7.3. New sealing and fire-proof materials for power enterprises

7.3.6. Hermetic shafts of centrifugal pumps

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For sealing the pump shafts the CJSC "Unikhimtek" produces the sealing elements in the form of rings (KGN — low-density rings from material "Graphlex") and woven gaskets (NGF — woven gaskets from "Graphlex" material). These sealing rings are produced of several types: twisted (KGN-V) and laminated (KGN-SO, KGN-SOP).

The twisted rings are made by means of spiral winding of graphite ribbon with the sequent cold pressing in press-mold up to a certain density. As a result of such pressing, the foil layers are deformed as a flute in axial direction and are connected strongly between themselves providing the tightness. The density of rings pressing is determined by parameters and conditions of sequent operation. Usually for pumps P = 0.9...1.25 g/cm^3. As a rule, the density is increased with the growth of pressed medium parameters. These rings have the high lateral pressure coefficient ($K_б$ = 0.7...0.85). Therefore, they are used for providing the tightness with the small values of axial pressure.

The sandwiched rings consist of alternate horizontal layers of graphite foil cut off from plate (perpendicularly to the ring axis). The rings KGN-SO are made by means of bedding and splicing of layers between themselves. The rings KGN-SOP are made from graphite foil with alternate placement of each layer and the sequent cold prepressing. These rings have the high thermal conductivity in radial direction X > 120 W/(m·K) and the low lateral pressure coefficient ($K_б$ = 0.1...0.15). Therefore, they are used for heat removal and as throttling ones. Due to the small value of $K_б$, these rings even with the strong reduction render the minimal effect on shaft. As a result the very small slot is kept between shaft and ring during reduction. Here there is the throttling of medium flow that provides more favorable conditions for working of other rings. Therefore, these rings are the most optimal as end-capping. The conditions of sealing rings application and the rules for complete sets of sealing rings are presented in details in [4].

The woven sealing gaskets are made in the form of cord, mainly, with square cross-section and through, multiple-row, diagonal braiding. The filament for braiding is obtained by means of twisting the ribbon from graphite foil. In order to give strength to braided gasket at the stage of foil production, it is reinforced by filaments from different materials (cotton filament, glass fiber and other reinforcing materials). The braded gaskets are used for widening the properties of packing material in combination with other materials, in particular, with the reinforced polytetrafluroethylene, high strength fiber "Kevlar" (CBM). For increasing the sealing properties of braided filling as well as for decreasing their friction factor and corrosiveness, the impregnation by special compositions and lubricants is used.

The variety of technology for manufacturing the sealing products from "Graphlex" material allows assembling the complete sets of packing with prescribed consumer properties for the concrete operating conditions. Some main types of pressing and the optimal conditions of their application are presented in table 7.5.

The accuracy of installation and preparation of sealing products before their putting in the sealing joint has the considerable meaning together with the choice of seal type.

A large number of existing constructions of packing boxes of centrifugal pumps is fulfilled with bevels on the end side of gland chamber and in the closing sleeve. Under action of such bevel the end sealing elements feel the additional effort (p_{rad}), pressing them to the shaft sleeve (Fig. 7.20). As a result, the radial effort of end (first and last) sealing elements on the protective shaft sleeve is increased. Their wear is increased in much more degree and there is not only the wear of sealing material ,but as well of protective shaft sleeve. The operating practice showed the existence of typical zones of shaft sleeve wear in the area of location of these rings. As a result, the necessity of repair or substitution of protective sleeve will appear already in half a year or in a year, as well as the failure and leakages are possible. It is especially dangerous with pumping the toxic and ecologically hazard substances.

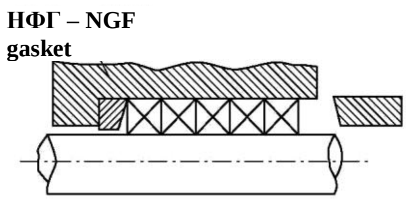

Fig. 7.20. Gland joint of existing centrifugal pumps of old construction.

As a rule, the depth of gland chamber was set for the large number of rings (6…12 pieces) that predominated the creation of large axial thrust with gland reduction, resulted in the growth of nonuniformity in radial direction and quick were of end sealing elements. For the joint of gland sealing of pump shaft, the construction of which will be developed for the target application of complete sets of seals from TEG "Graphlex", we recommend the changes presented in fig. 7.21.

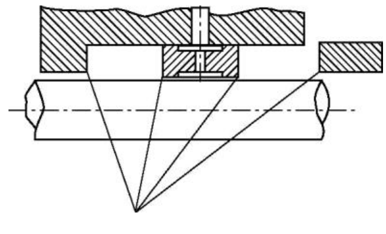

Fig. 7.21. Gland joint of existing centrifugal pumps of new construction

Table 7.5. **Range and application fields of seals «Graphlex» for pumping equipment**

Name	Working medium	Medium temperature T, °C	Medium pressure p, MPa	Allowable slip velocity υ, m/s
Sealing gland rings KGN-G-V and KGN-G-S Flanged gaskets on the steel base POGF Reinforced flanged gaskets PAGF Spiral wrapped gaskets (SNP) Unreinforced flanged gaskets PGF	Petrochemicals, water, steam, gas, acids, alkali	From –196 to +450 From –196 до +600 From –196 до +450 From –196 до +600 From –196 до +450	3.0* 40.0 20.0 20.0 40.0	25 - - - -
Woven sealing fillings made of TEG and reinforced hardened by fiber: «Graphlex» N 1100 — with cotton fiber «Graphlex» N 1200 — with glass fabric	The same	+150 +560	3.0*	25 20
Fillings woven from high-strength fibers: «Graphlex» H 5001 — aramid filament with impregnation «Graphlex» H 6503 — high-temperature carbon fabric with impregnation «Graphlex» H 6401 — low-temperature carbon fabric impregnated by fluoroplastic suspension	Steam, water, petrochemicals, media containing the mechanical impurities	+260 +400 +300	3.0*	15 15 20
Gaskets woven from PTFE: «Graphlex» H 3000 — from PTFE fabric; «Graphlex» H 4001 GORE GFO — from graphite-filled fabric PTFE	Gases, water, steam, solutions of acids, alkali, salts, petrochemicals	+260 +260	3.0*	10 25
Gaskets woven from the combination of TEG, PTFE and high-strength fabrics: «Graphlex» НУ 1240 — from graphite filament reinforced by glass filament, with angle braiding from graphite-packed PTFE «Graphlex» НУ 4051 — from fibers of graphite-packed PTFE with angle braiding from aramid fiber impregnated by fluoroplastic suspension	Steam, water, petrochemicals, gases, media containing the mechanical impurities	+260 +260	3.0*	20 18
Sealing rings, bush from composite «Tegrax» (polytetrafluroethylene with flexible graphite «Graphlex» and zirconium concentrate)	—	From –60 to +250	3.0*	15

*Medium pressure on gland

The end surfaces of closing sleeve and intermediate lantern ring are fulfilled perpendicularly to the shaft axis, without cants that allows providing the more uniform distribution of radial pressure on the shaft along the length of gland. The operating experience and the results of benchmark test showed that if the packing is installed without preliminary preparation, the high temperatures could appear in the moment of startup in the gland joint. These temperatures could result in the excessive heating of gland joint and the possible loss of seal. It is connected with the fact that when the packing of square cross-section is curved in the ring, the cross-section of packing adopts the form of trapezium. As shown in fig. 7.22, when the packing is pressed in gland chamber, the effect of pressing force concerns, first of all, the gasket layer, adjoining to shaft. As a result, the effect on shaft is increased and it can activate the excessive heating of gland joint and the loss of seal.

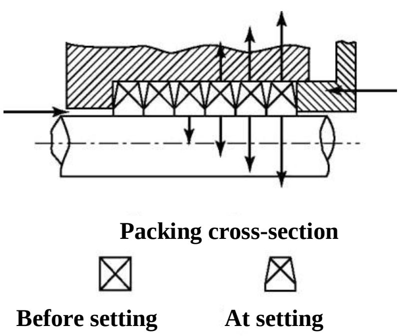

Fig 7.22. The changes of packing cross-section and pressure on shaft with packing bend

The results of parameters variation in gland joint during startup process are presented in fig. 7.23.

The analysis of these data shows that after startup, on the stage of running-in, which takes about 30 minutes, there is a reduction of leakage flow because of swelling of packing and its heating due to additional temperature effect on shaft (as seen from fig. 7.23, temperature achieved 120^0 at the first stage of startup during the first minutes). The appearance of a “steaming” effect is possible under influence of these factors and could result in the sharp reduction of leakage, the overheating of joint and its loss of sealing.

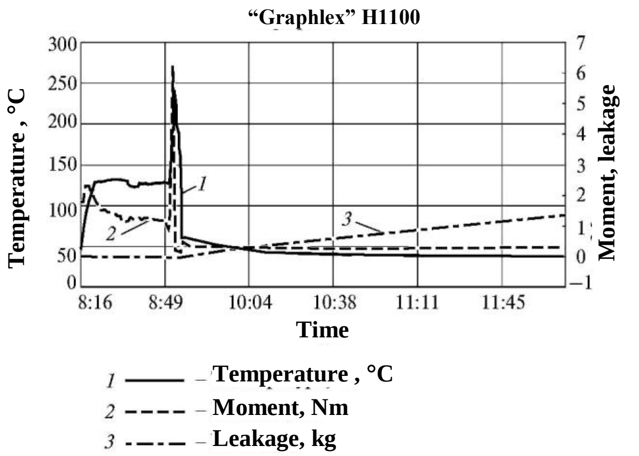

Fig. 7.23. Variations of packing temperature, leakage flow and applied shaft moment at the startup of pump with initially not prepressed packing:

Ring no.1 was installed and pressed by bottom box by 1/3*h* (2.7— 2.8 mm). The ring no.2 was installed; two rings were swaged approximately by 2.7—2.8 mm. The final clearance in bottom box is 2.1 mm

For removing the negative effect of excessive load on shaft, appearing due to the woven pressing, the experimental investigations on development of preliminary preparation of packing for mounting, were carried out. For that the blank for ring was put in the special press mold and the previous prepressing was fulfilled. The ring cross section has a shape of the regular square, as a result of prepressing. The additional effect on shaft doesn’t appear with installation of such ring in the gland unit. As the experimental investigations showed (fig. 7.24), the sharp growth of temperature in the beginning of startup (the temperature didn’t exceed 50°C, it became practically stable at once at the level of 45°C and was kept then at this level) doesn’t appear in this case as well. The value of leakage was stable and remained at the level V = 0.27 l/h without additional tightening.

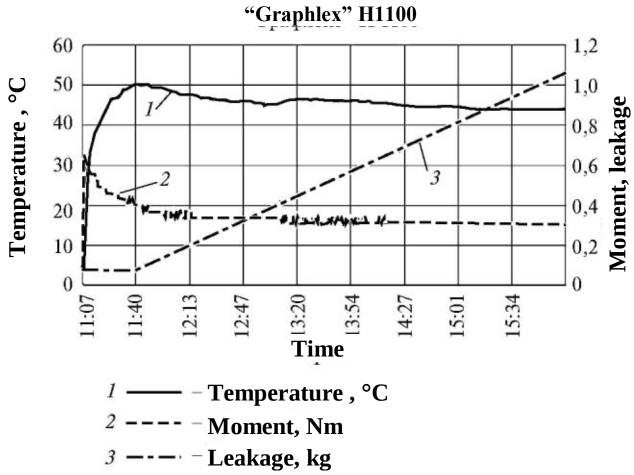

Fig. 7.24. Variations of packing temperature, leakage flow and applied shaft moment at the startup of pump with initially prepressed packing:

Initial clearance in bottom box is 3.6 mm for 50 kg (constant during the whole experiment). The rings 1 and 2 were swaged at piezometer up to 30 % *h*

The obtained results showed that before installation of packing in pumps, it is necessary to carry out its initial prepressing. The optimal packing density after prepressing is ρ = 1.15…1.25 g/cm^3 with initial density equal to ρ = 1.0 g/cm^3 depending on the parameter of the packed medium.