Special reprint from Kunststoffe international 3/2012

HANSER

Thomas Brettnich and Simon Geltinger

The Ultimate in Precision

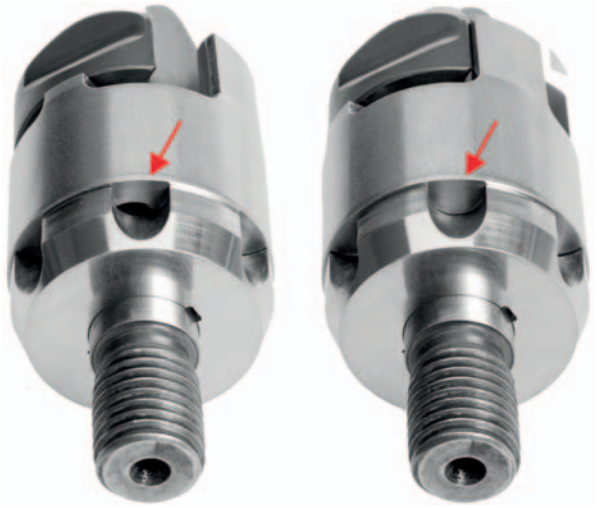
Process Reproducibility

Sumitomo SHI DEMAG

Sumitomo (SHI) Demag Plastics Machinery GmbH
info-dpde@dpg.com
www.sumitomo-shi-demag.eu

The Ultimate in Precision

Process Reproducibility. As there is no way to directly influence the closing of conventional non-return valves in all-electric injection molding machines for high-precision parts, this represents a potential weak point with regard to process reproducibility. This problem can be eliminated with a development which is thus far unique in the European market: a switchable non-return valve.



The switchable activeLock non-return valve in the opened (left) and closed (right) state. Closing of the melt channels prior to injection ensures a very small, reproducible melt cushion in front of the screw across all cycles, and thus leads to high process reproducibility

(photos, unless otherwise specified: Sumitomo (SHI) Demag)

THOMAS BRETTNICH
SIMON GELTINGER

When the melt is transferred from the plasticizing unit into the injection mold, the non-return valve plays an important role, acting as a separating mechanism between the screw and the space in front of the screw and preventing the melt from flowing back into the screw flights during injection. In the past few decades, two concepts have become established for this purpose: the ring-type **(Fig. 1)**, which is the most common, and the ball-type. The two of these are based on the same principle: During metering, the melt is moved forward by the rotating screw and passes through the open melt channels of the non-return valve into the space in front of the screw. It is not until the beginning of the injection phase that pressure builds up in front of the screw, pressing the check element, i.e. the ring or ball, against a stop, and thus sealing the space in front of the screw against the screw chamber.

Translated from Kunststoffe 3/2012, pp. 33–36
Article as PDF-File at www.kunststoffe-international.com; Document Number: PE110976

The Principle of Conventional Systems Harbors Inaccuracies

This is precisely the weakness of the concept. At the beginning of the injection phase, the non-return valve is open and melt continues to flow back into the screw flights until the valve is fully closed. This leakage flow would not be a problem if the process were always the same. However, there are numerous aspects that affect the closing behavior of the non-return valve and thus directly affect the reproducibility of the process. These are typical fluctuations which occur in many production shops: fluctuations in temperature or batches of material, for example, change the viscosity of the melt. Furthermore, the ambient temperature and residual moisture levels play a role in engineering thermoplastics.

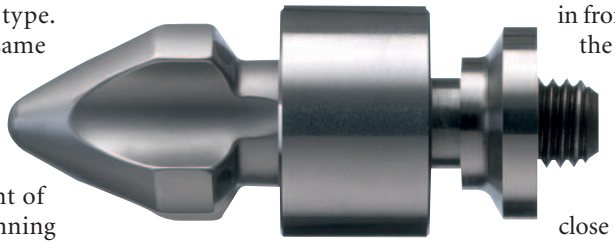


Fig. 1. In conventional ring-type non-return valves, the closing behavior is dependent on various process parameters and cannot be actively influenced

Even deviations in the temperature of the mold or hot runners can lead to variable build-up of back-pressure in the space in front of the screw and prevent the non-return valve from closing in a reproducible manner.

Undefined closing of the non-return valve is always directly reflected in poor reproducibility of shot weight, and fluctuating part quality. One way to improve the closing behavior of conventional systems is to apply a decompression stroke at the end of the metering process. By means of a screw-back, the melt pressure in front of the screw can be reduced and the ring of the non-return valve brought into a defined position. One disadvantage of this approach is an increased risk of blisters and scorch marks due to entrained air. Another common approach is to close the non-return valve as quickly as possible by raising the injection speed. Limiting factors here are the part geometry, the melt viscosity and possible surface blemishes in the manufactured parts. Generally, conventional ring-type and ball-type non-return valves suffer from the disadvantage that closing is a passive process which can only be indirectly influenced by executing a decompression stroke or via the injection rate.

For the majority of injection molding applications, the resulting inaccuracies in

the melt cushion have a negligible impact on part quality – relative to the precision of the injection molding installation as a whole. For parts which require very high precision and process reproducibility, however, the undefined closing behavior of conventional non-return valves represents a weak point. Such precision articles, especially those required in the electronics and medical industries, are molded in high-precision molds on all-electric machines in order that tight tolerances on dimensions and weights may be met.

Switchable Valve Seals Reliably After Metering

In an overall system of this kind which is geared toward high precision, the non-return valve creates a gap in precision which Sumitomo (SHI) Demag Plastics Machinery GmbH, Schwaig, Germany, has now closed with a development which is both new and unique to the European market.

Since K 2010, the company has offered precision injection molders that use all-electric machines a switchable non-return valve which seals the space in front of the screw with great precision and reproducibility. Sumitomo (SHI) Demag markets the concept under the term activeLock. The principle behind the switchable non-return valve differs substantially from that of conventional ring-types or ball-types. The crucial aspect is that activeLock closes at the end of the metering process and so isolates the space in front of the screw during the entire injection phase.

Inside the component, a rotatable seal ring is closed by a counter-rotating movement of the screw **(Title picture)**. During plasticizing, the valve is open by virtue of the screw rotation and the melt flows through the open channels into the space in front of the screw. After metering, the screw rotates in the opposite direction and thus closes the melt channels of the non-return valve completely and reliably. This process takes place in isolation from other process steps and is independent of process fluctuations. The closing movement, which is thus defined and can be actively influenced, manifests itself in a significant increase in process reproducibility. The fact that the valve closes fully prior to the injection phase is illustrated by the pressure conditions measured during injection **(Fig. 2)**.

The technology of using rotation to close a non-return valve was patented several years ago by the Japanese parent company, Sumitomo. As several thousand switchable non-return valves are already in use on all-electric Sumitomo (SHI) Demag machines in Asia and the USA, customers in Europe stand to benefit from a wealth of experience. Even before the official sales launch at K 2010 – since when over a hundred have been sold in Europe – a number of field test customers (including Wago, Dehn + Söhne, Fischer) had begun using the technology.

Increased Process Reliability in Field Test

One of the very first activeLock users was Fischer GmbH & Co., KG, Sinsheim, Germany. Specialized in plug-connector systems, this fabricator decided in 2004 to switch to all-electric injection molding machines. Robin Kemter, responsible for project management and process optimization at Fischer, reported in a presentation at Fakuma 2011 that activeLock further improved the process reliability above and beyond the improvement arising from the use of all-electric machines. Greater reproducibility, improved part quality, less scrap, larger process windows and less dependence on temperature and viscosity values were the key outcomes, he said.

By way of proof, Kemter explained the results obtained during the manufacture of a two-pole contact fuse **(Fig. 3)** made of PBT-GF20. The 0.62-g parts were manufactured in a 16-cavity mold with quadruple hot runner on an IntElect 50 (500 kN, screw diameter: 25 mm), once with a conventional ring-type non-return valve and once with the activeLock version. Over the course of 600 shots, the scatter plot for the standard non-return valve revealed 18 cycles outside the tolerance band of the melt cushion **(Fig. 4)**. Such outliers did not occur with activeLock.

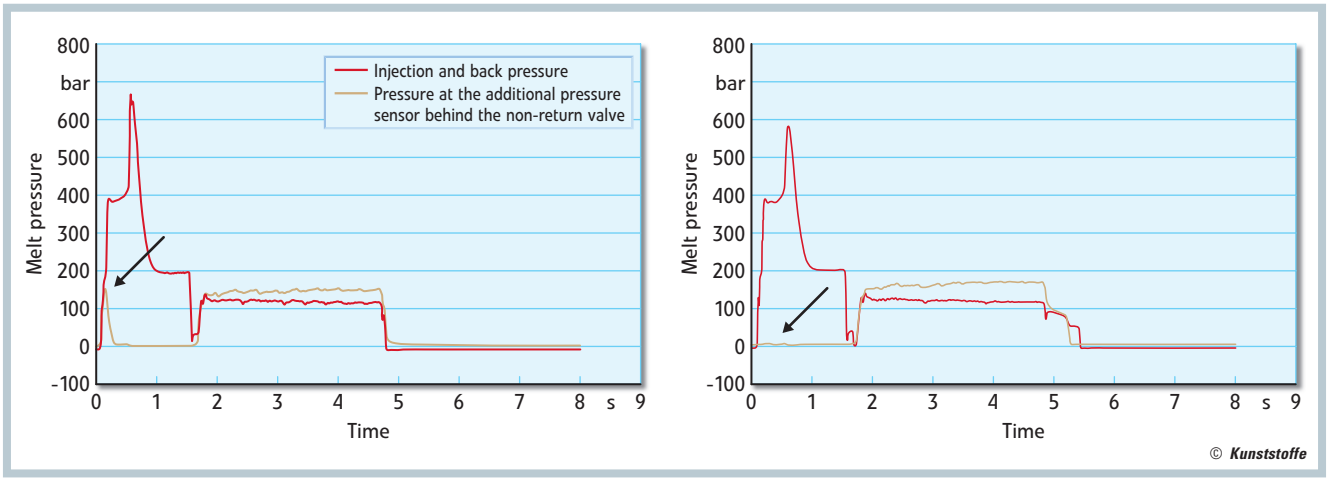


Fig. 2. The pressure peak during injection (material: PA6.6) behind the standard non-return valve indicates melt flow-back (left). In contrast, no pressure buildup is detected when the activeLock is used (right)

Reliability in both processing and the use of its products is a top priority for Dehn + Söhne GmbH and Co. KG., Neumarkt, Germany. This family-run company focuses with its own product range on the three areas of surge protection, lightning protection/grounding and industrial safety. In the field test, Dehn used an

Contact

Sumitomo (SHI) Demag Plastics Machinery GmbH
D-90571 Schwaig
Germany
TEL +49 911 5061-0
→ www.sumitomo-shi-demag.eu

Non-return valve	Shot weight			Melt cushion	
	Absolute	Scatter	Scatter	Absolute	Scatter
	[g]	[g]	[%]	[cm³]	[cm³]
Standard	42.094	0.037	0.09	6.485	0.190
Switchable	42.035	0.017	0.04	4.719	0.087
Change to standard [%]		**–54**			**–54**

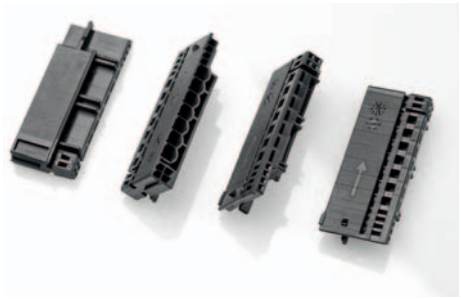


Table 1. This plug-connector housing made of PBT-GF20 was produced in an eight-cavity mold by Fischer on an IntElect 160-500 (1,600 kN, 40-mm screw, 42.0 g shot weight, cycle time: 15 s). This switchable non-return valve demonstrably improves the reproducibility of the shot weight and the residual melt cushion (source: Fischer)

IntElect 50-110 (500 kN, screw diameter: 25 mm) fitted with an eight-cavity hot runner mold to make a high-precision, PA6.6 part weighing 1.2 g for a surge protection device. Compared with those for the ring-type non-return valve, deviations from set part weight for the switchable valve moved within a narrower range. The values were calculated both for the individual cavities and as the average value for a lot size of 100,000 **(Fig. 5)**. On average, activeLock halved the deviations.

Better Melt Cushion Reproducibility, and More

In general, melt cushion fluctuations can be improved by the order of 30 and 50 % **(Table 1)**. Moreover, the defined closing behavior in the cavities creates reproducible pressure conditions, which in turn reduce fluctuations in density, crystallinity, and warpage and so increase the dimensional accuracy. In this new development, Sumitomo (SHI) Demag is focusing on precision injection molding with engineering thermoplastics, such as polyamides, PBT, PEEK, PEI and LCP materials – materials that have extremely low viscosity in the melt and whose scrap rates must be minimized simply on account of the high price.

The main process advantages of activeLock come to the fore in applications with small screw diameters and strokes. Here, it is only logical that the negative influence of the switching operation of standard non-return valves decreases with increase in screw diameter **(Fig. 6)**.

In addition, the injection stroke plays an important role: the shorter the injection stroke, the greater is the negative influence exerted by the switching operation of conventional non-return valves. Where a switchable valve is employed, however, tiny injection strokes of much less than 1D can be executed reliably. This affords greater flexibility in the use of injection molding machines. Thus, tiny parts can be made to high precision on electrical standard injection molding machines. An important aspect here is that where standard plasticizing units are employed there is no need to use costly micro-pellets.

Micro-injection molding on standard machines has long been a staple of Stamm AG, Hallau, Switzerland. This fabricator, well-known for its micro-processor specialties, produces 55-mg planetary carriers made of POM in a four-cavity mold on an IntElect 50-45 (500 kN, screw diameter: 14 mm). Stamm, too, exploits the advantages of activeLock and has boosted in this case part-weight reproducibility by a good 50 % compared with the results obtained with a standard non-return valve **(Table 2)**.

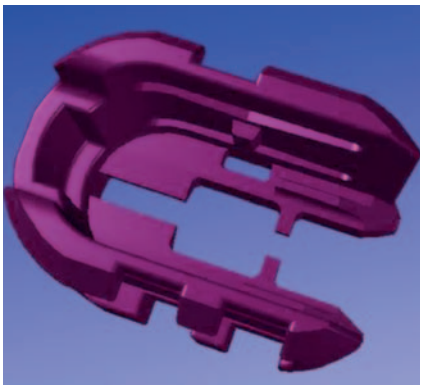


Fig. 3. This two-pole contact fuse made of PBT-GF20 was manufactured during the field test with both a conventional ring-type non-return valve and the activeLock version (photo: Fischer)

Exploiting Precision Potential in Full

Since the end of the field test phase, Sumitomo (SHI) Demag has been providing the new product for all screws in the diameter range of 14–35 mm. As the standard non-return valves employed hitherto have identical dimensions and connecting threads, retrofitting an activeLock does not usually present a problem. In the NC5 controller, an additional screen view facilitates operation. For the determination of the three variables, rotation angle, rotation speed and timing of the closing process, Sumitomo has worked out simple ground rules on the basis of numerous technical tests.

The non-return valve which can be switched via a screw-back rotation has

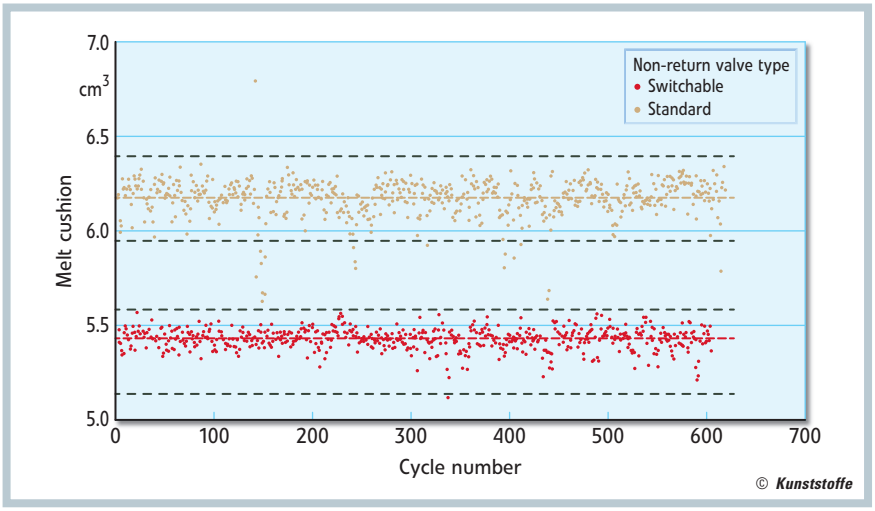


Fig. 4. During manufacture of the two-pole contact fuse (see above), the switchable non-return valve not only reduces the melt cushion, it also ensures compliance with tighter limits (figure: Fischer)

Non-return valve	Part weight (4 cavities)		
	Absolute	Scatter	Standard deviation
	[g]	[g]	[g]
Standard	0.0552	0.0016	0.000461
Switchable	0.0556	0.0011	0.000218
Change to standard [%]		**–31.3**	**–52.7**

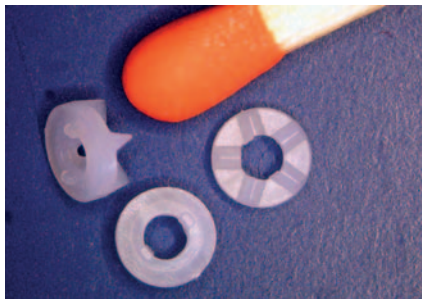


Table 2. This 55-mg planetary carrier made of POM is produced by Stamm AG in a four-cavity mold on an IntElect 50-45 standard all-electric injection molding machine (500 kN, 14-mm screw). Even for the micro-application, the switchable non-return valve makes a marked improvement in weight reproducibility (source: Stamm)

been patented by Sumitomo. In the European market, no other manufacturer offers this technology. To take maximum advantage of the precision and efficiency potential of all-electric injection molding machines, Sumitomo (SHI) Demag has developed a number of other modules to support the switchable non-return valve. With activeDynamics, for example, precisely matched motors, frequency converters and machine controllers can achieve very short scanning times for the axis controller, this enabling even complex injection profiles to be adjusted accurately and reproducibly. The function activeFlowBalance for multi-cavity molds compensates the melt pressure in the various cavities by actively stopping the screw at the transition from injection to holding pressure and thereby enhances part quality. ■

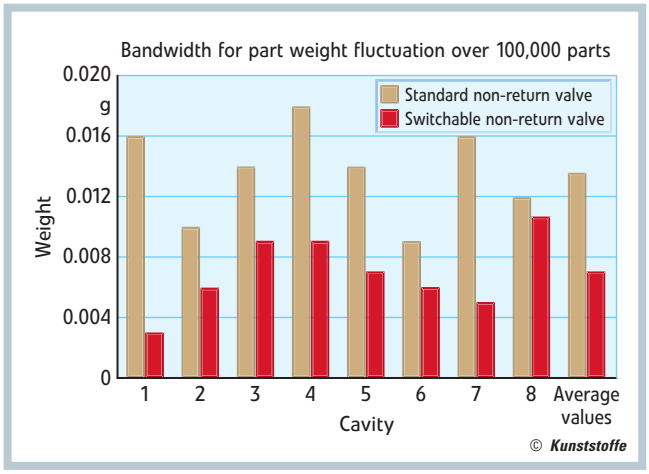


Fig. 5. Precision parts made of PA6.6 and weighing 1.2 g deviate from the set part weight within a narrower range when activeLock is used. The values were calculated for each of the eight cavities and averaged for a lot size of 100,000 (source: Dehn + Söhne)

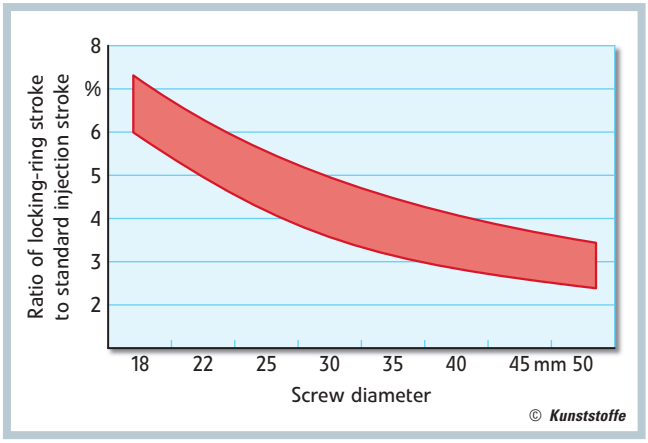


Fig. 6. Stroke of the locking ring of a ring-type non-return valve in comparison with the usual screw stroke (usual injection stroke-values assumed). As the screw diameter increases, the influence of the switching cycle decreases

THE AUTHORS

DIPL.-ING. (FH) THOMAS BRETTNICH, born in 1979, is head of Technology Development at Sumitomo (SHI) Demag Plastics Machinery GmbH, Schwaig, Germany; thomas.brettnich@dpg.com

DIPL.-ING. (FH) SIMON GELTINGER, born in 1981, is responsible for Technology Development Plasticization at Sumitomo (SHI) Demag; simon.geltinger@dpg.com

IntElect – The Precise Machine

„Precision with the highest efficiency.“

Peter Gladigau, Product Manager Electric Injection Moulding Machines, Sumitomo (SHI) Demag

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