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Improved Seals in Pipelines and High-Pressure Hoses

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Abstract—A threaded joint for pipelines and high-pressure hoses is described. The benefits of the new design are outlined. A test prototype is presented.

Keywords: pipeline joints, high-pressure hoses, stepped bushes, sealing lip, connector, nipple, coupling nut

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In hydraulic transmissions, the sealing of joints in high-pressure pipelines and hoses is of great importance. Such transmissions are widely used in machines and machine tools on account of benefits such as compactness [1]. Sealing is also a concern in high-pressure pipelines used in the oil and gas industry.

Today, couplings in high-pressure pipelines and hoses mainly employ metallic seals. We may distinguish between soldered connections and threaded connections (Fig. 1a). In Russia and elsewhere, the most reliable connections are used: threaded couplings with an insertion ring (Fig. 1b). The maximum pressure permitted for couplings with an insertion ring is 60 MPa, according to State Standard GOST 23354–78 [2]. While ensuring high reliability and sealing of the joint, the insertion rings may differ in design, the grade of steel employed, heat treatment, and the type of rolling. That expands the manufacturing options.

In Fig. 1b, we show the design corresponding to State Standard GOST 23354–78. The manufacture of such rings involves machining. However, some designs permit the use of stamping from sheet blanks or strip [3–5]. In Fig. 1b, *A* denotes the sealing zones.

In Fig. 1a, we show different sealing methods.

(1) By means of inserts made of nonferrous (aluminum or copper) alloys (A_1). Such seals are relatively reliable, but call for high pressure in the contact zones *A*. That leads to wear and plastic deformation of the inserts, which must then be replaced.

(2) By means of a cone–cone system (A_2). In this case, the sealing surfaces must be manufactured to high precision, and their roughness must be low.

(3) By means of a sphere–cone system (A_3). This approach is widely used at present. As in system A_1, sealing depends on high pressure, which ensures linear sphere–cone contact. That leads to wear of the contact surfaces, which lose their sealing properties over time.

Among soldered joints, the sphere–cone system A_3 is the best. Pressures no greater than 20 MPa are recommended [2].

The main problem with such seals is their repair. Since hydraulic transmissions in machines and machine tools transmit variable and vibrational loads, as a rule, the couplings must frequently be repaired. However, the coupling of the seal and the pipeline by soldering or insertion rings is practically impossible to reverse. Therefore, special repair equipment is required. That prevents satisfactory repair in operating conditions.

Note also that, in some cases, the constraints on the pressure and the diameter of high-pressure pipe-

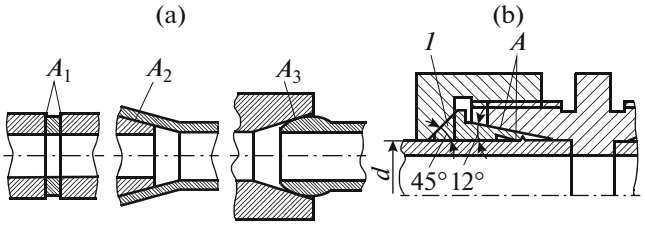

Fig. 1. Soldered joints of different types A_1–A_3 (a) and a coupling with an insertion ring (b). In the latter case, the sealing zone is denoted by *A*.

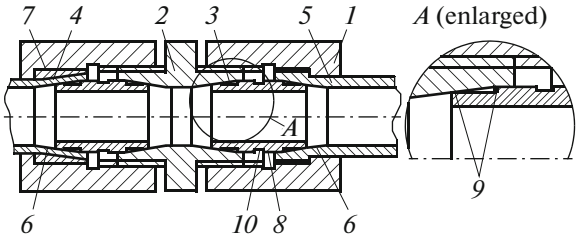

Fig. 2. Coupling seal for pipelines and high-pressure hoses [10]: (*1*) coupling nut; (*2*) connector with internal surfaces *3*; (*4*) pipe; (*5*) nipple; (*6*) conical surfaces of pipe *4* and nipple *5*; (*7*) ring; (*8*) stepped bush with sealing lips *9* and wrench *10*.

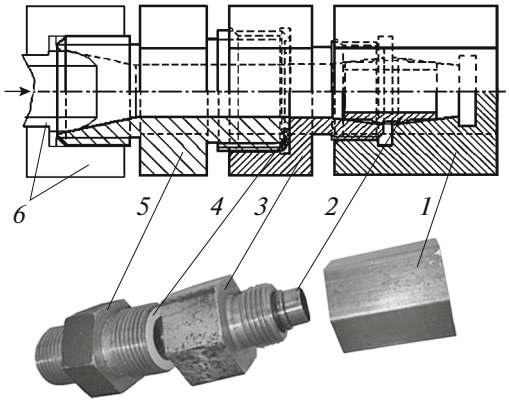

Fig. 3. Prototype seal: (*1*) coupling nut; (*2*) stepped bush; (*3*) connector; (*4*) sealing pad; (*5*) adapter; (*6*) sealing nipple and coupling nut.

lines and hoses prevent the use of the available couplings in oil- and gas-industry equipment [2–8]. For example, the diameter of the apertures in fountain valves must be within the range 50–150 mm, while the pressure must be 7–105 MPa [9].

In view of these problems, a fundamentally new coupling seal for pipelines and high-pressure hoses has been developed and patented [10]. It is shown in Fig. 2.

The basic element of the seal is a stepped bush *8*, which permits reliable sealing of joints in pipelines and high-pressure hoses. The seal operates as follows. In assembly of the seal, stepped bushes *8* are inserted in nipple *5* and pipe *4*, so as to connect the sealing lips *9* with the conical surfaces *6* of the nipple and pipe. Then, using coupling nut *1*, the nipple and pipe with built-in bushes *8* are screwed together by connector *2*. By that means, the lips *9* of the stepped bush are pressed against the internal surface of the connector and the nipple until they are sealed. To replace the bush, the coupling nut and connector are simply unscrewed. If the bush jams, it may be loosened by means of wrench *10*. To simplify assembly and disassembly, the bushes may be magnetized. Ring *7* permits standardization of the coupling nut. If there is no need for standardization, the coupling nut may be combined with the ring.

The benefits of this design include the following: ease of repair; improved positioning and operation of the stepped bush, thanks to its four sealing lips; and assembly and disassembly without the need for special equipment.

To determine the performance of the proposed seal, we design and manufacture a prototype corresponding to the principles in [10] (Fig. 3). In the prototype, the coupling nut *1* serves as both pipe (Fig. 2) and cap. Its conical surface includes contact zone *A* at stepped bush *2* (as in Fig. 1).

Stepped sealing bush *2* has four sealing lips formed by the intersection of the cylindrical and end surfaces. Connector *3* performs the same function as connector *2* in Fig. 2.

Sealing pad *4* is mounted in the adapter *5* and ensures sealing of the joint between the end surfaces of connector *3* and adapter *5*.

Adapter *5* connects the prototype seal to component *6*, which consists of the sealing nipple and the coupling nut.

Assembly of the prototype seal is similar to the sequence for connecting the components in Fig. 2.

Tests on a laboratory hydraulic system at Don State Technical University (in the hydraulics department) show that it performs well at 12.5 MPa, which is in the high-pressure range [6].

CONCLUSIONS

(1) A new design of threaded seal has been patented. This design facilitates the repair of connections in high-pressure pipelines and hoses during operation.

(2) Tests of a prototype prove successful.

(3) The proposed seal is competitive with existing designs and may be used with high-pressure pipelines and hoses of larger diameter.

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