A new type of pump makes it possible to successively produce polymers with different flow behavior on one system. Source: Shutterstock.com

Pump optimization creates the prerequisite for widened fields of application in plastics production

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In today's plastic production and processing, external gear pumps are usually the first choice, because they can gently convey both high and low-viscosity polymer melts through the system. In addition to this flexibility, the pumps allow a large pressure generation in these applications and achieve a high volumetric efficiency. A new technology now makes these pumps even more efficient. It is essentially based on an optimization of the internal geometry. The resulting higher volumetric efficiency enables these pumps to be used in far more applications than before.

Every optimization focuses on volumetric efficiency, because it represents a technological benchmark for the quality of a gear pump. The new pump class sets a milestone in increasing efficiency thanks to increased pump efficiency and performance. The operating window for the maximum achievable differential pressure for low-viscosity products has been increased by up to 80 percent. In addition, up to 40 percent higher throughputs can now be achieved at the same level of bearing temperatures.

These improvements also mean that the new generation pump can be used in areas that were largely outside the limits of the previous model. There are two situations in which the optimized pump is superior to the classic one. On the one hand, when it comes to pumping very low-viscosity products – for example, in the initial phase of the polymerization process. Until now, the viscosity has severely limited the efficiency and the maximum achievable differential pressure. On the other hand, to serve the new trend in the plastics industry, to pump comparable polymers of very different Melt Flow Index (MFI) one after the other.

Optimized polymers need optimized pumps

The customizing of solutions today increasingly begins with the polymer materials. In addition to the already-established variation in viscosity, often characterized by the MFI (Melt Flow Index) over the chain length, specific properties in the raw material are increasingly also being created by modification of other block components and control of the chain and branching structure. This achieves properties that can otherwise only be attained by using expensive additives. However, this customizing also has a massive influence on behavior during processing and requires increasing flexibility and wider application windows for the pumps used in these systems.

With the improved volumetric efficiency and the more stable hydrodynamic lubricating film of the x6 class pumps, wider application windows are supported with a very high degree of robustness. This was achieved by consistently redesigning the shafts and bearings with larger bearing surfaces and improved lubricant flow control. These characteristics are a basic requirement for operating a pump safely against a high differential pressure in low viscosity applications.

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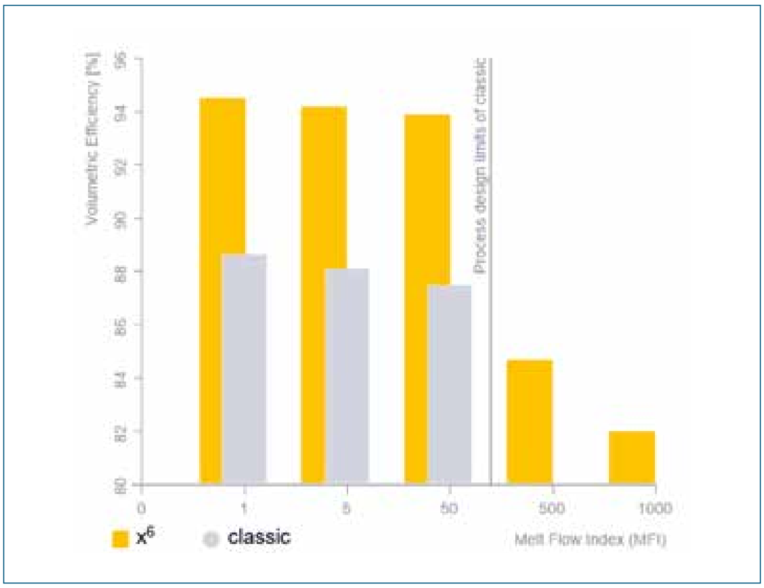
The optimized design makes it possible to configure and operate smaller pumps at higher speeds within an optimum operating window – though that does also require a certain amount of rethinking with regard to the operators' empirical data values. In operating phases with lower throughput, there is substantially less risk that the pump turns too slowly, meaning the lubricating film cannot be built up properly and so causing the gear pump to run in mixed friction. The higher flow rate in the bearing reduces the dwell time, and so also cuts the risk of product degradation in the pump. The results are higher product quality and operational reliability in a much wider range of applications.



Source: Maag

Fig. 1: Example case - calculated volumetric efficiency in relation to the polymer MFI.

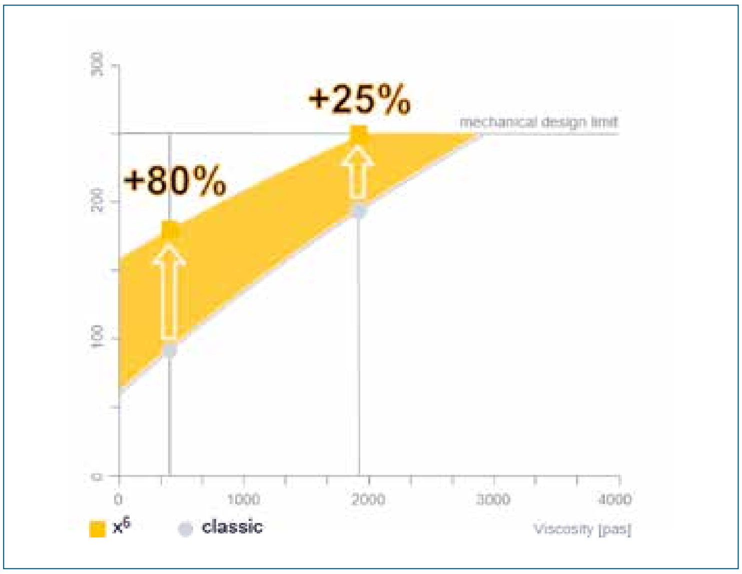


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Fig. 2: Example case – calculated maximum achievable differential pressure in relation to the polymer viscosity.

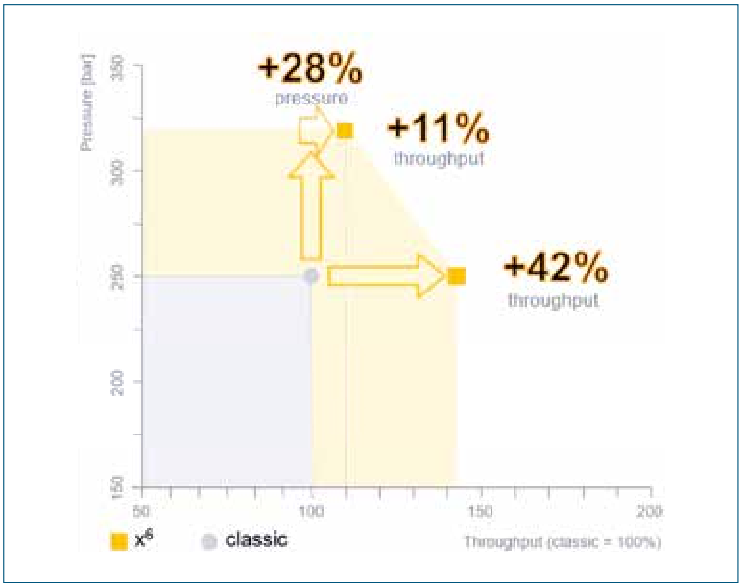

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Fig. 3: Expansion of the design limits of the classic design

The new pump class sets a milestone in increasing efficiency through increased pump efficiency and performance.“

Depending on the application, the innovative pump types can be used to increase the polymer throughput or the differential pressure, respectively. As much as 28% higher pressure can be achieved, and up to 42% more polymer can be pumped compared to the conventional design.

Another aspect is the flow optimization of the x6 class's inlet geometry compared to the classic design. This enables a more even filling of the pump with polymer, especially in the case of extraction pumps. As a result, the pump can run with lower filling levels and so with shorter product dwell times in the reactor.

Additionally, all x6 class gear pumps benefit from a reduction by as much as 50 % in the recirculation rate due to parasitic internal losses between the high and low pressure levels, thereby enhancing energy efficiency. The overall improvement in performance is demonstrated by a higher pump efficiency, meaning less loss. Also, in that context, the x6 class pumps consume less energy and need smaller drive motors.

Complex linking of different parameters

The design of the gear pump is based on a complex combination of various parameters and many years of practical experience. The first step is a systematic analysis of the general operating data, which then serves as the basis for general preselection of the pump type and pressure level. A basic distinction is made between extraction pumps and booster pumps for the conventional pumping of polymers with high or low viscosity characteristics and potentially corrosive properties. Booster pumps provide the pressure build-up directly downstream of the extruder during "compounding".

The general classification of the pump type is followed by an exact evaluation of the requirements (throughput, differential pressure) in conjunction with the given rheological characteristics and the interactions of the pumped medium, from which the geometric dimensioning of the pump components can be derived.

For full configuration of the gear pump, sealing variants, throttle designs and other application-specific requirements must be defined and specified.

Influencing factors in the pump system

Rheological analysis of the pumped medium is a key component in designing the gear pump. Part of the medium that is being pumped is used internally as lubricant between the shafts and bearings, flowing back to the suction side where it rejoins the delivery flow. The thickness and stability of the lubricant film is fundamentally determined by the rheological characteristics of the pumped medium and has a significant influence on operational safety and on wear between the shaft and bearing. The use of special geometries and grooves can significantly enhance the system behavior, while cooling systems for the shafts, bearings and seals are also available. The selection of these design elements also depends largely on the application. A solution for recycling plants will be very different from a highly filled compounder, and that is again very different from the solution used in polymer synthesis. The operating parameters such as temperature, throughput rate and pressure difference, together with the rheological characteristics of the fluid, are the key parameters in the detailed design of the pump. The calculation method is based on many years of experience and allows an exact prediction of the pump condition for the entire application window of the various configurations (size and clearance variations). The experienced application engineer selects the optimum solution from all the potential configurations. The outcome is a tailor-made pump for the specified application, guaranteeing the operational reliability of the gear pump over a long period of time.

New pump class tested in the field

Customers acquiring the x6 class generation of pumps – more than 1,000 of which are being successfully run in the field – benefit from a much wider application window in terms of throughput and maximum achievable differential pressure compared to the classic design. Thanks to its higher volumetric efficiency, the

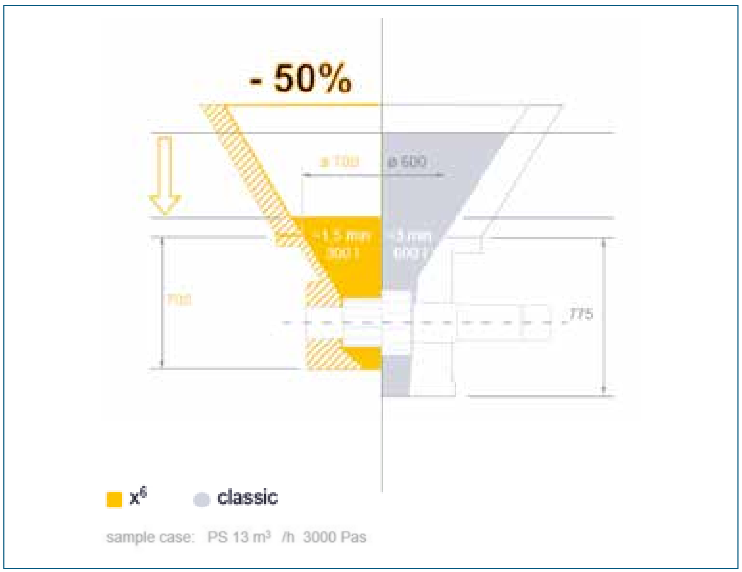

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Fig. 4: Example case – polymer, calculated minimum required polymer level for the new pump class versus the classic design.

mechanical and process-limiting design specifications of the pump can be used for both low and high viscosity products to increase throughput while maintaining consistent product quality. Based on the modified shaft and tooth geometry, improved volumetric efficiency and faster heat transfer from the bearings into the pump housing, higher speeds are possible without exceeding the maximum permissible bearing temperature dictated by the product.

Moreover, an efficient pump results in less heat-up of the bearings – and consequently a lower product temperature during pumping – while maintaining the same speed and throughput rate. The lesser risk of product degradation leads to higher product quality with reduced energy consumption.

The new pumps are also well suited for use in the polymerization of bioplastics. This type of plastic production with biological raw materials will gain in importance in the future. In terms of process technology, it works in a similar way to conventional polymerization. However, bioplastics sometimes place higher demands on the materials of a pump. The most commonly used bioplastic, polylactide (PLA), for example, is based on aggressive lactic acid. The pump material must therefore be designed in such a way that it avoids corrosion.

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Source: Maag

Fig. 5: The largest gear pump in the world weighs 48 tons and has an inlet diameter of 3 meters.