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Leak Resistance of Some Lubricants Used for Petroleum Tubular Threaded Connections

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Abstract

This paper presents the experimental researches regarding the tightness of the conical threaded connection in the case of using thread compound and the dependence between the lubricant leak pressure and thread flank contact pressure. In order to perform the experimental research, the clearance between the flanks of the round thread (conical spatial spiral) was modeled like a plane spiral (Archimedes's spiral).

Key words: *contact pressure, leak, thread compound.*

Introduction

The threaded connections of all types of thread used in the petroleum tubulars manufacturing have to assure at the same time the resistance to the exploitation loads and the adequate tightness requested when the liquid circulates under pressure inside them.

The loss of tightness of the thread connection can be caused by the following:

- inadequate constriction of thread connection;
- the straining or the deterioration of threads coiling due to the load strength that occurs in time of handling, make-up or exploitation works;
- the thread wear;
- the action of corrosive medium inside the well bore or the action of extracted medium.

In the case of threaded connections with round thread the tightness is realized by creating an adequate contact pressure between the connection elements (pin and box) and by using the suitable lubricants.

Therefore, to increase the thread connection tightness, the producers of thread greases have manufactured different lubricants that contains solid compounds (thread compound) which improve the lubrication quality at high contact pressure and obturate the spaces between coiling threads [3,4].

The thread compounds used to grease the thread tubular connections must assure continuously make-up, without seizing, and tightness of the connection in different temperature conditions. These requirements are sensitively influenced by the lubricant characteristics such as: the lubricant base nature and the lubricant solid compounds. The lubricant base nature influences some properties, such as: the tempering or solidification stability, the water absorption stability, etc. The lubricant solid compounds improve the lubrication quality of the lubricant at high contact pressure (eg. graphite powder and copper scalds) and the tightness (eg. zinc powder) [1].

Even the thread compound must satisfy a lot of resistance requirements (penetration value, dew point, evaporation point, etc.), and there is no methodology recognized world-wide for its evaluation from the point of view of tightness assurance [5,7].

This paper presents the results of experimental researches regarding the tightness capacity of the thread compound by determining the dependence between the contact pressure upon make-up of the connection and the pressure when the loss of tightness of the connection occurs (leaking of the lubricant between the coiling space) [2,6].

Research Methodology

In order to study the dependence between the tightness capacity of the lubricant and the contact pressure, the clearance between the coiling round thread (conical spatial spiral) was modeled like a plane spiral (Archimedes's spiral). The plane spiral has 5080 mm length (200 in) and a rectangular cross section having the area equal to that of thread clearance (taking into consideration the form and the maximal tolerances of the dimensions required by the thread standards - fig. 1) [8,9,10].

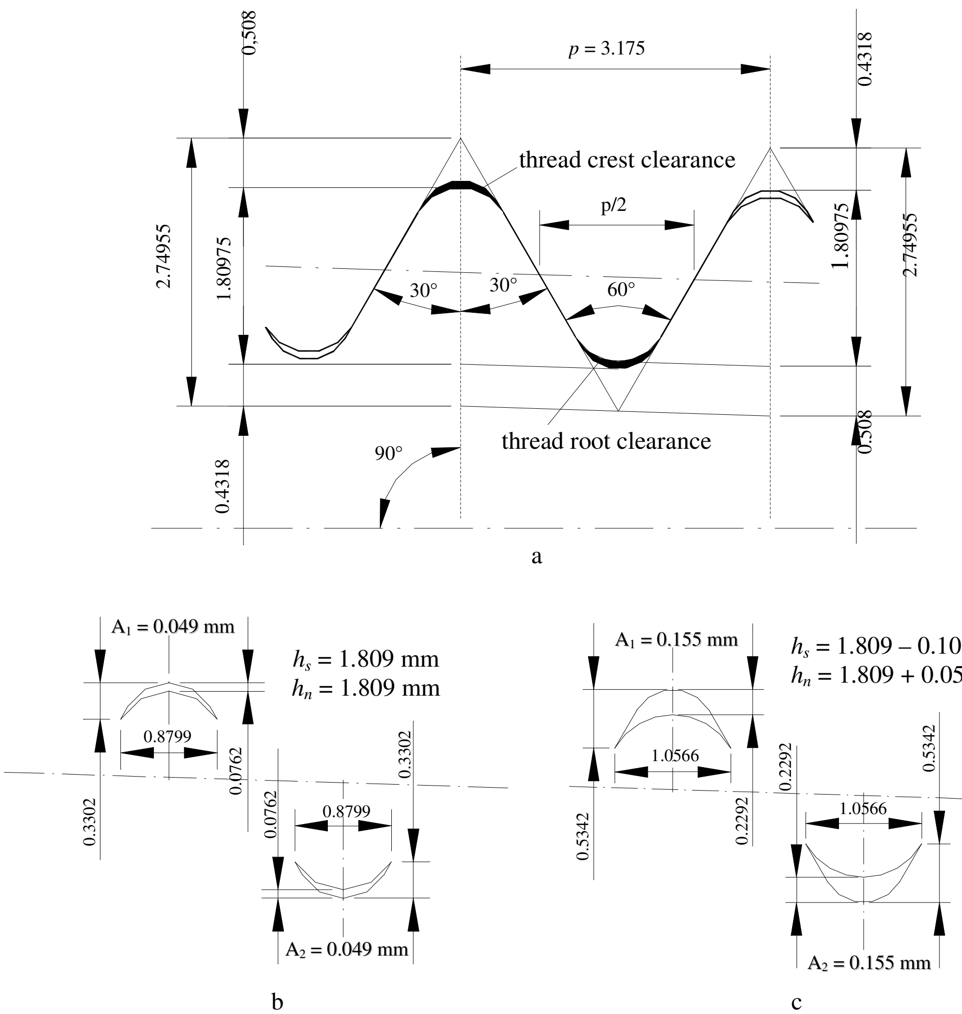

Fig. 1. The clearance form and dimensions of round thread
a) dimension of the round thread; b) thread without deviation; c) thread with maximal admitted deviation

The model was concretized by designing a steel plane plate (engraved plate - fig. 2), which was engraved with plane spirals on the frontal surface. The plate has the cross area section of 0.31 mm^2, equivalent with the sum of the clearance cross areas measured from the root and the crest thread. The conjugate piece necessary to close the clearance was designed like a steel plane disc where the pressure is introduced through its center into the central engraved plate cavity. The contact surfaces of both pieces after cutting processes are planes and have a minimal roughness (0.4 μm) obtained by rectification and grinding processes. Concomitantly, the execution of the spiral channel was performed with high precision, the roughness of its inner surface was 1.6 μm in order not to influence the lubricant movement (flowing) through the channel.

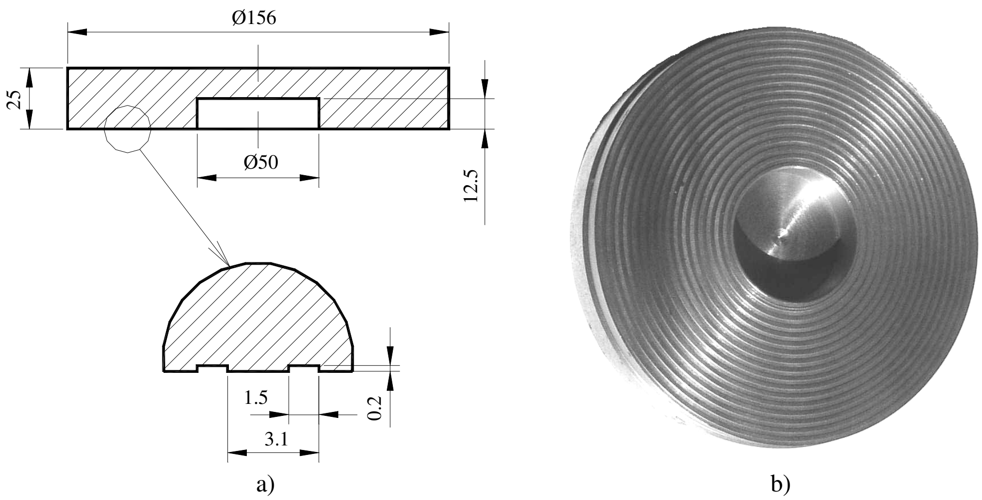

Fig. 2. Engraved plate:
a) engraved plate form and dimensions; b) engraved plate photo

In order to simulate the pressure that occurs in the make-up process on the thread flank, the discs were pressed, at different strengths, by using a hydraulic press that is able to assure maximum loads of 900 kN. Figure 3 shows the schematical representation of the principle of the device designed to characterize the lubricants from the tightness assurance point of view.

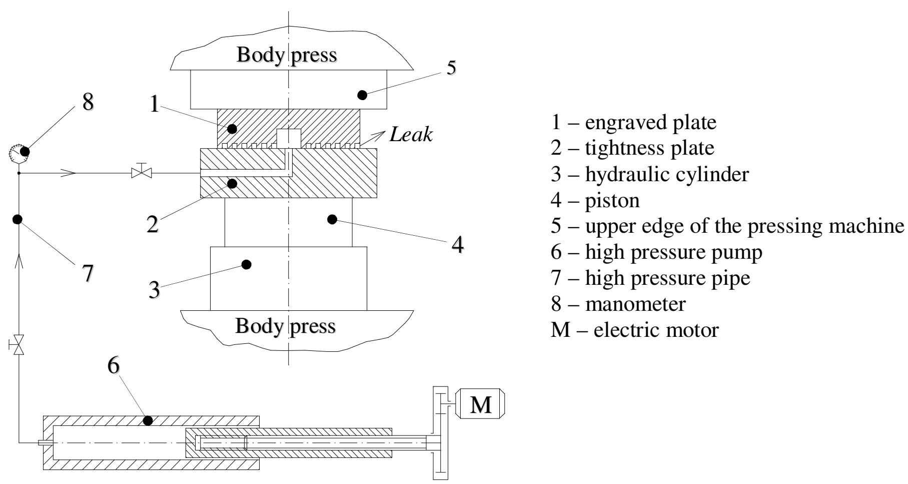

Fig. 3. The schematical representation of the principle of the device used to characterize the lubricants by using the loss tightness at internal pressure test

The testing methodology consists of the following steps. First, the tested lubricant is introduced in the coiling engrave on the plate (1) until the coiling is fully filled with it. Then the engraved plate (1) and the tightness plate (2) are assembled and fixed in the pressure device (hydraulic press), between the piston (4) of the hydraulic cylinder and the upper edge of the hydraulic pressing machine (5). The tightness plate is connected by using the high pressure pipe (7) to the high pressure pump (6). The values of the working pressure are measure using the manometer (8). After the assembly is finished both plates are pressed between the uppers edge of the pressing machine with suitable load.

The inner pressure is obtained by introducing the existent oil from the high pressure pump (6) into the central cavity of engraved plate. The pressure is increased very slowly. The maximum value of the pressure, when the oil is expelled from the engraved coiling, is registered. This pressure corresponds to the load value.

Experimental Results

Four different types of lubricants, used to lubricate the casing threads, were tested by using the research methodology presented above. These are:

- lubricant 1 – based on anhydrate soap of calcium and mineral oil, graphite and zinc powder;
- lubricant 2 – based on anhydrate soap of calcium and mineral oil, graphite (20%) and zinc powder (20%);
- lubricant 3 – silicone lubricant for thread type API, having in composition silicone oil, mineral oil, graphite powder, lead powder, zinc powder and copper scald;
- lubricant 4 –lubricant for thread type API, with polymers.

At the end of the test, we have obtained, for the applied pressing strength, the tightness loss pressures presented in table 1. The contact pressures, resulted by the pressing strength applied on both plates, were determinated by taking into consideration the fact that the contact occurs on a spiral surface with the area: $A_c = 9276\ \text{mm}^2$. Figure 4 presents the variations of lubricant leak pressure with the contact pressures occuring between the engraved plate and the tightness plate.

Table 1. Tightness loss pressure (lubricant leak pressure)

Pressing strength, kN	Contact pressure, N/mm^2	Leak pressure, N/mm^2			
		Lubricant 1	Lubricant 2	Lubricant 3	Lubricant 4
400	43.1	33.2	32.0	19.0	29.0
500	53.9	38.8	37.0	24.3	33.5
600	64.7	42.0	40.3	28.5	37.0
700	75.5	43.8	42.2	32.0	39.8
800	86.2	45.0	43.7	35.0	42.5
900	97.0	45.2	44.0	37.2	44.0

Taking into consideration the evolution of the lubricant leak pressure, from the engraved coiling, it is obviously clear that by increasing the contact pressure between the plates, the lubricant leak pressure increases. The experimental research shows that the value of the leak pressure and its variation with the pressing strength are specific for each type of lubricant. In this way, in the case of using lubricant 1, the leak pressure is higher with 26.51% (at 600 kN) and with 35.54% (at 800 kN) than the expel pressure obtained at 400 kN (332 bar). In the case of using lubricant 2, the leak pressure is higher with 25.94% (at 600 kN) and with 36.56% (at 800 kN) than the leak pressure obtained at 400 kN (320 bar). In the case of using lubricant 3, the leak pressure is higher with 50.00% (at 600 kN) and with 84.21% (at 800 kN) than the leak pressure obtained at 400 kN (190 bar).

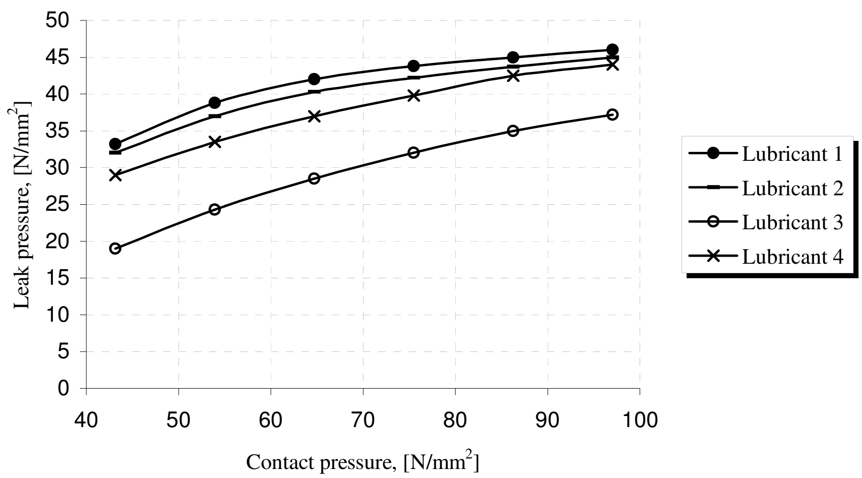

Fig. 4. Variation of tightness loss pressure with the contact pressure occurring between the engraved plate and the tightness plate.

Another important fact, resulting from the experimental research, is that by increasing the contact pressure, the leak pressure remains constant (about 90 N/mm^2 in the case of lubricants 1 and 2).

The leak pressure increase, by increasing the pressing strength, is explained by the contact pressure between the engraved plate and the tightness plate. At small contact pressures the lubricant, under pressure, slowly increases the distance between the two plates, allowing in this way the lubricant expulsion through the coiling space and through the plate's clearance. In the case of using conical thread connections this phenomenon is possible due to the radial movement of the box up to the pin, occuring at the moment when the inner pressure and the lubricant pressure, from the thread clearance, simultaneously act upon the thread connections.

Conclusions

1. The proposed method is able to determine, for a given lubricant and for a given clearance geometry, the maximal pressure value for which the lubricant ensures the tightness at the threaded connection, at an adequate contact pressure occurring between the coiling thread.
2. The presented research methodology allowed to compare different lubricants and to choose the suitable lubricant to ensure maximal performances from the point of view of the tightness of the thread connection.
3. The experimental researches, with the main propose to study the tightness loss pressure, have showed the dependence between the tightness capacity of the thread connection, the contact pressure between the thread flanks and the lubricant nature.
4. If increasing the contact pressure between the thread flanks, the tightness loss pressure is increasing. Above a certain value of the contact pressure, specified for a given lubricant, the tightness loss occurs practically at the same value of the inner pressure.
5. In conditions when the clearance dimensions between the thread are known, the thread connection have to be constricted to ensure in this way a contact pressure, between the thread flanks, that gives the maximal tightness loss pressure.

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Cercetări asupra capacităţii de etanşare a unsorilor consistente pentru filetele burlanelor de tubaj

Rezumat

Articolul de faţă prezintă cercetările efectuate asupra asigurării etanşeităţii unei îmbinări filetate conice de către o unsoare consistentă, precum şi dependenţa presiunii de expulzare a unui lubrifiant de presiunea de contact dintre flancurile filetului. Pentru realizarea cercetărilor s-a modelat interstiţiul dintre flancurile filetului rotund (spirală spaţială conică) sub forma unei spirale plane (spirala lui Arhimede).