Plasmatec GmbH

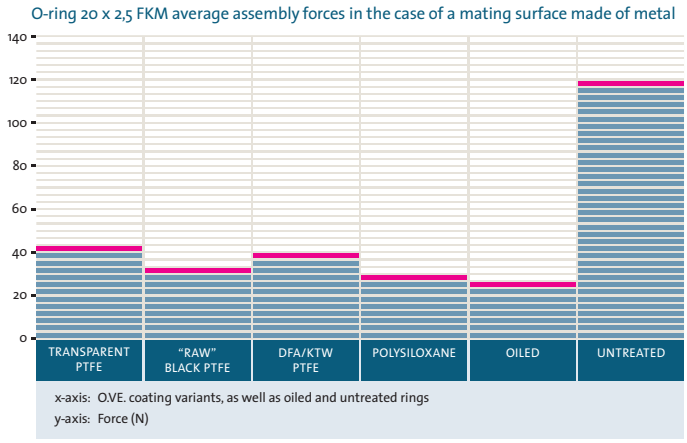
Surface modification of elastomeric components

Seals are a widely diversified class of important construction elements for nearly all products. They are used in such diverse products as **cars** and **kitchen appliances**, **aircraft**, **power stations** and **process engineering plants**, and even the **furniture industry** has developed a taste for them. The original purpose of a seal is to separate two functionally different spaces in such a way that no substances can pass between them – or that otherwise the exchange of substances is limited to a permissible extent. **Elastomers, with their profile of properties, are an ideal substance for making seals**. However, unfortunately such a portfolio of properties also includes major friction, which can cause problems, and not only during the assembly and in respect of the functioning of the device. **Surface modification comes to the rescue here**.

›› PROBLEMS FACED

Many users have to face the following problems:

- Parts that are glued or adhere to one another make assembly difficult, or cause interruptions during the automatic assembly process.
- High friction exacerbates or prevents automatic feed.



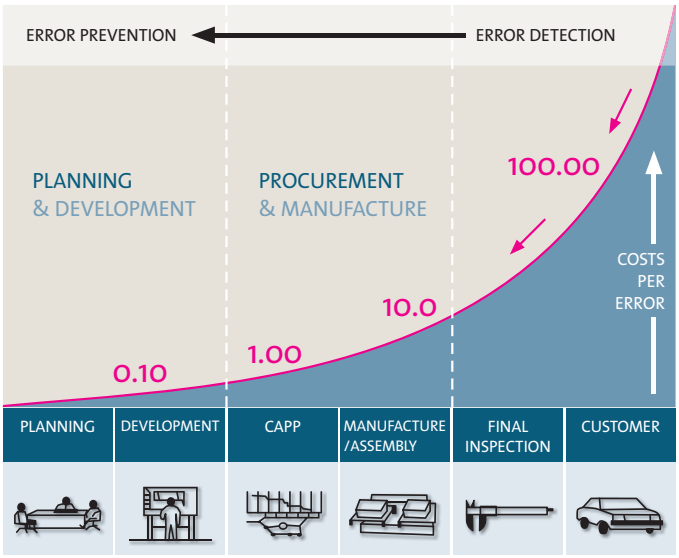
- Staining problems due to residues of oil, separating agents and silicone when 'freshly' manufactured components are delivered.
- Sealing elements are not colour-coded, so there is an increased risk of them being confused with one another.
- It is not only in the case of dynamic applications that high friction coefficients lead to premature wear and tear, and thus to a reduction in the service life.
- Creaking and squeaking noises.
- High breakaway forces.
- A shorter useful life.
- Volatilisation of lubricants during the useful life. The elastomer absorbs a portion of the lubricant and releases the remainder into the environment.

Fig.: Comparison of assembly forces

In order to eliminate these acute problems, additional financial expenditure can often not be avoided. Additional expenditure for the standstill of conveyor belts or machinery, urgent manufacture and deliveries, sorting expenses, possibly even certain components having to be reconstructed do not solely mean time delays, but generate costs that were not anticipated at the planning and initial construction stages.

A scientific definition of this dilemma – the 'rule of ten' – proves that the cost of remedying errors increases exponentially from the moment that the idea for the product is born until such time as the product is about to be launched on the market. In this respect, this rule of a tenfold increase states that, as a rule of thumb, it can be assumed that the cost of errors will increase tenfold at each additional stage further down the line.

It transpires from the latter that it is more cost-efficient to avoid potential errors than to remedy errors that have already occurred. Suppliers should therefore already be involved in the product development. This means using expertise where it is best available, i.e. involving suppliers not only as agents who deliver on call or act as an extended workbench, but through strategic collaboration to build-up a long-term link and partnership, rather than swapping suppliers on a case-by-case basis.



Source: Cf. Wittig, K.-J., Qualitätsmanagement in der Praxis, B. G. Publishers Teubner, Stuttgart 1993

Fig.: Rule of ten

›› POSSIBLE SOLUTIONS

Simple lubricants
A prevalent and cost-efficient practice for reducing friction and enabling assembly is to oil or grease the components to be processed, or apply talcum powder to them. Lubricants were, and are still to this day, largely applied manually, by being applied by hand or using methods that are not procedurally reliable, such as tumbling, agitating, dipping, etc. This, however, entails a whole series of serious drawbacks and potential errors:

- **Too much lubricant** causes staining of the component, the environment, assembly equipment and any monitoring sensors. In addition, further checks may be needed, for example in the case of automobile manufacture, if excess lubricant is detected when conducting the final inspection.
- **Too little lubricant** increases the risk of damage to the component when it is installed (shearing, crushing, etc.). Should the damage to the seal not be detected during installation, there may be serious consequences. If a damaged seal is identified prior to installation, that leads to interruptions during assembly or manufacture.
- **Volatilisation of the lubricant** – basically, lubricants are volatile, and cannot be permanently applied to elastomeric materials. Depending upon the length of time the lubricants are stored, how the components are handled, and the lubricants' exposure to ultraviolet radiation etc., they volatilise over the course of time, along with the desired properties in regard to reducing friction and enhancing assembly. Unlike metals, elastomers are dynamic materials, which absorb lubricants during the period of use, or also emit production residues encapsulated inside into the environment. It is, for example, known from practice that a silicone oil applied to an elastomer may no longer be present on the surface within a week. If one wants lubricants to be successfully applied to a seal, and the latter to likewise subsequently be successfully assembled, what kind of staining may basically occur in regard to assembly equipment, the component, the environment and staff may not be left out of consideration. The resulting cleaning costs and increased maintenance expenditure should, in that regard, be considered.
- Absence of **PWIS** not **possible** – PWIS (paint wetting impairment substances) prevent even wetting of the surface to be varnished, thus causing funnel-shaped defects and the formation of recesses in the layer of varnish. Since the introduction of varnishing with nearly solvent-free varnishes (proportion of solvent > 3%) in the automotive industry, absence of PWIS is required for production material, technical facilities and tools. As it is not known which substances lead to such defects, materials, components and groups of components are tested for absence of PWIS. Absence of PWIS cannot be achieved with lubricants currently on the market.
- **No way of indicating whether a layer has been applied** – When volatile or transparent lubricants are applied, it is not possible to clearly determine whether a layer has in fact been applied.

Anti-friction coatings – efficient and easy to customise
Seals refined with anti-friction coatings are used in the most diverse industries: They are, for instance, used in the automotive and mechanical engineering industries, the food industry, the pneumatics industry, the sanitary industry, medical engineering, etc. Finally, they are used everywhere where seals are utilised.

Surfaces that are dry and touch-proof make for a clean assembly environment. The entire process, from pre-treating the components up to varnishing them, is computer-controlled, and is documented for each order. In that respect, every customer order has its individual history, and thus a personalised tribological system, with its own formula. Depending upon the application parameters, such as the mating surface, the temperature range, media utilised, environmental and compression pressure, assembly forces, the choice of materials, etc., the optimum solution is chosen from a large number of different methods of modifying the elastomeric surface.

Once a promising setup has been identified, the corresponding anti-friction coating is applied to the sealing element. The varnish is applied in thin and flexible layers (2-8 µm), which do not alter the topography of the components, but only form lubrication pockets on the surface. The result is that splendid adhesion between the elastomer and the layer of varnish is achieved. Even 150% expansion is not a problem, and any flaking of the layer can be excluded. Thus, the accompanying abrasion resistance of the coating provides additional protection for the elastomer.

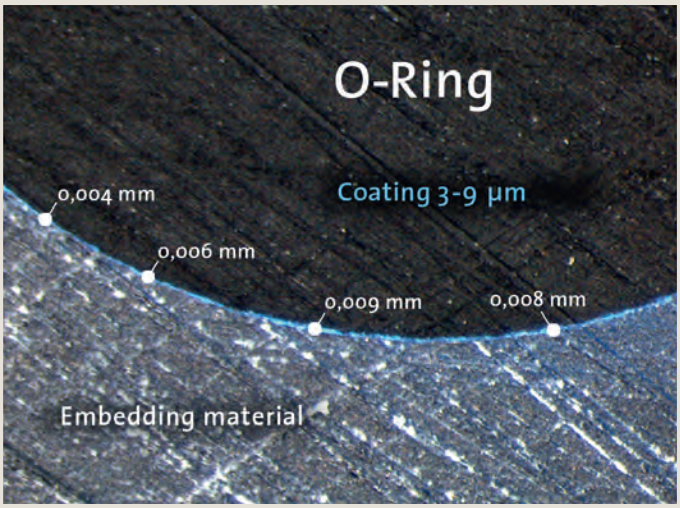


Fig.: Measuring layer thickness

All elastomeric materials can be coated, and there is meanwhile even a varnish available for silicone materials that guarantees excellent adhesion. The colouring of the individual types of varnish makes it possible to distinguish the coated materials according to colour. Coloured varnishes are available as either functional or decorative coatings. For instance, yellow coatings are a good choice for gas applications. In addition, most applicable anti-friction coatings offered are PWIS-free. Meaning that a sealing element cleaned in a PWIS-free manner can take a PWIS-free coating. Ultraviolet indicators are utilised to determine whether sealing elements are coated. By means of ultra-violet light, it can thus clearly be determined whether the sealing element used has been treated in accordance with the specifications. The installation of untreated components can therefore be avoided.

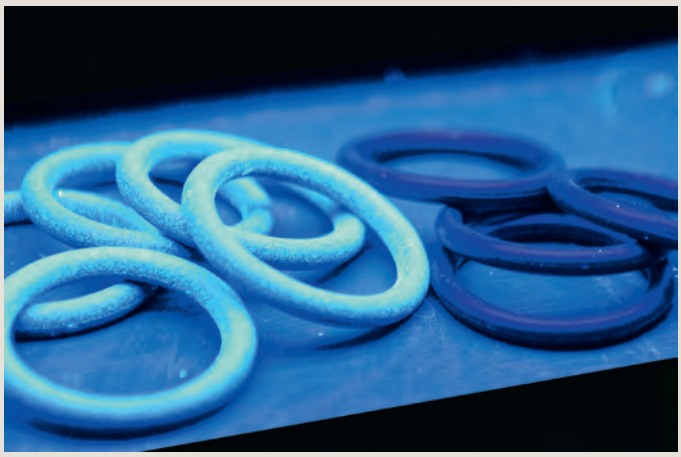


Fig.: Coated seals with ultraviolet indicator (on the left)

Taking all the advantages of coating surfaces together, the bottom line is medium and long-term savings in additional costs. Thus, new opportunities are available to the draughtsman, as the plugging forces and torques of joints to be sealed can be significantly reduced. Moreover, the stick-slip effect can be avoided, and wear and tear reduced. Valves or switches not activated very often do not stick, and it is possible to ensure absence of PWIS. When purchasing, it should be taken into consideration that increased acquisition costs are more than made up for by healthy savings due to friction-free assembly and a reduction in potential functional defects. Moreover, the increased efficiency and extended functionality may result in further savings potentials. For quality managers, surface coating offers greater reliability, for instance through a reduced „long-term“ tendency towards adhesion.

Another positive aspect is the eco-friendliness of the water-based anti-friction coatings. Solvents and chemical pre-treatments harmful to the environment are entirely avoided.

›› EXPERTISE NEEDED

Possible pitfalls should be taken into consideration, as high quality coating requires an intensive pre-treatment process and sound materials expertise.

Our pre-cleaning process evolves in a number of different stages, and, among other things, comprises wet cleaning of the surface, as well as low-pressure plasma treatment.

Essentially, the following applies: The condition of the components as delivered does not affect the properties of the materials once coated. The right pre-treatment process eliminates any substances which might interfere, such as oils, greases, residues of separating agents, talcum powder or any other kind of powder prior to coating. Thus, the adhesion is outstanding.

Awareness of the various different elastomeric materials (NBR, FKM, EPDM, silicones, ACM, etc.) and the different shore hardnesses is a fundamental prerequisite for high quality coating. The performance of different materials varies greatly – even with materials from different production sites that are supposed to be the same.

And only someone in a position to handle such heterogeneity will always be able to manufacture products with procedural reliability. Against the background of the foregoing, it is necessary to investigate the relevant expertise of the coating company.

O.VE. Plasmatec GmbH has over 25 years' experience in the field of sealing technology. When we coat elastomers with anti-friction water-based varnishes we do so based on ten years' experience in customising tribological systems.

›› CAPACITIES

Production area:	2,400 m²
Wet cleaning:	40 washing machines
Plasma capacity:	7 low-pressure plasma systems with a total volume of 13,550 litres
Coating:	11 tumble spray coating machines
Waste water:	Waste water treatment plant

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