot volume, screw stroke, hydraulic pump pressure (in this case 180 bar), and general construction. It can be seen from Figure 2 that with the same maximum pump pressure, the maximum available specific injection pressure is 398 bar lower for Machine A than Machine B, assuming a maximum pump pressure of 180 bar hydraulic. This means that Machine A will require a higher hydraulic pressure of 1.196 bar compared to Machine B for each 1 bar incremental change. Such a small difference may seem insignificant but when the box mould tool is sited in Machine A the transfer of identical hydraulic pressure settings will not produce the same component as produced from Machine B.

Based upon the process trials when commissioning the box mould tool using Machine B, it was found that an optimum fill time of 0.58s was required to obtain both the visual and structural requirements of the box moulding. At this filling time an injection pressure of 158 bar hydraulic pressure (2,127 bar specific) was recorded. When converting this filling time into a volumetric injection rate, a value of 179cm^3/s of molten PP is obtained. Upon reviewing the data given in Figure 2, the maximum injection rate for Machine B is 187cm^3/s, while the injection rate for Machine A is

Figure 2: Injection unit specifications for Machine A and Machine B shows performance differences despite similar screw diameters, L/D ratio, and shot capacities

		Machine A	Machine B
Injection unit classification		430	600
Screw diameter	mm	40	40
Screw geometry		Standard	Standard
L/D ratio		20	20
Specific injection pressure	bar	2025	2423
Maximum cylinder head volume	cm^3	231	231
Maximum shot weight (PS)	g	210	210
Maximum injection rate	cm^3/s	224	187
Plasticising rate (PS)	g/s	52	32
Maximum screw stroke	mm	184	184
Nozzle sealing force	kN	80	80
Number of heating zones		4	4
Screw cylinder heating capacity	kW	11.1	11.1

Source: Sumitomo SHI Demag

224cm^3/s. Such differences will require a different linear speed to be set to achieve the same injection time for both machines, highlighting the importance of recording both the injection time as well as the linear injection speed.

A more important feature regarding the 0.58s fill time is related to the injection pressure needed to achieve box mouldings of consistent quality when the mould tool is sited in Machine A. The derived injection pressure value of 2,127 bar used in Machine B cannot be achieved from Machine A, where the maximum specific pressure value derived is only 2,025 bar at a corresponding 180 bar hydraulic pump pressure.

This lack of injection pressure will prevent the mould cavities being consistently filled on a cyclic basis, causing component quality and productivity issues. In moulding terms the cavities will be filled using Pressure Control rather than the more preferred technique of Speed Control (reference Article Nine). Even though Machine A can deliver the required volumetric injection volume in cm^3/s to suitably fill the box mouldings in 0.58s, the inherent resistance in both the hot runner system and impressions of the mould tool necessitates a filling pressure of 2,127 bar.

In an attempt to reduce this resistance pressure with the objective of achieving a value of 2,025 bar or below, the linear injection speed can be reduced resulting in a longer fill time and/or the melt temperature, in association with the hot runner temperatures, can be increased to lower the inherent resistance. Such a reduction will allow the manufacture of the box mouldings to be consistently produced using Speed Control but not with full structural integrity.

It can be inferred from the above that replication of the processing parameters cannot take place from one moulding machine to another in this case, even though the moulding machines would be deemed identical on the surface.

This discussion will be continued in the next edition.

About the author:

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