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# FLANGED JOINT TIGHTNESS AND FLANGE'S RIGIDITY INFLUENCE

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***Abstract:*** *This paper presents the results of an experimental research about the tightness of flanged joint, equipped with gaskets from marsit. As a consequence of the experimental data processing, the calculation relations of the tightening of the gaskets, depending on the inner pressure and on the gasket dimensions are established. As well, was quantified the influence of circumferential deformation of flanges about the specific pressure on the gasket.*

***Key words:*** *flanged joint, pressure vessel, gasket, tightness, seals.*

## 1. INTRODUCTION

The flanged joint is used in all activities domains, their role being to achieve demountable connection among the constructive elements for different type of equipments.

In the particular case of pressured vessels and pipelines, this demountable assemblage must assure, plus in, and the tightness of equipment from structure whom does the part, because without the assurance tightness isn't feasibly the operation of the vessel to the projected parameters, and the environment pollution and the loss of useful substances can touch important values. Consequently, is can said as the tightness is the property which is due to subordinated whole process of designing of an assemblage with flanges.

The tightness of assemblages with flanges is a factor conducive to insure of working safety for numerous equipments from chemical industry installations and from other activity domains (energy industry, metallurgical industry, food industry etc.).

Taking account of them importance for a good function of installations, these subsets did the numerous object of research themes, and their construction were regulation through normative of projection still of now better of a hundred years. Nevertheless, after some estimation, approximately 25 % from the installations damages from the chemical industry is produced because of flanged joint.

Because a flanged joint is composed from very different constructive elements (flanges, bolts, nuts, gasket), to his projection is due to taken count of the fact as each among these elements conduce to the tightness assurance. Thus, from existing date in the literature result as the element most responsive to the loss tightness is the garniture.

This thing is reflected through the fact as more of 53 % from the possibility of flanged joint damage is owed of the destruction of the gasket as far back as the phase of mounting.

Hence results the importance of correct determination of gasket tightening force, because in this kind can be solved the following essential problems for the tightness assurance:

- the avoiding of garniture destruction because a too big tightening force;
- the avoiding of useful substances leak-off because a too small tightening force;
- the correct determination of bolts exploitation force, the correct design of bolts and the assurance of adequate work conditions for flanged joint.

In numerous articles is studied the tightness of flanged joint below the appearance of leak-off rate of flow, in others is analyzed the necessary force from bolts in the phase of mounting, or the admissible difference of temperature among bolt and flange [1, 2, 3].

In the present work the authors proposed the experimental determination of tightness loss curves for gaskets from marsit, in the case of constant inner pressure, constant initial tightening force and normal temperature of work. Also, is determined the influence of circumferential deformation of flanges about tightness of flanged joint.

## 2. THE LOSS OF TIGHTNESS CURVES DETERMINATIONS

### 2.1. Describe of experimental installation and work procedure

The experimental installation for the testing of gaskets was thus designed that simulate the solicitation of gasket mounted on an assemblage with flanges, with a plane tightness surface. The installation assures a uniform and controlled tightening of gasket, with forces between 4 000 and 40 000 N.

The garniture 1 is compressed between the die 2 and the anvil 3, by dint of piston 4, which glide in the hydraulic cylinder 5 (Fig. 1). The pressured oil delivered of the pump 6 is conducted wit the help of distributor 7, above or below of piston 4, coming down or raising the piston, according as the position A, respectively C, of handles 10.

When the handle 10 is in C position, the hydraulic cylinder 5 is connected with the reservoir 8 and its inner pressure is canceled. In order to determine the value of inner pressure $p_i$, which produce the loss of tight ness for

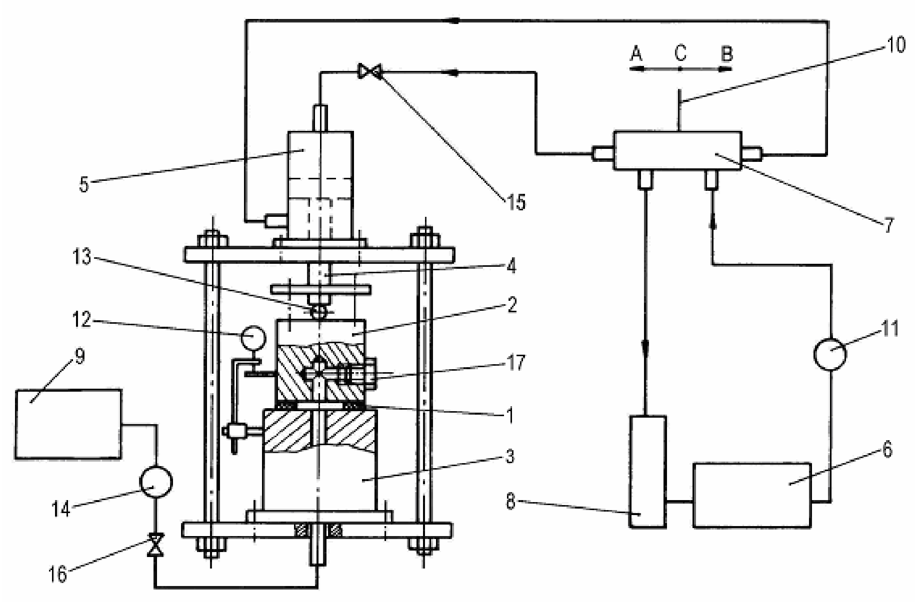


**Fig. 1.** Experimental set-up. a certain value of specific pressure and for a certain type of garniture, between die and anvil is introduced pressured water with help of the pump 9. In the moment of the first drop of liquid apparition is marked the indication of manometer 14.

The massive pieces between which is compressed the gasket eliminate the rotations and deformations of a real flanged joint, what enables to is put in evidences the behavior of gasket oneself, merely from the viewpoint of tightness (Fig. 2). Were tested gaskets with thickness of 1.5 mm, 3 mm and 4 mm, and widths of 5 mm, 10 mm and 20 mm for each thickness of gasket.

After the compression of gasket with a certain force $F$ and the establishment of the specify pressure onto gasket, the inner pressure $p_i$ is gradually increased, recording her value whereat the tightness of flanged joint is compromised, as well as the corresponding specify pressure on the gasket, $q_{dez}$.

## 2.2. Results and discussions

The results obtained are represented in coordinate $q_{dez} - p_i$, on the basis of averages values measured in four attempts executed in same conditions. On this path were determined the so-called tightness loss curves, for gaskets with different width, but with same thickness (Fig. 3).

After experimental researches were obtained the following results:

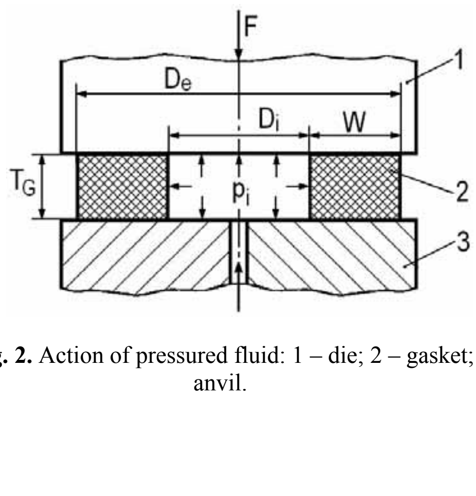


**Fig. 2.** Action of pressured fluid: 1 – die; 2 – gasket; 3 – anvil.

- is put in evidence the influence of gasket's width about tightness: for the same value of specific pressure on gasket, the gaskets with the bigger width assure the tightness to higher values of inner pressure;
- for the same value of the width (to same value of specific pressure on garniture), the garnitures with the bigger thickness have a upper behavior, assuring the tightness to higher inner pressures.

The loss of tightness curves (Fig. 3) can be used for the settlement of specific pressure on gasket $q_{dez}$, videlicet, the necessary compression depending on the inner pressure $p_i$.

Also, can be established relations between two one parameters, which can be used to the calculus of the forces from the flanged joint in the mounting phase.

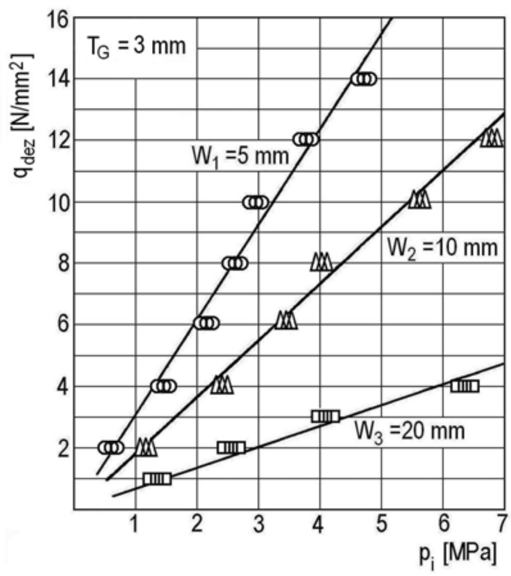


**Fig. 3.** Dependence of specific pressure on garniture vs. internal pressure what cause the loss of tightness, for the gaskets with the thickness of 3 mm.

Thus, in accordance to the experimental results published in the literature [4], for the gaskets with the thickness $T_G$ = 3 mm, were obtained the following relation for the calculus of the specific pressure on gasket, corresponding of the loss of tightness:

$$q_{dez} = \left(10.042 \frac{A_i}{A_e}\right) \cdot p_i \,, \qquad (1)$$

where $A_i$ is the inner area (the cylindrical surface area where acts the inner pressure); $A_e$ - the outer area (the surface area on which is achieved the tightness – Fig. 2):

$$A_i = \pi \cdot D_i \cdot T_G \,, \qquad (2)$$

$$A_e = \frac{\pi}{4}\left(D_e^2 - D_i^2\right). \qquad (3)$$

The minimum specific pressure necessary to mounting were obtained with relation:

$$q_{nec} = C_s \cdot q_{dez} \,, \qquad (4)$$

where $C_s \geq 3$ is the safety coefficient for gasket compression.

Afterwards, applying the relations (1)–(4) for the sizes flat flanges with the tightness surface type PU (according to STAS 9801/4–90), one can see as the value of specific pressure on gasket $q$ = 11 N/mm$^2$, established in PT C4/2 – 2003 [5] is covering until the maxim work pressure of 2.5 MPa (Fig. 4).

This observation confirms the validity relation (1) and recommends its use for the determination of minimum specific pressure on garniture to mounting.

On the other hand, we have to mention taht the relations of calculus presented were deduced with of the help of an experimental installation in which the flanged joint was simulated by means of perfect rigid elements. For this reason, to solve the tightness problem of flanged joint, one must take into account the elastics deformations of flanges.

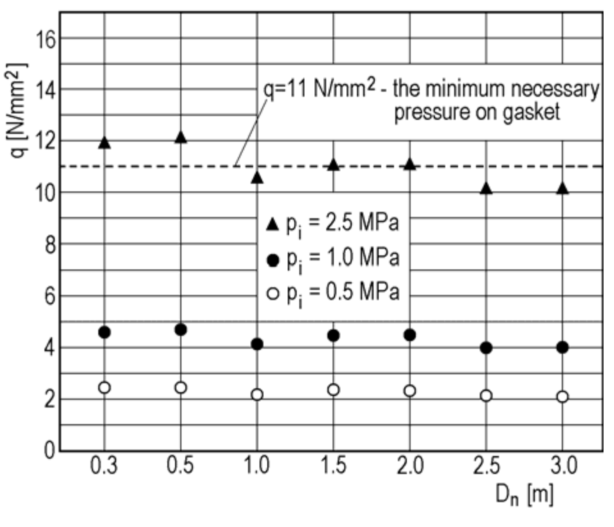


**Fig. 4.** Minim specific pressure on gasket necessary to mounting for flat flanges with the tightness surface type PU, at different values of inner pressure.

## 3. INFLUENCE OF CIRCUMFERENTIAL DEFORMATION ABOUT TIGHTNESS

To the initial tightening of an assemblage with flat flanges, because of the limited rigidity of flanges, their circumferential deformation appears. This deformation reaches a maximum value $\Delta f_{\max}$ at the middle of distance between two bolts (Fig. 5):

$$\Delta f_{\max} = f_{\max} - f_{\min} \,. \qquad (5)$$

Consequently, the initial tightening force are not uniformly distributed along the median circumference of gasket (Fig. 6), and the specific pressure on gasket will be maxim below nut of bolt, $q_{\max}$, and minim at the middle of distance among two bolts, $q_{\min}$. In Fig. 6 the following notations were used: $t$ − distance between bolts; $D$ − medium diameter of gasket.

The value wherewith diminishes the specify pressure on gasket $\Delta q$, because of circumferential deformation of flanges $\Delta f_{\max}$, can be determined with relation [6, 7]:

$$\Delta q = \frac{2 \cdot \Delta f_{\max} \cdot E_G}{T_G} \,, \qquad (6)$$

where: $E_G$ is the elasticity module of gasket's material; $T_G$ – the thickness of gasket.

In the present article, for a number of 26 flat flanges designed according to STAS 9801/4–90, the maxims arrows of flanges on circumference, corresponding of maxims work pressure indicated in this standard were determinate. These calculi were realized for three thickness of gasket (4, 3 and 1.5 mm), which are manufactured from marsit (SR 3498−1:2000).

The results of this research put in evidence the fact that the values of minim specific necessary pressure on gasket obtained with relation (1) must increase approximately, on average, with 10%.

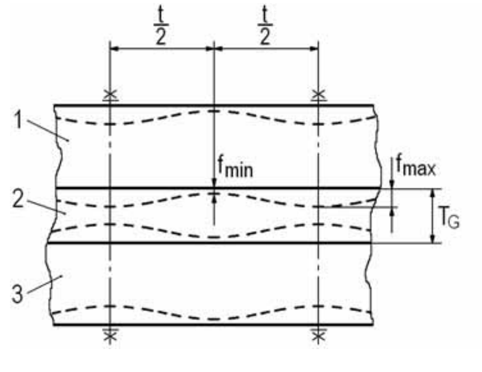


**Fig. 5.** Circumferential deformation of flange: 1- flange; 2- gasket; 3- flange.

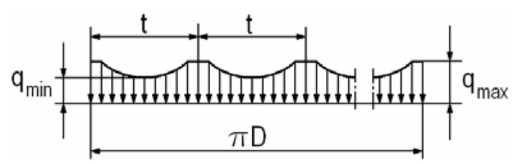


**Fig. 6.** Pressure distribution on gasket after the initial tightening.

## 4. APPLICATION

Considered a flanged joint with the nominal diameter of flanges $D_n$ = 1 000 mm, equipped with a gasket from marsit which have the inner diameter $D_i$ = 1 016 mm, the exterior diameter $D_e$ = 1 059 mm and the thickness $T_G$ = 3 mm. Knowing as the flanged joint must assure the tightness of a pressure vessel with the inner pressure $p_i$ = 2.5 MPa, is asked the determination of tightening minimum specify pressure necessary to mounting. In these conditions is asked to taking into account and of rigidity of flanges, respectively of her circumferential deformations.

The minimum specify pressure on gasket necessary to mounting can be calculated with relation (4), where $C_s$ = 3, and $q_{dez}$ are determined according to relation (1).

Because the inner and the exterior areas of gasket have respectively values, relations (2) and (3):

$$A_i = \pi \cdot 1016 \cdot 3 = 9575.57 \text{ mm}^2,$$

$$A_e = 0.785(1059^2 - 1016^2) = 70077.15 \text{ mm}^2,$$

it results:

$$q_{dez} = \left(10.042 \frac{A_i}{A_e}\right) \cdot p_i = 1.37 \cdot p_i.$$

Therefore, the specify pressure on gasket must have the minimum value:

$$q_{nec} = 3 \times 1.37 \times 2.5 = 10.275 \text{ N/mm}^2,$$

and it takes into account of circumferential deformation of flange:

$$q_{nec} = 11.5 \text{ N/mm}^2.$$

## 5. CONCLUSIONS

The aim of the present article is to establish the influence of geometric parameters of the garnitures from marsit about flanged joint tightness. Also, it is considered the flange circumferential deformation influence on the tightness of flanged joints.

After the experimental researches the following results were obtained:

- for the same value of specific pressure on garniture, the flanges with garnitures with the bigger width assure the tightness to higher values of the internal pressure;
- for the same value of the width (to same value of specific pressure on garniture), the garnitures with the bigger thickness have a upper behavior, assuring the tightness to higher internal pressures;
- on the basis of the tightness loss curves $q_{dez} = f(p_i)$, calculus relations for the minimum specific pressure necessary to mounting were proposed, in the case of the gaskets with different thickness;
- the influence of flanges rigidity on the tightness of flanged joint are revealed.

Finally, it should be noted that the minimum values of the specific pressure on the gasket, which are provided in the norms, should be considered approximate and valid for low pressure. On the other hand, the experimental results of this work demonstrate that the true value of this parameter can be determined only if it is taken into account, apart of the concrete work conditions, and the flanged joint rigidity.

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