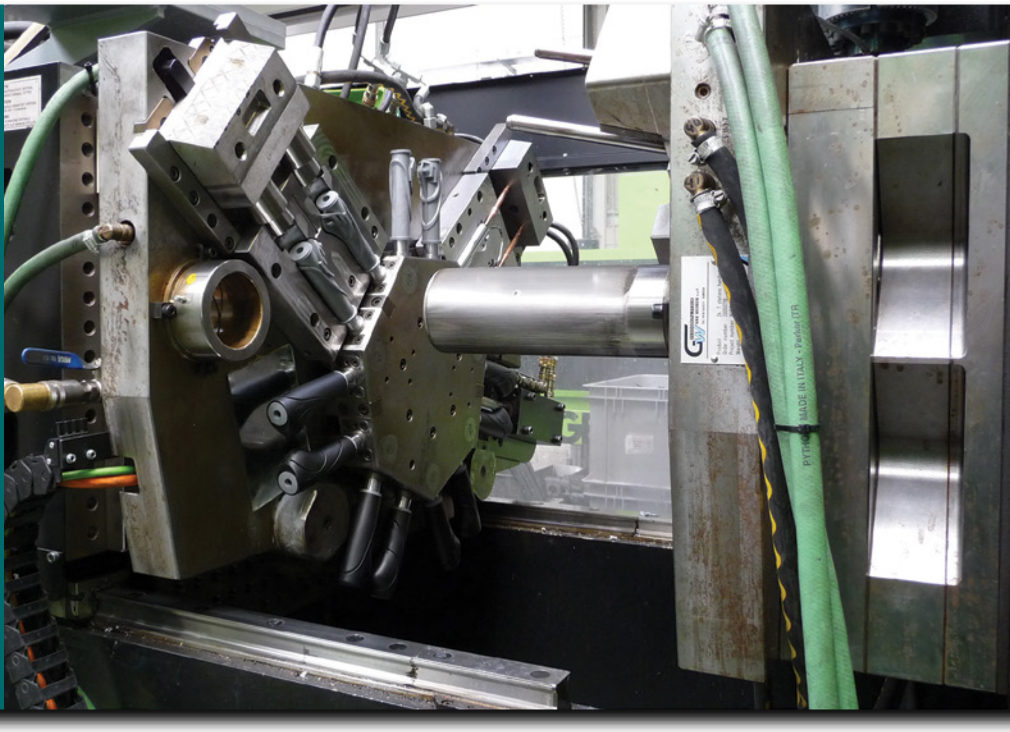
PHOTO: ENGEL

Injection mould clamping force selection is an important processing decision. Moulding expert **John Goff** provides some practical advice for moulders in his latest masterclass instalment



Understanding clamping forces

Main image: Bulky moulds with projecting slides require specific machine consideration

Selection of the appropriate clamping force for a particular combination of machine, mould tool and material is an important factor that should not be overlooked. Filling of the mould during the injection moulding process takes place at high pressure and this must be countered if the mould is not to be forced open.

The magnitude of the force acting to open the mould halves is dependent upon the pressure generated within each cavity (and also in the cold runner feed system, if present) during both the mould filling and holding pressure phases. In good moulding practice, the cavity or cavities are filled to between 95 and 98% of full capacity before switching the injection pressure over to a lower (adjustable) holding or packing value. It is at this point that the maximum force is often generated.

Clamping force is measured in either metric tonnes (imperial tons in the US) or the more technically correct kiloNewtons (kN) – tonnes being a measure of mass rather than force. The appropriate clamping force value is the amount of force required to oppose the opening effect created during mould filling and keep the mould closed throughout.

The term "clamping pressure" describes the pressure in the hydraulic line (pipe or hose) which is connected to the hydraulic actuator that generates the force required to keep the mould tool closed during mould filling and packing. This pressure is frequently confused with the actual measured cavity (melt) pressure generated by the flowing molten material as it passes in and around the cavity.

The clamping force value is quoted and used for an injection moulding machine with a hydraulically-actuated (direct) clamping mechanism. Where the moulding machine includes a mechanical lever that is actuated either hydraulically or by electric servo motors (such as a toggle system), then the terms clamping force and locking force are typically used.

The term locking force is frequently misinterpreted as the clamping force applied to the mould tool upon closure. Locking force is the term used to explain the force value applied when the molten plastic is injected into the clamped mould tool. In the case of a toggle clamp machine, the clamping force applied is generated by the stretching of the steel tie bars - the greater the stretching of the bars, the higher the clamping force applied to the mould tool. The amount of stretch induced is maintained within the limit of proportionality for the chosen tie bar steel and is monitored using linear strain gauges to ensure consistency of force application.

In order to keep the halves of the mould tool tightly clamped together during mould filling, additional stretching of the tie bars takes place and this exerts a higher force to the mould faces. It is common to use a Dial Test Indicator (DTI) to measure, usually in millime-


PHOTO: GEFIT

Left: Clamping force should be optimised for the parts and type of feed system used. Over clamping wastes energy and compromises part quality

tres, the extent of linear opening and closing movement of the mould halves upon injection. This additional force is termed as the locking force and can typically be up to 10% of the maximum available clamping force the moulding machine exerts.

The clamping force created by a hydraulically-actuated clamping system is not determined by stretching of the tie bars but by the product of the hydraulic oil system or pump pressure and the area of the ram head contained within the hydraulic actuator. While, some movement of the tie bars takes place it is considerably less than takes place in a toggle-actuated mechanism.

When considering production of a new injection moulded component, the number of mould tool impressions is typically the first consideration followed by determination of the required clamping force (size of the clamping unit). There are a number of well-established approaches to estimation of such values and it is not the intention to cover them in this article.

However, once the necessary calculations and/or software derivations have been performed, the estimator will usually apply a safety factor, generally in the region of 10-15%. As an example, a predicted clamping force of 270 metric tonnes would be rounded up to 300 tonnes.

Clamp force is, of course, not the only consideration in machine sizing. Other factors that can determine the machine requirements include:

- The space between the tie bars through which the mould tool must pass on installation and the maximum daylight between the platens required to accommodate the shut height of the mould tool.
- The ability to safely and effectively clamp the mould halves to the machine platens, particularly the configuration of the bolt holes in both platens and the location and size of the register or locating rings. Most moulding machine manufacturers provide standard bolt hole configurations according to either DIN or Euromap standards but, of course, specific configurations can be requested and additional holes machined at a cost.
- The need to remove machine parts to install moulds with hydraulically actuated cylinders, motors and rack/pinion assemblies or other hardware required for additional movement and/or opening sequences. This additional mechanical equipment can prevent the mould tool being readily loaded between the tie bars, making it necessary to remove a tie bar on a standard machines or to use a tie bar free design (such machines readily accommodate this problem where the entire platen area is often employed).

Traditionally, moulding machines are acquired based upon the maximum clamping force they can apply and the situation will often arise where the available clamping force is considerably more than is necessary to effectively produce the moulded component. What is more interesting is that when the machine/mould tool/material combination is run in production, the maximum available clamping forced is often used.

When too much clamping force is employed, any changes in the moulding process that may ultimately affect the final moulding quality can go undetected. These changes can often be the cause of failure of the moulded component in service.

Generally, the application of too high an applied clamping force can result in:

- Poor part quality
- Reduced mould tool life
- Increased energy usage/consumption
- Narrowing of the process window for component manufacture

These factors will be considered in detail in the next article, which will also discuss how to determine the correct clamping force value for a particular machine/mould tool/material/ product combination in practice.

About the author

John Goff is a chartered engineer, a Fellow of IoM^3 (Institute of Materials, Mining and Metallurgy) and managing director of injection moulding process consultancy G&A Moulding Technology (www.gandamoulding.co.uk). This is the 22nd instalment in his Moulding Masterclass series of injection moulding process optimisation articles. You can read the most recent instalments **here**, **here** and **here**.