GLAND PACKING FOR ROTARY SHAFTS

by

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In this article a brief description of the problem of obtaining suitable packing materials for rotary shafts is given, together with a description of the materials in general use. In general these materials are made up into proprietary brands of packing and but little basic data is available as to their relative merits. It is anticipated that it will be possible to devise tests to grade packings as against the personal tastes of the manufacturers of machinery, and it is hoped that this article will assist the user in realizing the problem of obtaining correct packing of glands.

In recent years a considerable number of designs of mechanical seals have also come into use for sealing rotary shafts. The employment of these is severely restricted in naval machinery by the fact that they require to be threaded along the shaft and cannot therefore be used where the shaft has a solid coupling. Their use may well, however, extend and a separate article on them will be required when they are in more general use.

Operating Conditions

No packing will be really effective and have long life unless the following conditions exist :—

(i) Absence from vibration.

(ii) Absence of shaft deflection—resulting from poor hydraulic or mechanical design, bearings out of alignment or excessive movement of the shaft in oil film lubricated bearings.

(iii) The shaft or shaft sleeve surfaces must be smooth and truly circular.

(iv) The packing must be kept cool—either by leakage along the shaft, transmission of heat through the packing to the outside of the stuffing box, or both. If the liquid to be sealed tends to evaporate on reduction to atmospheric pressure quenching arrangements must be fitted.

(v) Gland, neck bush or lantern ring clearances must be sufficiently close to prevent the packing from extruding along the shaft.

(vi) The radial faces of the gland, neck bush and lantern ring should be at right angles to the shaft to prevent the packing being closed on to or forced away from the shaft.

(vii) The packing must be properly fitted.

Choice of Packing Material

Choice of material depends upon the nature, pressure and temperature of the fluid to be sealed. It also depends on the materials used for the shaft and parts of the stuffing box assembly.

In general the material must have the following properties :—

(i) Ability to withstand local temperature conditions due to both the initial temperature of the liquid and the temperature rise due to friction.

This covers charring, melting, plastic flow and excessive expansion, all of which are undesirable.

(ii) Ability to withstand pressure conditions, due to the liquid pressure which may be concentrated on one ring of packing, or to the pressure resulting from tightening of the gland.

This covers crushing and extrusion of the packing which are again undesirable.

(iii) Ability to withstand abrasion, erosion, solvent action and chemical or electrolytic effects of the liquid.

(iv) In addition the material must be resilient and capable of being moulded into rings without buckling.

These requirements are seldom met by one material alone and in practice a combination of materials is used.

The range of material suitable for packing is not very great ; the most common are asbestos, cotton, flax, hemp, lead and lead alloys, copper, aluminium, rubber and certain plastics, which may be made up with various lubricants and in various ways. Each combination or type has distinctive properties which make it suitable for a particular service. A broad indication of types of packing and the service for which they are suitable is given in Fig. 1.

PROPERTIES OF PACKING MATERIALS

Asbestos is capable of withstanding high temperature conditions, is resistant to most forms of chemical attack, and is not subject to electrolytic action. It has the disadvantage of a very abrasive surface, which, if not protected by a lubricant, such as graphite, or by white metal wire inserts, can cause serious shaft wear. A further disadvantage lies in the heat insulating properties of asbestos. This can be overcome to some extent by the use of metal inserts or by making the packing porous. The main type of asbestos used for packing is chrysotile or white asbestos which possesses a white silky and very flexible fibre. The length of fibre varies from $\frac{1}{8}$ in to 5 in, with a diameter of about 1/500,000 inch (about 1/100th of the diameter of a cotton fibre). Crocidolite or blue asbestos is also used, but to a lesser extent. This type is more abrasive than the white and generally has a shorter fibre. It will, however, withstand greater heat and is more chemically resistant. The grade and length of fibre used for packing depends on the method of construction, braided packing being made from long-fibred asbestos. Short-fibred asbestos is unsuitable for braiding and is usually contained within a metal or plastic binder. A percentage of cotton is always included with asbestos in order to assist in spinning a thread. Cheaper grades have a higher percentage of cotton.

Asbestos may be braided, plaited or formed into moulded rings. Long-fibred Italian chrysotile is preferred for most applications.

Cotton tends to decompose in a wet state, is not capable of standing up to high temperatures and has poor thermal conductivity. Consequently the surface of the packing in contact with the shaft is liable to overheat and char with little external evidence.

The charred cotton surface causes serious shaft wear. Cotton does, however, possess good resilient properties, is not subject to electrolytic action and is capable of being easily formed into braided or plaited rings. Long-fibred staple cotton is preferred.

Flax is similar to cotton but does not decompose when wet and is capable of withstanding a higher temperature. As with cotton, overheating chars the surface causing serious shaft wear.

Hemp is similar to flax though of a coarser nature, but is cheaper.

Service	Working Pressure lb/in.	Working Temperature ° Fah.	Type of Packing suitable
Boiler feed	Up to 800	Up to 250	Braided asbestos, graphite lubricant.
Hot fresh water ... Hot salt water ... Hot brine	Up to 400	Up to 180	Moulded asbestos, graphite lubricant. Braided asbestos with W/M or other wire inclusion. Graphite lubricated. Flexible metallic with asbestos core. Flexible metallic.
Cold fresh water ... Cold salt water ...	Up to 250	Up to 120	Braided asbestos, graphite lubricated. Braided flax. Braided asbestos with W/M inclusion. Braided flax with W/M inclusion. Grease packing.
High pressure air ... High pressure carbon dioxide.	600 to 4,000	—	Whitemetal.
Low and medium pressure. Air, freon gas ... Ethyl chloride ...	Up to 200 Up to 175 Up to 150	—	Mechanical seal.
Fuel oil ... ... Lubricating oil ... Diesel oil	Up to 400 Up to 100 Up to 100	—	Braided flax, graphite lubricant. Braided flax, graphite or W/M inclusion. Mechanical seal.
Gasoline	Up to 100	—	Asbestos with special grease lubricant.
Stern tube	—	—	Braided flax with tallow lubricant.

FIG. 1.

Lead. Lead or whitemetal possesses good bearing qualities but lacks the resilient quality of non-metallic packing with which it is often combined. Flexibility is obtained by forming the packing from foil. Lead foil without a soft core is unsuitable for fluctuating temperature conditions owing to expansion and contraction which it is too inflexible to accommodate. Its temperature resistant properties are superior to cotton, flax, etc., but inferior to asbestos. Thermal conductivity is better than other packing materials. Electrolytic and chemical action is possible.

Metal faced blocks are commonly used for high pressure applications. Considerable accuracy of alignment and fitting is, however, required for satisfactory operation of this type of packing.

Plastics. Plastics are not at present in general use, except in oil refineries where nylon, polythene and similar materials are used in contact with by-products.

Certain plastics have a tendency to swell in contact with water.

Rubber. Rubber is used extensively as a binder for fabric, graphite and other loose elements, also as a core. Temperature and oil resistant synthetic rubbers are under development.

Grease. Although not strictly a packing material, it is worth noting that grease packing is being used to an increasing extent on low pressure and temperature applications.

In this case a wide lantern ring is fitted between two header turns of soft packing. The intervening space is filled with a special quality of very stiff grease which forms the sealing medium and is forced in with a plunger type lubricator. Then header turns are fitted to prevent loss of grease.

LUBRICANTS FOR PACKING

A lubricant is introduced into packing to assist in manufacture and to reduce friction under running conditions. Graphite, grease, mica, oil and tallow, or a combination of lubricants may be used. The pumped liquid itself is usually employed, except where it is undesirable for it to leak out of the gland. In this case, sealing liquid is forced in at a point along the gland at sufficient pressure to prevent the pumped liquid leaking to the outside. A most important function of liquid lubricant is that of quenching or cooling the gland. For this reason it is best to have a slight leakage along the shaft, particularly in the case of asbestos packing where it is difficult to remove heat from the rubbing surface owing to its insulating properties.

Graphite. Graphite is used with grease or tallow in the majority of soft and flexible metallic packings. For good results it is essential that colloidal graphite be used. In some cases there is evidence that electrolytic action results, particularly when graphited packing is used in conjunction with stainless steels.

Grease. Mineral grease may be used for soft and flexible metallic packings. After some time in service the grease works out. Its use is precluded in feed-water service where contamination of the feed-water would result.

Mica. Mica talc is used as an alternative to graphite where there are objections to the use of the latter. It is not as good a lubricant as graphite but does not encourage electrolytic action.

Oil. Heavy mineral oil is preferred to grease and is used in most soft and flexible metallic packing, either by itself or as a binder for graphite or mica.

Tallow. Tallow is used in place of grease in some forms of soft packing It is very liable to melt and run out if the temperature rises.

CONSTRUCTION OF PACKING

The properties of a packing are closely connected with the method used in its construction. The most usual types of construction are die formed, woven, woven with metallic inclusions, rolled and solid.

The smallest possible cross-section consistent with strength and resilience is preferred in order to allow heat flow through the packing and to reduce the tendency for buckling at the inner surface.

Die Formed. Rings are formed in metal foil, asbestos or rubber under compression, to the correct shape and dimensions for fitting. Lubricant is included before or during manufacture. Rings made in this way are rigid and suitable for high pressure applications.

Woven. The majority of packings are made up by plaiting or braiding. Asbestos, cotton, flax and hemp are particularly suited to this form of construction.

Woven packing possesses great flexibility and may be readily formed into rings. The degree of rigidity depends on the number of strands made up into a packing section and the use of inserts, cores, etc. The surface of a braided or plaited packing has good friction reducing qualities due to wedge effect of the liquid which is retained at the rubbing surface.

Inclusions or wire of white metal, lead, aluminium or monel metal are made up in some forms of woven packing. Their use improves the wearing quality, increases rigidity and improves conduction of heat through the packing. The danger of an abrasive surface occurring as the lubricating medium works out is lessened. The choice of metal depends on the operating temperature, and the nature of the liquid to be sealed.

Rolled. Asbestos, cotton, flax and hemp fabric may be rolled with or without a core to form a packing ring. The whole is bonded with rubber or similar plastic compound, or may be protected and held together by an outer wrapping. Packing made in this way has a smooth outer surface and is rigid. A wide variety of cross-sections can be achieved. Packing of this type is especially suitable for big and medium pressures in reciprocating service.

Solid. Solid metal rings of wedge or lip section are closely machined to size. Whitemetal is commonly used at the wearing surface. Solid plastic packing rings may also be moulded. Various ingenious means have been used to take up wear and keep solid packing in contact with the shaft, but there is in general insufficient flexibility, and wear on a rotary shaft is concentrated in narrow bands. Reciprocating shafts working under high pressure are frequently packed with solid packing.

FITTING THE PACKING

Die formed packing made to correct size is easier to fit and more effective in service. If rings are made up from lengths, care must be taken to avoid buckling at the inner surface and to butt the two ends correctly. The ends of soft metal and metal foil packing should be cut to form a diagonal joint at 45°. Hard packing is butt jointed with a gap to allow for expansion.

A combination of alternate hard and soft packing is sometimes used for fairly high pressure applications to combine the resilient properties of soft packing with the good high pressure sealing qualities of hard packing. The higher the pressure the fewer the number of soft rings required. A plaited fabric ring is sometimes placed next to the gland bush to wipe back gritty water. Combinations of this sort have a greater safe compression range than is achieved by packing with one type of ring alone.

It is important that no ring of packing is compressed so that the ring extrudes or is pressed tightly on to the shaft and cuts off leakage. Some leakage along the shaft is essential to lubricate and cool the packing.

The rings should be loaded so that the initial starting up pressure (usually the highest pressure experienced) can be met.

If the rings are insufficiently compressed, however, pump pressure will work behind them and force the packing on to the shaft. Leakage in this case occurs between the packing and the stuffing box wall.

There is therefore a range of compression for each set of packing within which the packing will work satisfactorily.

Above the upper limit, leakage will be cut off and the packing run hot.

Below the lower limit, leakage will occur around the packing which may be forced on to the shaft, again causing the packing to run hot. Easing off the packing in this latter case will have no good effect.