Plasticising unit
Improved performance, lifetime and operating efficiency of injection moulding machines
It all depends on the plasticising unit. Both the quality and the performance of modern injection moulding machines depend on it. The plasticising unit defines the achievable melt quality, the repeatability of the injection moulding process, and above all, the life expectancy and cost-effectiveness of the machine.

- **Best melt quality**
  Excellent material and thermal homogeneity for a variety of process conditions.

- **Repeatability**
  Maximum precision. Shot by shot.
  Through highly-developed components.

- **Service life and cost effectiveness**
  Application-specific material executions.
  For maximum cost effectiveness.

- **High plasticising capacity and throughput**
  Screw geometries designed to match the type of plastic guarantee maximum throughput and plasticising capacity.

- **Best in class service and support**
  Countless types of plastic, appearance, and combinations, as well as increasing demands on products and cost effectiveness, require expert consulting and support.
Solutions according to material
The optimum design for your plastic type

The best Basic Package

ENGEL sets standards in terms of appeal and quality. And this starts right from the basic package. Even the Basic Package has extraordinarily high-grade equipment: The bi-metallic barrel as well as the laser alloyed ring non-return valve are standard in this package. This allows for the extremely efficient and cost-effective production of multiple applications, such as utility objects made of polypropylene or polystyrene.

- Nitrided screw – excellent surface hardness through nitriding
- Bi-metallic barrel – standard equipment
- Laser-hardened ring non-return valve – standard equipment

For non-reinforced thermoplastics, for example, PE, PP, PS.

The versatile Advanced Package

Thanks to a hardening process and welded flights, the plasticising components in the Advanced Package achieve excellent corrosion resistance, high abrasion resistance, and a long service life. For example, large screws, starting at a diameter of 80 mm, are produced with premium welded flights: PTA welding (Plasma-Transfer-Arc-Welding) is used to weld a hard alloy layer onto the flight surface – with a thickness of 1 to 2 mm. Wear protection in the screw channel base is ensured by a layer of chrome. The chrome layer additionally provides corrosion protection; a corrosion-resistant base material is also used here. Through-hardening is the way to achieve performance in smaller screws up to a diameter of 70 mm. When manufacturing the screw, a chromium steel with a high carbon content is hardened, resulting in an abrasion-resistant, martensitic structure.

- Abrasion and corrosion-resistant screw material
- Bi-metallic barrel
- Laser-alloyed non-return valve

Typical plastics: for thermoplastics with reinforcement content (glass fibres or fillers) up to 30%, such as PA (Nylon).

The powerful High-Performance Package

Plastic parts, such as those used in the car engine compartment, fulfill a highly demanding requirement profile: they are designed for increased mechanical strength, a long service life at high operating temperatures, and permanent exposure to fuel, oil and brake fluid. And they still need to be lightweight, while meeting strict safety requirements. These challenges are usually met by using plastics with a high filler content, or reinforced plastics. The High-Performance Package is the perfect answer to these and many similar challenges. Maximum wear and corrosion resistance, robustness and a maximum service life of the plasticising components ensure impressive economic benefits for your injection moulding production.

- Through-hardened PM (powder-metallurgy) steel screw
- Tungsten carbide (WC) reinforced bi-metallic barrel
- Laser-alloyed non-return valve

For thermoplastics with reinforcement content above 30%, for example PA with 50% glass fibre content.
Versatile: Solution to increase throughput

SPS (special purpose screw) – double-flighted G2.3 screw

Advances in mould and temperature control technology have resulted in a continuous reduction in cooling times and significantly higher throughput, by shortening cycle times through parallel movements in all-electric and hybrid machines. The new double-flighted screw ensures the required performance – in a very cost effective way.

With its optimised feed zone, the double-flighted screw ensures a high level of shear energy which results in a high degree of molten material even prior to compression. A second flight is starting in the feed zone directly opposite the first, allows for a more uniform distribution of the forces during plasticising resulting in a symmetrical pressure profile. In this way, significantly higher throughput can be achieved compared to the single-flighted screw, particularly in technically challenging applications. They include, for example:

- Technical parts made of PP
- Thin-walled technical parts made of PA
- Parts made of low-viscosity POM

Homogeneous: Solution for direct colour mixing

SMS (standard mixing screw) – Mixing screw (G13)

When the task is producing moulded parts in different colours, it makes sense to colour the material directly in the injection moulding machine. Very often, master batches, consisting of a carrier material and concentrated colour pigments, are added. Excellent mixing results are ensured not only by the right choice of screw geometry, but also by the right choice of carrier material for the master batch.

The standard mixing screw (G13) ensures uniform distribution of the colour pigments in the melt.

Plasticising technology solutions
For your special requirements

Determined by geometry. While 3-zone screws are versatile, barrier screws offer maximum productivity. ENGEL offers a wide range of application-specific geometries. They ensure maximum plasticising performance, impressive mixing quality and outstanding plasticising capacity.
Robust: Solution for high throughput, output and colour

MBS (mixing barrier screw) – Barrier screw with mixing head (G16S)

Polyolefins can pose major challenges in processing, in particular where very high throughput is required and the plastic is coloured with master batches. The solution for this is to use barrier screws with dynamic mixing heads. The engineering principle of separating the solid and molten material through the barrier flight guarantees the highest level of melting capacity, while an additional dynamic mixing head ensures highly uniform colour pigment distribution.

Flexible: The automotive solution

UAS (universal automotive screw) – double-flighted screw with mixing head (G18)

Requirements in the automotive industry demand a screw concept that delivers high performance in a wide range of applications. With the double-flighted screw concept, the large screw surface allows energy to be introduced into the plastic in a targeted manner. The downstream mixing and shearing sections homogenise the melt with little stress. This results in a very high throughput across a wide range of applications, especially in the automotive sector.

- Technical parts made of PP-ABS blends
- Parts made of PC-PET
- Bumpers made of PP-EPDM or PP-talc

Fast: The solution for high throughput and output

UBS (universal barrier screw) – High performance barrier screw (G16)

High-performance machines, such as the all-electric ENGEL e-motion T, deliver the shortest cycle times and the highest level of productivity. One example of application is the packaging industry. Another would be medical technology, e.g. the production of polystyrene petri dishes, or blood vials. The plasticising components have to be geared towards achieving the required plasticising and throughput levels while simultaneously maintaining optimal melt quality. All while performing at the highest degree of process consistency. With its high performance barrier screw, ENGEL provides the ideal solution for these requirements.

As compared to other high performance barrier screws, the design of this screw stands out with its broad range of uses, while at the same time achieving a high melting capacity. This allows for processing a wide range of plastics (partially crystalline, amorphous, and plastic mixes) with a high throughput.

One step ahead: Excellent self-cleaning behaviour

Residence time and energy input have been optimised through the increased pitch of the barrier flight as compared to the main flight in the barrier zone. Gentle changes in the channel depth and flight-pitch in the transition areas between the individual zones result in improved self-cleaning behaviour, even at maximum performance.
Forward thinking with non-return valves

hard shell – tough core

The challenge | Ready for high loads

There is hardly a part on the injection moulding machine that has to fulfil such different requirements as the non-return valve:

Injection and holding phase
From a functional point of view, it prevents the melt from flowing back in the injection and hold pressure phase. Achieving a repeatable shut-off behaviour at the start of the injection process is one of the most critical parameters for the quality of the moulded parts. In this phase, the dynamic load is extremely high – pressures of 2400 bar or more can occur.

Plasticising phase
In this phase the non-return valve is open. The critical factors here: a pressure requirement which is as low as possible for the through-flow to ensure high conveying capacity of the screw, and very good self-cleaning behaviour. In both process phases, that is during injection and plasticising, the forces between the individual components are very high. Therefore the hardness and toughness of the tips has to be particularly high in order to achieve a long service life.

The solutions
ENGEL’s impressive materials expertise has also led to innovative solutions in non-return valves. For example, laser alloying of the non-return valve tip – a development patented by ENGEL – ensures fracture safety while maximising the service life. Many of the tips that ENGEL uses are equipped with this extremely beneficial laser alloy.
Carbide hard material phases are designed to withstand maximum stress and therefore best meet very challenging requirements. This material execution includes a laser-alloyed tip that reduces the wear between the tip and the sleeve.

The alloy is applied using laser technology. This ensures a melt-metallurgical bond with the base material. Thanks to this technology, the base material of the tip can be designed to be very tough. The advantage: the tip can absorb high dynamic loads. The sleeve in the UNR9 valve is made of a powder-metallurgical Cr steel with very high abrasion and corrosion resistance.

ENGEL developed the OPR9 non-return valve specifically for crystal clear applications. Compared to the UNR9 non-return valve, all of the OPR9’s components additionally have a PVD coating. This further improves what is already very good self-cleaning behaviour of the UNR9 non-return valve.

The QUR9 is another version of the ring non-return valve specifically developed for high-speed applications. This non-return valve is characterised by a shortened stroke and a long service life.
Ball non-return valve tough-shut TOR10

The larger the diameter of the non-return valve, the more challenging it becomes to achieve a very good closing behaviour. Highly-precise mould filling is essential, especially in the production of thin-walled parts. The best way to meet these requirements for larger screw diameters is with a ball non-return valve—especially if screw decompression after plasticising is not a possible option because of the required part quality.

Multi-ball non-return valve clear-shut CLR12

The requirements for processing crystal clear plastics with high shot weights are: excellent closing behaviour combined with very good self-cleaning properties. To ensure high quality in optical parts, the injection speed has to be very low at the start of the injection process; this places very high demands on the closing behaviour of the non-return valve.

These requirements are best met with a multi-ball non-return valve. This design already has chromium nitride coating as a factory standard. The advantage: the coating reduces the build-up of deposits in the non-return valve area, while at the same time substantially improving self-cleaning performance.

Non-return valve smart-shut SMR13

Although state-of-the-art, electrical injection units perform movements to the highest levels of repeatability, the non-return valves are the critical elements for a constant process. The ENGEL smart-shut self-locking non-return valve reduces weight variations to a minimum.

This is how the new, intelligent ENGEL smart-shut solution works: after the plasticising process, the screw is briefly rotated in the reverse direction; a specially designed wedge moves the sleeve in shut-off direction. The non-return valve is therefore already closed before the injection phase. The ENGEL smart-shut meets the highest demands in terms of constant closing time and shot weight.
Perfectly matched
Focus on customer-specific solutions

ENGEL can provide, on request, optimised plasticising systems that are precisely tailored to a variety of application specific requirements.

Stable processes with the PVC-U Package

PVC-U dry blend or pellets, also known as rigid PVC, belong to those plastics classes that pose very special requirements for the entire injection moulding machine. Low shear, high torque and chemical resistance characterise the machine equipment. The modifications of the PVC Package perfectly cover the demands placed on the machine’s equipment.

- Corrosion-resistant bi-metallic barrel with air-cooled barrel heating bands
- Specially developed low-compression screw (SPS-G3) for combined use of pellets or powder
- Additionally optimised screw geometry for pure powder processing (SPS-G3DB)
- Integrated screw tip for excellent self-cleaning behaviour
- Hollow-drilled screws for the installation of a screw temperature control system
- Increased torque and reverse rotation lock during injection
- “Pre-injection” program for improved part quality

An ENGEL injection moulding machine with the PVC Package is suitable for processing PVC in both powder form (also known as dry blend) and pellet form.

Rugged processing of fluoropolymers

For processing fluoropolymers, for example, PVDF, but also PFA, highly corrosion-resistant materials are used for all plasticising unit components. High alloy nickel base materials stand for maximum corrosion resistance:

- All components are made of nickel-based material
- Bi-metallic barrel with nickel-plated feedthroat
- Screw with welded flights and non-return valve
- Barrel head and nozzle
Focused engineering: Optical Package

Optical parts with large wall thicknesses pose a particular challenge for the plasticising unit. After all: Large wall thicknesses mean long cooling times and therefore long residence times of the plastic in the plasticising unit, the hot runner and the mould. Particularly gentle melting behaviour and best homogenisation are therefore the prerequisites for lens production. The use of optimised screw geometries and material executions helps to extend the process window for the user. If required, material can be fed to the machine in a controlled manner. With this option “starve feeding” is possible. This reduces the residence time, leading to improved part quality.

- Bi-metallic barrel with nickel-plated feedthroat
- Specially developed custom geometry G15 with PVD coating for PMMA
- opt-shut (OPR9) ring non-return valve (PVD-coated)
- Barrel head and nozzle corrosion resistant
- Corrosion-protected design of the material hopper sliding unit
- optional peripherals:
  - Starve feeding package
  - nitrogen flush
  - material dust extractor
  - extraction of volatile components
- For PMMA, PC, COC, transparent PA

Fast material changeovers: Self-Cleaning Package

The duration and effectiveness of a material or colour change in a plasticising unit is mainly determined by the front-end design (barrel head & nozzle). A special Self-Cleaning Package was developed to improve the self-cleaning and material changeover behaviour.

This package consists of the following specially designed components:
- CrN-coated ring non-return valve with extended tip and shortened stroke
- Optimised barrel head geometry (flatter angle) including a separate barrel head heating band and control
- Nozzle body with reduced melt transitions and screw-in nozzle
- The screw should be selected as a function of the application. The package can be combined with any screw geometry for processing thermoplastics.

The benefits of the Self-Cleaning Package for the processor:
- Significantly minimised number of shots or time required for colour/material changes
- Significantly improved part quality (avoidance of black spots, streaks, etc.)
- Reduced material stress (avoidance of material degradation and adhesion)
- The package can be used in many cases and various types of plastics to be processed.

Crystal clear: Glazing Package

When processing the two transparent plastics polycarbonate (PC) and polymethyl methacrylate (PMMA) for optical applications such as lenses, headlights, rear lights, panoramic roofs, etc., the Glazing Package has to be selected in order to achieve perfect part quality without optical flaws (streaks, black spots). The front-end design (barrel head & nozzle) again plays the main role in improving the self-cleaning behaviour.

Similar to the Self-Cleaning Package, the Glazing Package consists of:
- Optimised barrel head geometry (flatter angle) including a separate barrel head heating band and control
- Nozzle body with reduced melt transitions and screw-in nozzle
- CrN-coated multi-ball non-return valve CLR12 for best self-cleaning and shut-off behaviour
- Depending on the application, the package can be combined with the GPS (general purpose screw), UAS (universal automotive screw) or UBS (universal barrier screw).

The benefits of the Glazing Package for the processor:
- Significantly improved part quality due to very good melt quality (avoidance of black spots, streaks, etc.) and part properties (due to lower material stress)
- No decompression stroke required after recovery and achievement of the lowest possible injection speeds (by using the CLR12)
The fast performer with the Cap Package

Maximum speed, dynamics and performance: The ENGEL speed plasticising unit is designed for durable high-performance from beginning to end. Fast rotating screws, short strokes and fast, precise injection; all system components are capable of handling the most extreme demands and are ideally suited for intensive use in the packaging industry. The G16CAP barrier screw is specially designed to meet the requirements of the packaging industry in the manufacture of PE-HD caps for beverages.

High-strength material execution, paired with a sophisticated geometry, lead to maximum performance with the best melt homogeneity. The G16CAP is only used in combination with the highly wear-resistant cap-shut CAR11 ring non-return valve. This non-return valve is equipped with a particularly hard lattice layer to extend the lifetime of the non-return valve.

- High throughput with homogeneous melt preparation
- High plasticising capacity
- Optimised CAP barrier screw (G16CAP) for PE-HD ≤ 8 g/10 min MFR
- Highly wear-resistant cap-shut (CAR11) ring non-return valve with 4 flights

For easy foaming: foammelt (MuCell®)

Precision light-weight parts with a micro-foam inner structure are manufactured in line with the MuCell® principle using ENGEL foammelt. The physical foaming agent, nitrogen or carbon dioxide, is injected into the melt in a controlled manner and a homogeneous polymer-gas solution is formed through intensive mixing. The foaming process only takes place after injection into the mould cavity. The result is an integral foam structure consisting of a compact skin layer and a foamed core. The screw has an efficient mixing section which homogenises the polymer-gas mixture such that the gas distribution and the foaming result are optimised.

The plasticising units feature one or two gas injectors and utilise screw lengths with an L/D ratio of up to 25. The G25S screw, specially developed for foammelt, ensures a very stable process and good melt homogeneity.

- Foammelt Package for plastics with ≤ 35% glass fibre content
- Optionally with two injectors

MuCell® is a registered trademark of Trexel, Inc.
Overview of plasticising units
by colouring level and plastic types

<table>
<thead>
<tr>
<th>Type</th>
<th>Standard application</th>
<th>High-performance application</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>General Purpose Screws</td>
<td>Universal Automatic Screw UAS</td>
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<tr>
<td></td>
<td>GPS</td>
<td>SMS</td>
</tr>
<tr>
<td>Geometry</td>
<td>G1</td>
<td>G13</td>
</tr>
<tr>
<td>Length L/D</td>
<td>up to 24</td>
<td>up to 28</td>
</tr>
<tr>
<td>Screw ø ≤ 70</td>
<td>S1N</td>
<td>S8</td>
</tr>
</tbody>
</table>

- **PE**
- **PP**
- **PP-EPDM**
- **PPT**
- **SAN**
- **TPE**
- **PA**
- **PBT**
- **PET**
- **ABS**
- **ABS blend**
- **PPE blend**
- **ASA**
- **PC**
- **COC**
- **PC blends**
- **PVC soft**
- **POM**
- **PPS**
- **LCP**
- **High temperature**

<table>
<thead>
<tr>
<th>Geometry</th>
<th>G1</th>
<th>G2.3</th>
<th>G3</th>
<th>G3G6</th>
<th>G5</th>
<th>G6</th>
<th>G7</th>
<th>G8</th>
<th>G15</th>
<th>G19</th>
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<tbody>
<tr>
<td>Length L/D</td>
<td>up to 25</td>
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<tr>
<td>Screw ø ≤ 70</td>
<td>S9</td>
<td>S8</td>
<td>S8</td>
<td>S8</td>
<td>S8</td>
<td>S8</td>
<td>S10</td>
<td>S1</td>
<td>S8</td>
<td>S10</td>
</tr>
<tr>
<td>Screw ø ≥ 80</td>
<td>S4V-B</td>
<td>S4V-B</td>
<td>S4V-B</td>
<td>S4V-B</td>
<td>S4V-B</td>
<td>S6</td>
<td>S4V-B</td>
<td>S6</td>
<td>S4V-B</td>
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- **Fluoro-plastics**
- **PP**
- **PP + LGF**
- **PA**
- **PA + LGF**
- **PVC-U**
- **PVC-C**
- **Thermoset**
- **BMC**
- **Elastomer**
- **LSR, LIM**
- **PM**
- **PC**
- **PMMA**
- **PBT**

<table>
<thead>
<tr>
<th>High-Performance Package</th>
<th>S10: Powder metallurgical PM plastic mould steel, through-hardened</th>
<th>S13H-T: Q &amp; T steel, HVOF coated, with welded flights</th>
</tr>
</thead>
<tbody>
<tr>
<td>M3: Ni bimetallic barrel with tungsten carbide reinforcement &gt; 40% GF</td>
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</tr>
</tbody>
</table>

- **Basic Package**
  - S1N: Nitriding steel, quenched and tempered and plasma-nitrided, CrN-mod coated
  - S1H-P: Nitriding steel, quenched and tempered and plasma-nitrided, CrN-mod coated
  - S1N-B: Screw with welded flights, nitriding steel, plasma-nitrided
  - M3: Fe bimetallic barrel

- **Advanced Package**
  - S4V-B: Screw with welded flights, quenched and tempered plastic mould steel, chrome plated
  - S8: Tool steel with high chrome content, through-hardened
  - S13V-B: Screw with welded flights, Q & T steel, chrome plated
  - M3: Fe bimetallic barrel

- **Glass fibre content < 0%**
- **Glass fibre content ≥ 30%**

This is an excerpt from the ENGEL product portfolio for plasticising systems. Other designs are available on request.
The history of plastics is the history of rapid change.

The requirements on the plasticising unit are continually becoming tougher. Plastics with special properties continually require the use of the latest additives or other mixed-in materials to fulfill requirements. Lower part weight, lower material costs, higher mechanical properties and constantly changing framework conditions motivate continuous further development. With a view to increasing productivity, these new plastics need to be processed faster and with premium quality on state-of-the-art injection moulding machines. These factors lead to increased stress on all plasticising unit components.

The Centre of Excellence for Plasticising Technology at ENGEL in St. Valentin is the organisational unit responsible for both the function and the production procedure of the plasticising units. In the Concurrent Development process, all relevant requirements are given equal consideration. A team of experts from Metallurgy, Welding Technology, Rheology, Plastics Technology, Design and Production Engineering develops new screw concepts. Continuous improvements in manufacturing and process assurance are just as important for this team as research into complex physical and chemical processes.

The continuous and complete electronic integration (CAx) of the data into the design and production process is the prerequisite for consistently high part quality. The Support Team aids our customers at the highest level and implements projects successfully.
Modern laboratory

ENGEL has a well-equipped materials laboratory for testing processes, materials and plastics. In addition to the standard equipment of a good materials laboratory, which ranges from various hardness testing methods through preparation and etching techniques to various optical microscope examination methods, a scanning electron microscope, a white light interferometer and a tribometer are also available. This enables our metallurgists to investigate the chemical structure and the microstructure of our metallic materials, to measure the surfaces-quality of the plasticising components in three dimensions, and to characterise the sliding properties (tribology). A team of plastics engineers determines rheological parameters that form the basis for the simulation, design and optimisation of plasticising components. Furthermore there is the possibility to determine the corrosion behaviour of a material through electrochemical investigation using a potentiostat.

In-house screw testing lab

A separate injection moulding machine is reserved in R&D for material and geometry developments of plasticising screws, mixing heads and non-return valves. A comprehensive sensor system in the barrel area allows engineers to “peek” into the plasticising unit and precisely analyse the plasticising and injection process.

With flexible expertise – solution-oriented support

The ENGEL Plasticising Support Team helps the customer on site or via remote maintenance with their plasticising issues. Whether a product change, plastic type change or performance optimisation – the expert team is available to improve your processes and solve problems. These highly experienced plastics engineers have methods and measuring tools at their disposal to carry out rapid troubleshooting and initiate corrective actions. Cost effectiveness considerations are just as important as technical solutions. In conjunction with development and production, customer-specific adaptations can be carried out quickly. Flexibility with expertise – creative and quick to implement – that’s what you can expect from the Plasticising Support Team.

Please direct enquiries to your local contact or submit them via our website at www.engelglobal.com.