UDC 621.41 (088.8)

B. Arapov, K. Seytkazenova, G. Seraliyev

South Kazakhstan State University it. M. Auezov, Shymkent, Republic of Kazakhstan

NEW DESIGN OF PISTON RODS SEALING UNIT OF STERLING ENGINE

The advantage of suggested design of sealing unit of Stirling engine actuating and displacing pistons is that due to supply to intergland space of medium with pressure half as large as average pressure of operating medium in working cylinder, pressure head on separate gland seals is decreased two times. This results in increase of durability of gland seals two times and more. Fluoroplastic seal glands have thin lobes with inner cone hole accommodating the sealed rod and are fitted on them preliminarily with interference. The lobes of gland seal are additionally pressed to the rod surface by high media pressure, thus providing high tightness and compensating possible displacement of rod surface from theoretical cylindricity.

Key words: *Stirling engine, piston rod, gland, tightness, pressure, durability.*

The engines, working on a cycle of Stirling, belong to engines of external combustion (ECE), have a number of advantages before internal combustion engines (ICE). Advantages of the first treat, their possibility to work from any kind of sources thermal energy, including firm types of fuel, solar and atomic energy, ECE are harmless, at their work emissions in the atmosphere with flue gases in tens times it is less than in ICE as it is possible to organize better fuel burning out of the cylinder of the engine and at last, ECE works silently and their efficiency are comparable with modern diesel internal combustion engines.

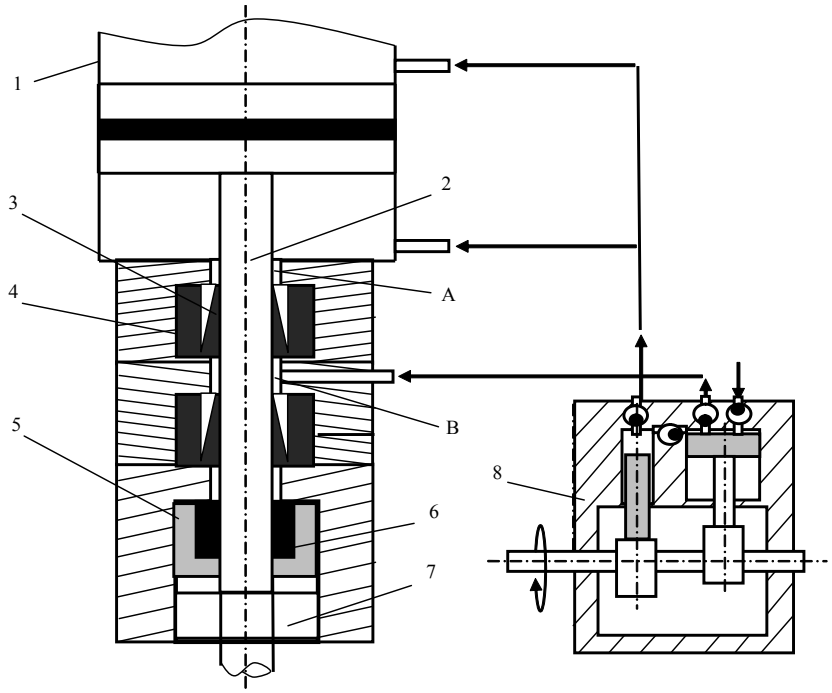
However engines of external combustion have an essential shortcoming which consists in complexity of ensuring tightness of the cylinder with a working environment of a high pressure. It is connected with that engines of Stirling effectively work at high pressures of the working environment, closed in the working cylinder which makes 20÷25 MPa. Thus the biggest complexity is represented by consolidation of a rod of the working piston being in the cylinder and transferring progressive movement of the piston to the crank mechanism. The working environment should be in the cylinder under a high pressure and its possible leakage through a gap between a rod and sealants reduces pressure of the environment in the cylinder which leads to sharp falling of efficiency and engine capacity. In this problem large scientific and production firms as «General Motors»,«Filli ps», «Unaided Stirling», «MAN/MWM», «Stirlingmash» and others thoroughly are engaged. In technical literature there are various designs or the seal, described in [1–3]. Despite it, the problem of ensuring absolute hermetically of pair «rod-case» and «piston-cylinder» up to the end isn't solved, and available development while is difficult and is expensive.

In SKSU it M. Auezov within performance of grant SIW No. 1132 the laboratory sample of the engine of Stirling with opposed located cylinders in which for seal of a rod of working and displace mental pistons was made the two-level sealing knot of a rod with sliding stuffing box seals was produced. Thus in interstuffing box space is given environment with pressure twice smaller, than average pressure of working gas (in our case working gas is air) that provides twofold decrease in a pressure of gas on separate stuffing box. This design of seal at the expense of decrease in a pressure on sealing elements of rods of working and displace mental pistons of the engine, facilitates work of stuffing box that leads to increase of reliability of their work and prolongs service life of sealing knot.

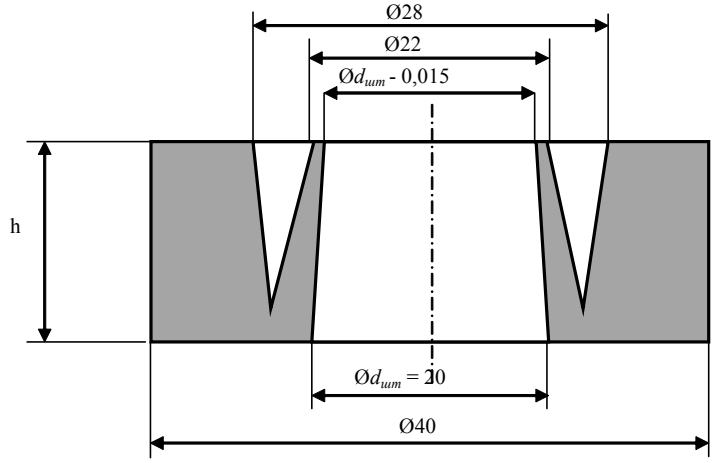
Operation of the engine and sealing knot is provided with us by the created small independent two-level air compressor intended for supply of compressed air in the working cylinder and in interstuffing box space. In case of application as a working environment of hydrogen or helium for providing work of the engine and knot of sealing are used cylinders with the compressed gas with reducers. Besides in the elaborating design replacement of worn-out stuffing box in sealing knot doesn't demand big expenses and work.

In drawing 1 the principle of work of two-level sealing knot with the independent air compressor is shown.

The knot of seal of a rod of the engine of external combustion contains (drawing 1) the working cylinder of the engine 1, a condensed rod 2, a sealing stuffing box 4, the bronze bushing – the case of a oil drain stuffing box 5, a oil drain stuffing box 6, a crosshead 7 and the two-level compressor 8.



Drawing 1. The schematic diagram of knot of seal of a rod in the engine of Stirling: 1 – working cylinder of the engine; 2 – a condensed rod; 3 – cone-shaped petal of stuffing box; 4 – ftoroplastical stuffing box; 5 – bronze case of a oil drain stuffing box ; 6 – oil drain stuffing box; 7 – crosshead; 8 – air compressor



Drawing 2. Cross-section (h) of the stuffing box is equal 6–8 mm

In drawing 2 the form of cross-section of stuffing box is shown. The stuffing box is made of a material ftoroplast (Teflon – 4) which keeps its the form and hardness to temperature 250 °C.

The internal opening of stuffing box is carried out in the form of a cone. Internal diameter of opening at level of atip of apetal is less than diameter of a rod on size (0,015÷0,02) d (d – diameter of rod) mm, that creates a preliminary tension of a petal on surface of rod . At operation of the engine from pressure of working environment petals of stuffing box in addition are press oneself to surface of rod. The knot of seal of a rod works as follows (drawing 1).

The working environment (air) from the second step of the compressor 8 having number of steps of compression corresponding to number of steps of stuffing box in knot of seal, with pressure equal to average pressure of a working cycle, is given simultaneously in working and buffer space of the working cylinder of 1 engine. In a cavity «A» sealing knot pressure of the environment will be equal to the maximum pressure of the environment in buffer space that creates compressing effort to an external surface of a thin-walled petal 3 stuffing box 4 which has a cone-shaped form (drawing 2), and presses it to surface of rod.

The pressing effort around a petal 3 stuffing box 4 allows to compensate some form of cone and ovality of surface of rod 2 and provides reliable hermetical of buffer space. Behind the first stuffing box

consistently on length of a rod is established the second stuffing box,which the principle of workthe same, as well as the first stuffing box. Thus in space «B» between the first and the second stuffing box from the first step of the compressor is given environment with pressure equal to a half of average pressure of a working environment of the engine. Thus, at two-level knot of seal on separate stuffing box are affected by a pressure twice smaller, than working pressure of the environment that increases service life of multistage seal in two and more times in comparison with data service of seal with one stuffing box. Regulating size of pressure of the environment in spaces «B», it is possible to establish optimum its value providing the greatest durability of sealing knot. Thus the compressor works at the beginning start-up of engine and at the working engine periodically will be automatically disconnected.

In this regard, important knot of the created engine with two-level sealing stuffing boxs, is the air two-level compressor calculated on creation in a working cavity of the engine of pressure of air to 11 MPa (110 kg/cm^2). It consists of two cylinders with pistons in diameter of the first step 35мм and the second step 10мм respectively, and the working course of both pistons identical and is equal 20 мм. The volume of the cylinder of the first step is equal to V_1 = = 19 cm^3 and the second, with account volume of a transitional opening makes V_2 = 1,6 cm^3 that provides extent of compression at the first step $K_1 = \frac{V_1}{V_2} = \frac{19}{1,6} \approx 11$. At the second step the extent of compression K_2 depends from volume of V_2 and the volume of cavity which is forming from an end of the piston of the second step, in position of the upper dead point, to discharge valve. Diameter of an opening for a saddle of the ball valve is equal 4мм, and the length makes 5мм. The volume of this cavity will make, taking into account space over piston which equal to one millimeter, V_3 = 0,16 cm^3. Then extent of compression of the second step equals $K_2 = \frac{1,6}{0,16} \approx 10$. Thus the general extent of compression of the compressor will make $K = K_1 \cdot K_2 \approx 110$.

List of literature

1. Круглов М. Г. Двигатели Стирлинга / М. Г. Круглов. – М. : Машиностроение, 1977. – 151 с.
2. Авторское свидетельство СССР №855241.
3. Патент Российской Федерации RU 2201517.

Поступила в редакцию 05.01.2013

Д-р техн. наук Арапов Б.Р., д-р техн. наук Сейтказенова К.К., канд. техн. наук Сералиев Г.Є. Нова конструкція вузла ущільнення штоків поршнів двигуна Стирлинга

Перевага пропонованої конструкції вузла ущільнення штоків робочих і витіснювальних поршнів двигуна Стирлинга полягає в тому, що завдяки поданню в міжсальниковий простір середовища, що має тиск на половину менше, ніж середній тиск робочого середовища в робочому циліндрі, натиск на окремі сальники зменшується в два рази. Це, у свою чергу, приведе до збільшення терміну служби сальників також в два і більше рази. При цьому сальники, виготовлені з фторопласту, мають тонкостінні пелюстки з конусоподібним внутрішнім отвором, що охоплює ущільнюваний шток, і з первинним натягом надіваються на них. За рахунок високого тиску середовища пелюстки сальника додатково обтискаються до поверхні штока, що забезпечує високу міру герметичності і компенсує можливі відхилення поверхні штока від ідеальної циліндричності.

Ключові слова: *двигун Стирлинга, шток поршня, сальник, герметичність, тиск, ресурс.*

Арапов Б.Р., Сейтказенова К.К., Сералиев Г.Е. Новая конструкция узла уплотнения штоков поршней двигателя Стирлинга

Преимущество предлагаемой конструкции узла уплотнения штоков рабочих и вытеснительных поршней двигателя Стирлинга заключается в том, что благодаря подаче в межсальниковое пространство среды имеющей давление на половину меньше, чем среднее давление рабочей среды в рабочем цилиндре, напор на отдельные сальники уменьшается в два раза. Это, в свою очередь, приведет к увеличению срока службы сальников также в два и более раза. При этом сальники, изготовленные из фторопласта, имеют тонкостенные лепестки с конусообразным внутренним отверстием, охватывающим уплотняемый шток, и с первоначальным натягом надеваются на них. За счет высокого давления среды лепестки сальника дополнительно обжимаются к поверхности штока, что обеспечивает высокую степень герметичности и компенсирует возможные отклонения поверхности штока от идеальной цилиндричности.

Ключевые слова: *двигатель Стирлинга, шток поршня, сальник, герметичность, давление, ресурс.*