Sealing Solutions for Industrial Gear Units

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1 Summary

Industrial gear units drive working machines in many different applications and uses. The environmental conditions are just as different as the operating ones. Indoor and outdoor assembly, dust, moisture, aggressive gases and liquids on the one side corresponds with speeds, oils and (oil-) temperatures, geometrical issues, manufacturing tolerances and installing positions and place highest demands on the shaft-sealing.

Flender is now expanding its range of configurable seals for industrial gearboxes, taking into account the application-specific and gearbox-related boundary conditions in a way that is easiest to act. The aim: reducing wear and increasing service life. Optimized lip seals and seal systems ensure reduced heat generation and longer service life.

In addition, it has now been possible to integrate a wear-free seal for environments with high contamination loads as standard: Tacolab - a seal that is even tight when stationary.

Besides the robustness against contamination, knowledge about dealing with the gear unit conditions is just as important - so extensive tests on seal and gearbox test benches show the performance and specific properties of the seal variants under different environmental and operating conditions. These are incorporated into the gearbox configurator as differentiation criterion, but before that, they are compared with the results of systematic evaluations with regard to field experience with the extensive Flender gearbox fleet – the result: With just a few inputs you can take into account Flender's extensive application experience and the configurator generates suggestions and options for the optimum seal.

2 Starting Position

Industrial gearboxes are available in different designs due to a wide range of appli- cations and requirements. A distinction is made between standard gear units (Fig. 1) and those that are designed application-specifically (Fig. 2). Standard gearboxes often have a modular character and can be used in several applications. Common to all gearboxes is the need to seal rotating input or output shafts against a stationary or rotating part with a different speed in order to protect the interior of the gear unit

from contamination and external influences and at the same time to prevent leakages to ensure the function of the gear unit. The shaft seals are di- vided into seals with contact sealing ele- ments and non-contact seals. Extensive information can be found at [1].

Flender has been serving a wide variety of applications (figures 2 and 3) for a long time with various gear unit concepts, too.

Figure 1: Flender standard gear unit

Figure 2: Examples for Flender's application spe- cific gear units

Figure 3: Applications served by Flender

This often involves the following points:

- Industrial gear units can have a wide range of parameters for the use of possible seals (e.g. diameter, circumferential speed at the shafts) due to their sizes, design and ratio spectrum.
- Dimensioning a lip seal, e.g. in the form of a service life calculation, is difficult due to the spread of many influencing factors.
- individual applications traditionally have specific sealing systems - the result is an ensuing complexity for the gear unit manufacturer. Changes in the seal or the sealing principle are met with skepticism.
- in addition to the oil change, the renewal of seals is one of the most frequent service measures for industrial gearboxes. The replacement of faults can lead to considerable dismantling and reassembly effort with corresponding downtimes.
- lip seals can create a significant proportion of the energy losses in gear units.

In certain cases, this situation is not really satisfactory for either the operator (degree of efficiency, time-consuming maintenance) or

the manufacturer of the gearbox (complexity, no exact description of the sealing properties, warranty issues). These experiences motivated several activities at Flender, which follow below.

3 Field Response

The extensive installed gear unit fleet of Flender allows a systematic and far-reach- ing evaluation of field experience. This is about points, such as

- service life, frequency of leaks
- environmental and operating conditions
- constructive design and its influences

We derive and incorporate the needs and improvements into the design. As an ex- ample, an evaluation of the frequency of seal failures (in this case: lip seal) depend- ing on the speed is listed in figure 4. An increase in failures (relative to the installed number of gear units) over the circumferential speed is clearly visible. For shaft seals, an earlier failure at higher speeds seems plausible, whereby these are within a permissible range for the built-in sealing ring types. On the basis of this example, you can see that even in areas that in principle should not be a high hurdle for a radial shaft seal, conceptual changes that

- result in a reduction in the temperatures at the sealing lip,
- provide improved protection of the sealing lip against contamination,
- systematically reduce or eliminate wear, e.g. by switching to wear-free labyrinth seals,

can be sensible or necessary.

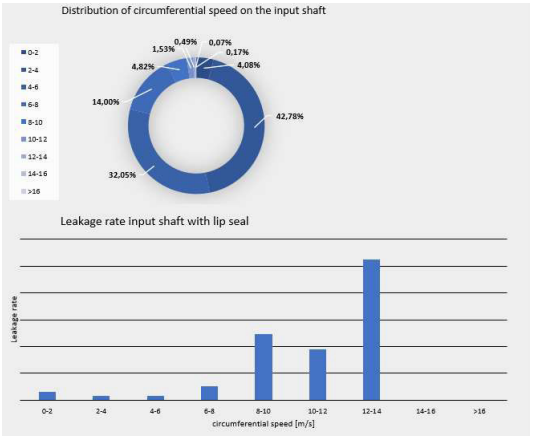

Figure 4: Example of an evaluation

4 Test Rigs

With the large number of influencing factors, a validation of the seals on test benches is sensible and necessary. There, the effectiveness of the seals at conditions with contamination can also be checked. Flender has its own sealing test benches; tests are also carried out together with seal manufacturers on their test benches (figures 5 and 6). In addition to validation, further objectives are:

- Optimizing the sealing design
- Determining the basic suitability
- Determining the service life

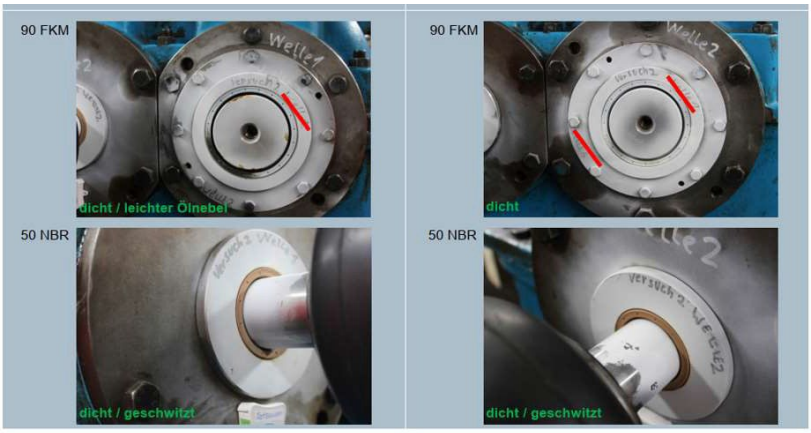

Figure 5: Sealing tests at Flender test rig: comparison of different seal materials

Figure 6: Sealing tests – test of a saft seal under contamination of a saft seal; source: Freudenberg sealing technologies

5 Types of Seals

In the following, we describe seal types that are intended for many gear unit types in the industrial gearbox sector at Flender. In addition, there are many other special solutions that arise as a result of customer or application experience.

5.1 Shaft Seal – One for Almost All

The radial shaft seal is the typical seal for gear unit input and output shafts. Available in a wide variety of materials and designs, accepting that it is (always) a wearing part, you can find a suitable design for almost every application and ambient conditions. Table 1 lists the advantages and disadvantages from a gearbox manufacturer's point of view. [2] provides information on the compatibility of lubricants and seals, an important issue in terms of durability.

Figure 7: Shaft seal

Table 1: Pros and cons for shaft seals

Pros	**Cons**
Can be used almost anywhere: installation positions, speeds, operating conditions	High demands on lubricant regarding compatibility
Lip seal – tight even under oil at standstill	Wear, limited lifetime, finite performance under challenging ambient conditions
Broad portfolio, good availability	Sealing lip creates friction losses
Sophisticated machine element	Time consuming disassembly and reassembly during sealing ring replacement
Potential for further development: materials, extended areas of application	Extensive range of types with relatively small areas of application ➔ complexity

5.2 Taconite – High Performance

Figure 8: Taconite seal

The Taconite seal received its name from the dust of the Taconite rock, which is mined for iron production and places the highest demands on gear seals. Flender has been engineering and building Taconite seals for more than 40 years – the seal is still the gold standard in robustness for applications with high dust and dirt accumulation. It has long since proven its performance also in splashing water and moisture (IP66). The relubricatable labyrinth conveys the dirt away from the upstream shaft seal, which seals on the gearbox side, thus obtaining protection and – protected from dust, dirt, sunlight, moisture, spills – achieving the maximum possible service life.

Table 2: Pros and Cons for Taconite sealings

Pros	**Cons**
Can be used almost anywhere: installation positions, speeds, operating conditions	High demands on lubricant regarding compatibility
Lip seal – tight even under oil at standstill	Sealing lip creates friction losses
Protection of the shaft seal, longer service life	Time consuming disassembly and reassembly during sealing ring replacement
Proven in adverse environmental and operating conditions, robust	
Standardized and available over a wide range at Flender	
Grease relubrication possible during operation	

5.3 Labyrinth – for Life Seal, a Step toward Maintenance-Free Gear Units

The Flender labyrinth seal works contactless and wear- less. A V-seal is installed for transport and preservation reasons only. Flender labyrinth seals creates a dynamic sealing effect and protect against dirt particles and leak-ages of oil up to protection class IP54.

Figure 9: Labyrinth seal

Table 3: Pros and Cons for Flender labyrinth sealings

Pros	**Cons**
Dynamic sealing effect	not dustproof at standstill
Non-contact, wear-free and mainte-nance-free	Oil lubrication of the gear unit must meet certain basic conditions
No friction losses	
Enables highest circumferential speeds and a wide temperature range	
Standardized and available over a wide range at Flender	

5.4 Tacolab – High Performance Seal For Life

Figure 10: Tacolab seal

With this seal, the wear-free nature of the labyrinth seal is coupled with the performance of the Taconite seal. Result: highest performance even under adverse con- ditions and freedom from wear. A built-in lock prevents grease from penetrating into the labyrinth and the gear unit.

Nothing stands in the way of 24/7 operation, as the relubrication of the Taconite seal can take place during operation.

Table 4: Pros and Cons for Flender Tacolab sealing

Pros	**Cons**
Dynamic sealing effect, dustproof – even at standstill	Oil lubrication of the gear unit must meet certain conditions
Non-contact, wear-free	
low friction losses	
Standardized and available over a wide range at Flender	
Enables highest circumferential speeds and a wide temperature range	
Grease relubrication possible during operation	

6 Describe Application and Environmental Conditions

The selection of the best possible seal requires a variety of information regarding

- Gearbox: lubricant, temperatures, speeds, circumferential speeds, installa- tion position, pressure conditions, level and dynamics of the lubricant, movements and distortions, air movements
- Application: Type and degree of contamination, temperatures and temper- ature ranges, requirements regarding robustness and service life, explo- sion protection, is there a risk as a result of leakage?
- Serviceability requirements
- Transport and storage: preservation, temperatures, speeds, service life re- quirements

7 Selection of the Sealing and Configuration

On the one hand, Flender configurators [3] have precise information about the de- sign possibilities of the gear units as well as the performance of the available sealing options, on the other hand, the operating conditions are assessed through detailed questions about the application and the boundary conditions, taking into account Flender's application-experience. The result: an optimal sealing solution with just a few clicks. This is not reserved for the Flender expert – it is easily feasible for every customer.

A special focus is on the comprehensive provision of friction- and wear-free sealing solutions without restrictions on suitability in the application. Flender will also further intensify its activities in these areas:

- Systematization of the generation of data for field experience
- Assessment and qualification of optimized and new seal types
- New development of sealing systems

Flender will develop new solutions from this data and make them available to our customers and to the configuration as quickly as possible.

8 References

[1] www.fachwissen-dichtungstechnik.de

[2] FLENDER SUPPLIES: Gear-unit and lubrication and gear-unit preservation – assembly and operating instructions 7300en, Edition 06/2020

[3] Flender configurator, available at: https://www.flender.com/de/spice/overview

9 Author

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