Advanced PTFE Compression Packing Filaments

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Abstract:
Compression Packings produced from PTFE filaments and yarns, along with Carbon fibers, are the most frequently used packings in industrial plants. The outstanding chemical resistance and sealing characteristics of PTFE packings make them some of the best alternatives for sealing rotating and reciprocating equipment such as valves, agitators and pumps. This Paper compares the performance of PTFE packings produced from filaments manufactured by the Split Peel Process with the performance of those produced by the Extrusion/Calendering/Expanding Process. Under laboratory conditions, the advantages of each process, as well as the benefits of the addition of certain fillers were also determined and are reported upon.

1. Introduction

For many years industry has recognized the inherent benefits of Mechanical Packings produced from PTFE-filaments and yarns. The outstanding chemical resistance and excellent sealability characteristics of PTFE in various forms make it one of the best available materials to seal rotating and reciprocating equipment such as valves, agitators, mixers and pumps.

Several different manufacturing methods are being used to produce PTFE-filaments and PTFE-yarns for packings. Until the mid-80's the most widely used yarns were made by a matrix spinning process. From that time until the end of the 90's a skiving/splitting process was the most popular. Since then, the slit-film filament, which is produced by an extrusion / expansion process, proved to provide significant benefits in both field applications and laboratory performance testing when compared with earlier generations of filaments.

An additional enhancement of modern braided packings is achieved by incorporating filler particles in the individual filaments during manufacturing. These fillers are used to enhance physical characteristics such as increased heat transfer and to providing a lower friction coefficient. Depending on the actual application, silicone oil or mineral oil is added either during the manufacturing process of the individual braiding filaments or during the actual braiding operation.

Testing of various types of mechanical packings shows clearly that the filament / yarn has a direct influence on practical performance. Measurement criteria include leakage data, maintenance intervals and overall packing life.

The most widely used PTFE-yarns are discussed in the following paragraphs.

2. Expanded Filaments

The latest manufacturing technologies are being used to produce expanded filaments for braided packings. An extruded tape is calendered and expanded. The resulting film is split into continuous filaments as shown in Figure 1. Packings produced from expanded filaments show better sealing properties than those made from skived yarns. The soft and porous nature of expanded PTFE absorbs and retains more lubricant, conforms better to the stuffing box, resulting in lower leakage rates. This is accomplished without the use of excessive gland pressure. The result is a lower wear- rate and less risk of shaft scoring. Packings produced from these filaments exhibit lower leak rates than packings made from skived yarns. All PTFE-filaments produced by the Teadit Group are of the expanded type.

Teadit packing-filaments can be grouped in three main categories:

- EW Series: white filament for valve and pump packings
- EG2G Series: high performance graphited PTFE filament for pump packings.
- EG6 Series: economical grafited PTFE filament for pump packings.

In the following sections of this paper the EW Series filaments for valves and pumps are described along with their respective performance in comparison to multi-filament yarns.

3. Skived Multi-Filament Yarns

These yarns are produced by skiving and splitting a sintered PTFE billet. Figures 2 show a typical skived multi-filament yarn. Packings produced from these filaments have the following disadvantages:

- Significant hardness: due to the nature of sintered PTFE considerably higher gland-pressure is needed in order for the packing to conform to the stuffing box, achieving good sealability.
- More friction: sintered PTFE is a very dense material that does not readily absorb or retain lubricants.
- Increased shaft wear: high gland-pressure together with the lack of internal lubrication results in fast consumption of the available surface lubricant. The result being more frequent maintenance adjustments, frequent line-shutdowns and lost productivity due to increased maintenance requirements.

A mixture of graphite flakes with PTFE-dispersion is used to impregnate the yarn to reduce the wear rate. A graphite-impregnated yarn is shown in Figure 3.

4. Matrix Spun Yarns

Matrix Spun yarns are produced by using a spinneret process. A combination of PTFE dispersion and a viscose carrier are spun resulting in a filament. During this process an oxidizing agent is introduced to remove the viscose carrier. As a result of the oxidizing process, the yarn is dark brown in color. The filament may undergo a secondary bleaching operation in order to remove the brown coloration. This adds significant additional cost and is purely cosmetic. These types of yarn – because of their higher cost and limited sealing properties - are no longer used for the production of mechanical packings. Figure 4 shows a typical Matrix Spun Yarn with its brown color prior to bleaching.

5. Unsintered Tape Filaments

PTFE unsintered thread sealant tape has been used to produce packing yarns. These are very low performance products, exhibiting a high shrinkage rate and low mechanical strength. These characteristics are very detrimental to the packing performance leading to high wear rates and extrusion. Due to its very low quality, unsintered PTFE thread sealing tape filament is not considered in this paper.

6. TEADIT EW White Filaments

EW-series white filaments are produced from pure virgin PTFE resin in combination with highly refined mineral filler particles. The filler is added to enhance the heat transfer and lubricant absorption (and retention) of the packing. Due to the proprietary manufacturing process of EW filaments, the filler particles are completely encapsulated and protected by expanded PTFE.

Figure 5 shows an EW2 filament with the tape unfolded to show the filler.

6.1. EW Valve Testing

This section describes a test protocol that is designed to determine if a specific valve stem packing is acceptable for use in controlling fugitive emissions. The test includes both thermal and mechanical cycling in order to simulate actual field conditions temperature and pressure. Figure 6 shows the Teadit Valve Test Bench.

The Qualification Protocol used is as follows:

Test Media: Nitrogen.

- 500 cycles at Room temperature and 1 MPa (150 psi) pressure.
- 500 cycles at 200º C and 1.5 MPa (225 psi) pressure.
- 500 cycles at Room Temperature and 1.5 MPa (225 psi) pressure.
- 500 cycles at 200º C and 2.0 MPa (300 psi) pressure.
- 500 cycles at Room Temperature and 2.0 MPa (300 psi) pressure.
- 500 cycles at 200º C and 2.5 MPa (375 psi) pressure.
- 500 cycles at Room Temperature and 2.5 MPa (375 psi) pressure.
- 500 cycles at 200º C and 3.0 MPa (450 psi) pressure.

The leak rate was recorded using the Pressure Decay Method[1].

A graphic representation of the test protocol is shown in Figure 7.

The packing tested was Teadit Style 2005 which is a firm, high-density interlock braided packing manufactured from Teadit EW3 expanded filled PTFE filaments. The valve stem was packed with six rings using 6.4mm (1/4 in) square packing coming from a standard spool.

The formula to correlate the mass flow to parts per million in volume (ppmv) per ESA[2] is:

$0.02784(sv^{0.733})$ g/hr, where sv is the concentration in ppmv

Temp. (º C)	No. of Cycles	Leak Rate (ml/min)	Conct. sv (ppmv)
Room	500	0.219	6.36
200	1000	0.093	3.66
Room	1500	0.155	9.41
200	2000	0.042	1.42
Room	2500	0.085	6.36
200	3000	0.034	1.42

The test results are as follows:

The packing produced from the Teadit EW Expanded White PTFE Filament met the required leak rate and number of cycles of the test protocol. The test was extended for 3000 cycles, twice the required minimum, without any decline in performance. The maximum concentration of 9.41 ppmv was significantly less than the current maximum of 500 ppmv allowed by United States Environmental Protection Agency (EPA) regulations.

6.2. Pump Testing

To compare the performance packings braided from Teadit EW2 Filament (Figure 5) and from Skived Multi-Filament (Figure 2) were installed in a Teadit Laboratory Test Bench that simulates the working conditions of a pump. The main performance parameters included leakage, power consumption and number of gland-packing adjustments were monitored in a 100-hour test. A schematic illustration of the Teadit Test Bench is shown Figure 8. The test parameters are shown below.

Parameter		Unit	Value
Shaft	Speed	m/sec	4.3
	Diameter	mm	47
	Finish	µm	0.4
Packing	Cross Section	mm	9.4
	Number of Rings	-	6
Test	Media	-	Water
	Pressure	bar	6
	Duration	hour	100

The leak rates along the shaft and on the stuffing-box side (bore-side) were recorded throughout the test. Both leakage rates should be 6 ml/min or less. If shaft leakage is more than this value, the gland-follower has to be adjusted to reduce the leak rate to 6 ml/min or less. If this value cannot be achieved, the gland-follower has to be adjusted to attain the lowest leak rate that will not overheat the packing. During the test, the range of gland-follower travel limits the number of possible adjustments. Due to dynamic sealing forces, the most important parameter is the leak-rate along the shaft. The average leak rate for each product tested is shown in the table below. A chart showing the leak rates throughout the test is shown in Figure 9.

Leak Rate ml/min	Filament	
	EW	Skived
Shaft Side	0.5	16.8
Stuffing Box Side	0.9	10.2

After achieving initial sealability, the number of gland adjustments and the cumulative gland travel will give an indication of the packing wear. A lower value indicates a longer packing life.

During start-up, the skived multi-filament packing required significant adjustment. After the first operational adjustment to achieve sealability, the maximum possible gland travel was used up. In the field, this condition would require line shutdown and subsequent repacking of the pump. The number of adjustments and cumulative gland travel is shown below.

Fila-ment	Gland Adjustments		
	Test stage	Number	Travel (mm)
EW	Start-up	1	3.4
	Operational	none	none
Skive	Start-up	3	4
	Operational	1	1.1

In comparison, the packing produced from Teadit EW yarn had a total gland travel of 3.4 mm versus 5.1 mm for the skived multi-filament.

Power consumption indicates the level of friction between the packing and the shaft. Lowering the gland pressure can reduce this friction. However, this reduction increases the leak rate. High-performance packings will have low values for friction and leak rate simultaneously.

Filament	EW2	Skived
Power consumption (watts)	700	500

The lower power consumption for the packing made from skived multi-filament yarn is directly related to the higher leak rate. No further adjustments could be made because the maximum travel of the gland-follower had been used-up, as previously indicated.

The test results indicate the superior performance of packings produced from Teadit EW2 in comparison to skived multi-filament yarn. The EW2 packing exhibited very low shaft and bore-side leak rates with no operational gland adjustment. Conversely, the skived multi-filament yarn packing showed a higher leakage rate, which necessitated significant gland adjustments (travel) during start-up. As a result, the packing made from skived multi-filament yarn was unable to provide adequate leakage control for the duration of the test. It must be noted; due to the skived yarn's inherent hardness, this packing was difficult to handle during start-up. Two tests were aborted because it was not possible to attain an acceptable leak rate.

Thermal Conductivity is considered an important parameter to evaluate filaments for packing applications. A higher value of this property indicates that the packing will have a better dissipation of the heat energy generated by the friction between the packing and the shaft. Figure 10 shows the Thermal Conductivity of packings produced from Teadit EW2 filament and from skived multi-filament.

7. Conclusions

The tests are clearly indicating that packings produced from Teadit EW expanded, filled PTFE filaments show superior sealing charac-teristics compared with those made from skived multi filament yarns

8. References

[1] Derene, M.; Payne, J. R.; Bazegui, A.; Marchand, L. – "PVRC/MTI Technology for Characterizing Gaskets Used in Bolted Flanged Connections" – Gaskets and Gasketed Joints, Part II, John H. Bickford – Marcel Dekker, Inc. New York 1998.

[2] ESA – Guidelines for safe seal usage – Flanges and Gaskets – ESA/FSA Publication N° 009/98.

Advanced PTFE Compression Packing Filaments

Figure 1

Figure 2

Figure 3

Figure 4

Advanced PTFE Compression Packing Filaments

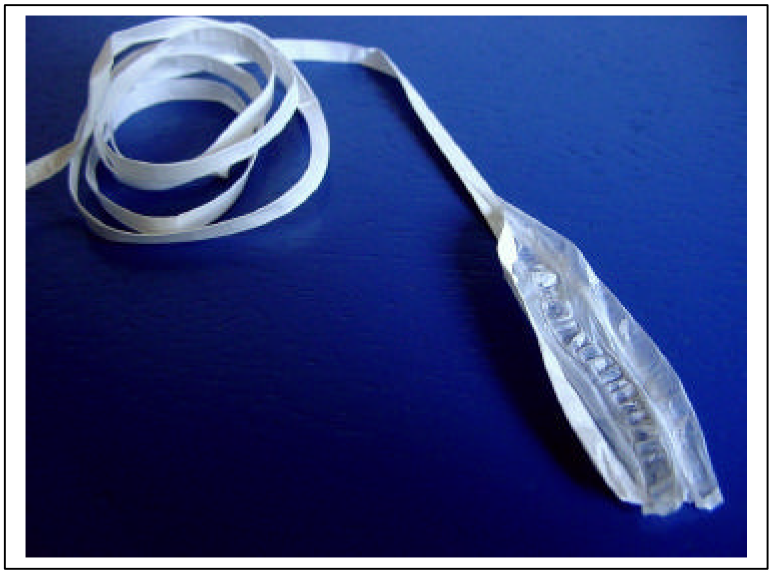

Figure 5

Figure 6

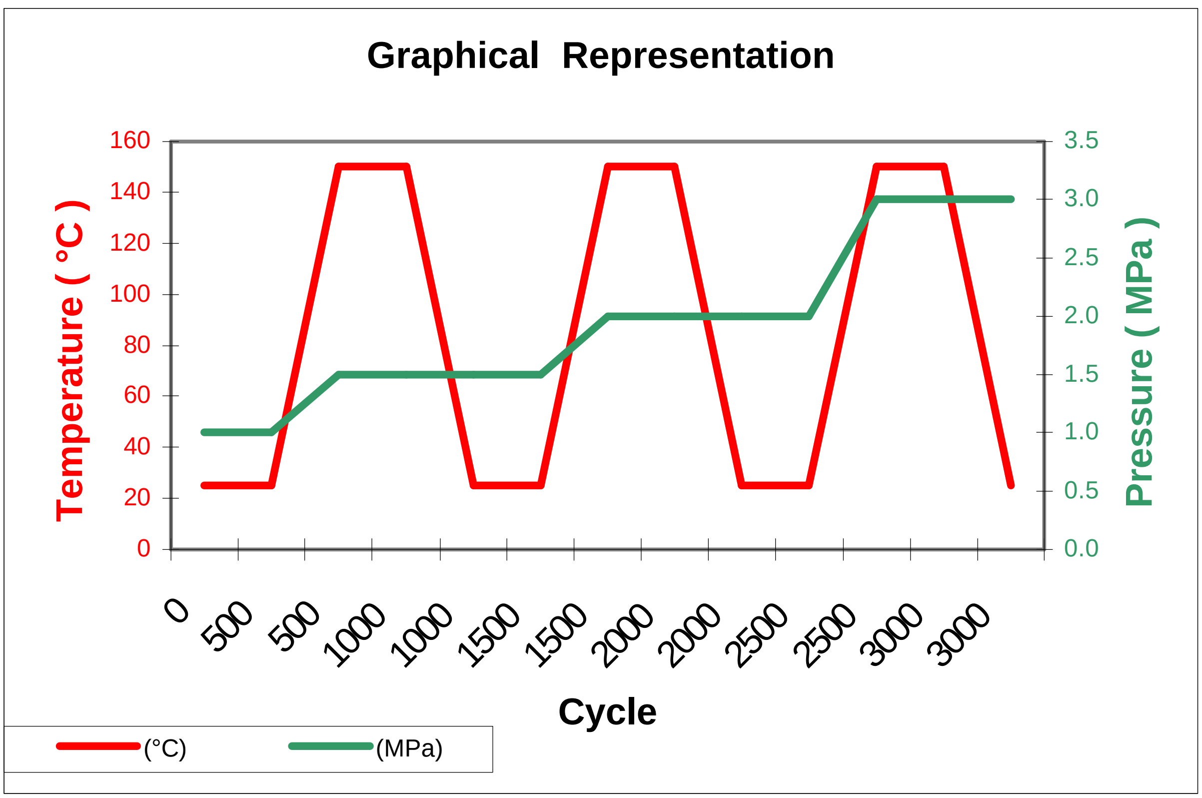

Figure 7

Advanced PTFE Compression Packing Filaments

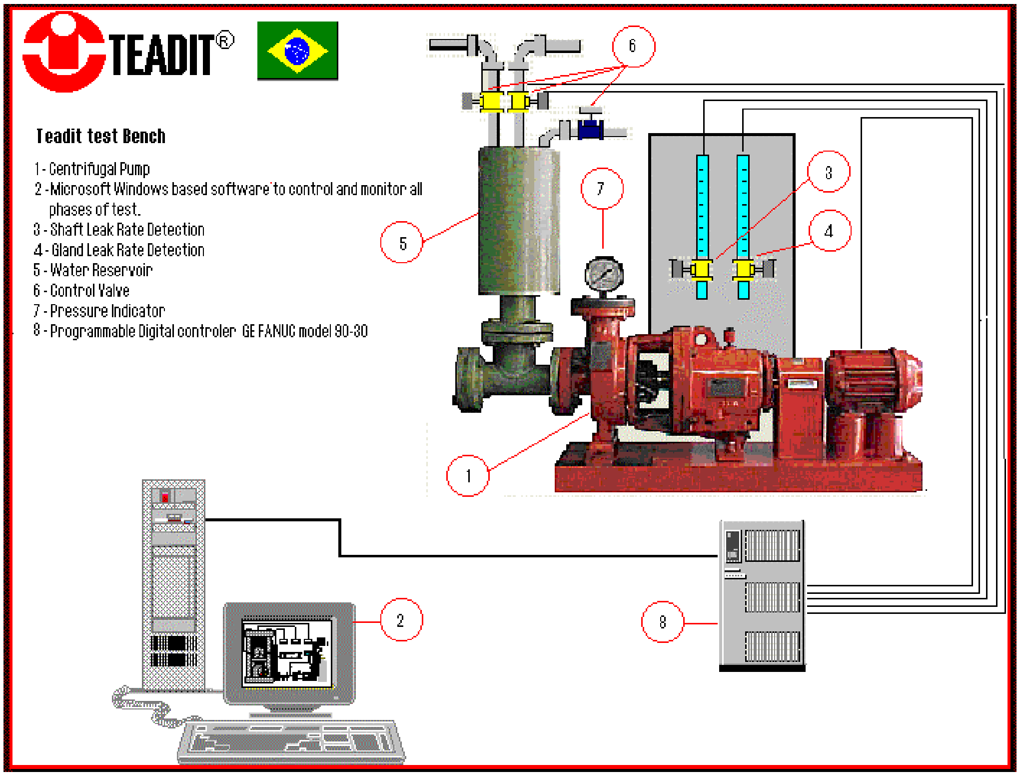

Figure 8

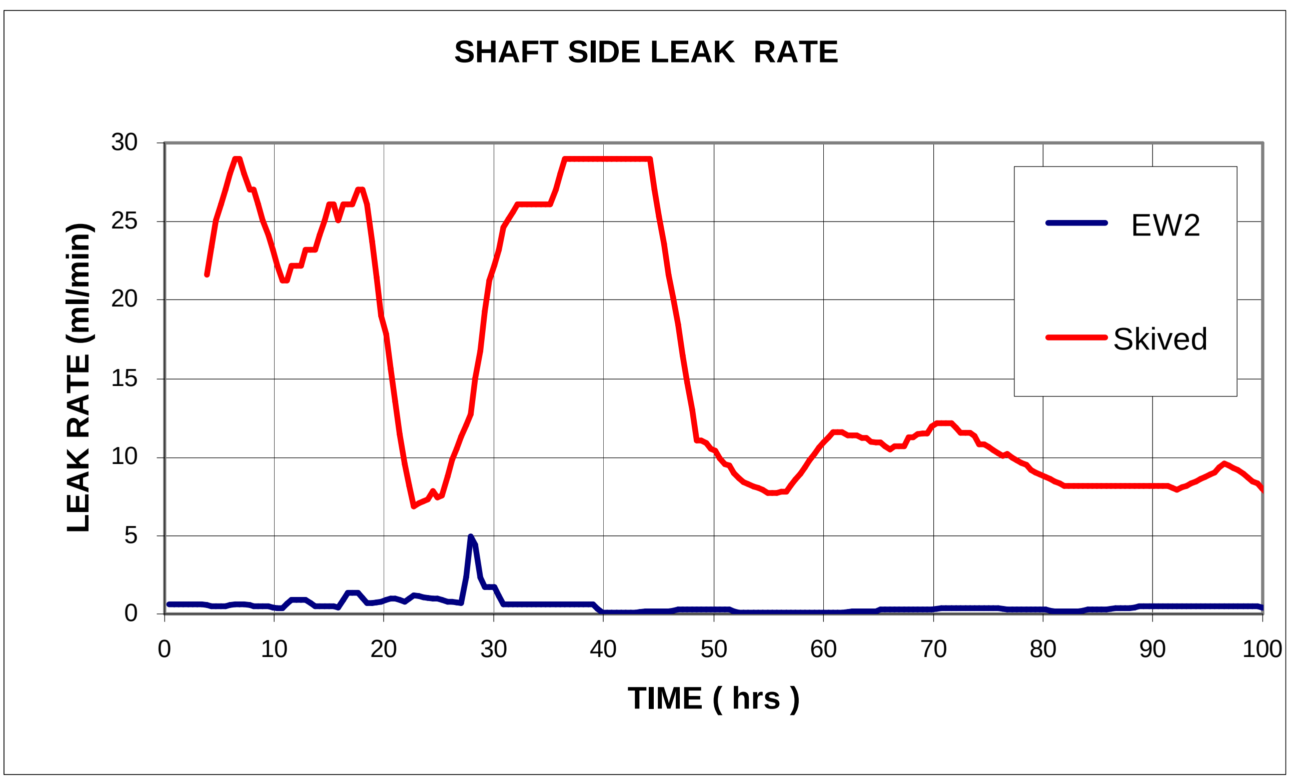

Figure 9

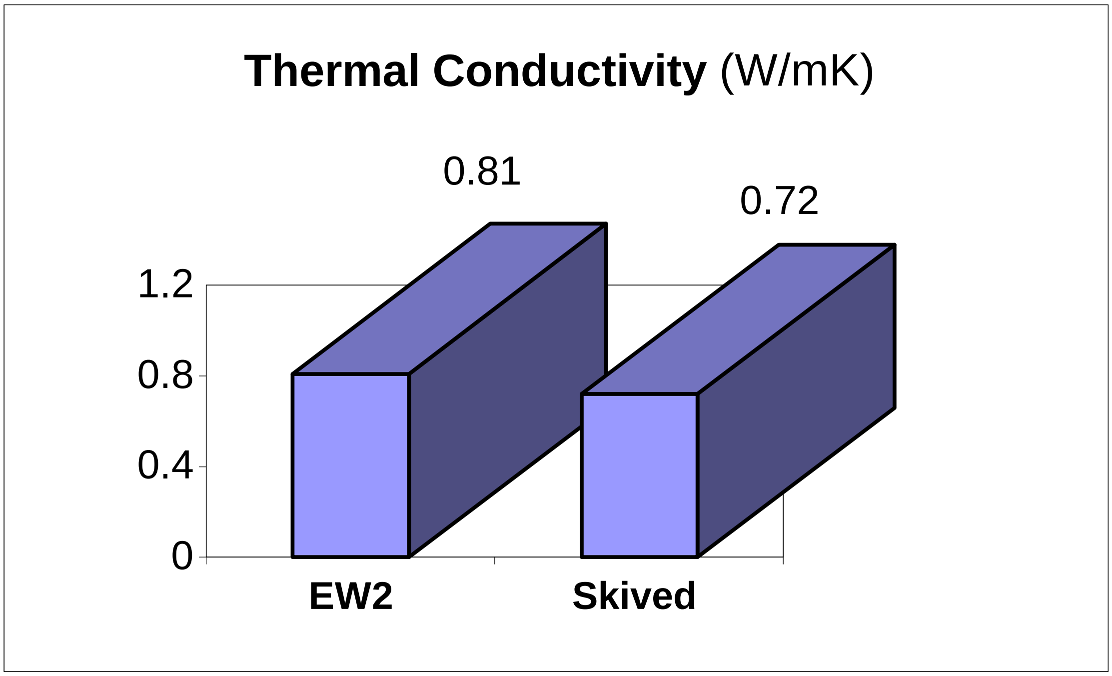

Figure 10