

"LINEAR COMPRESSOR"

Field of the Invention

The present invention refers to a linear compressor based on resonant oscillating mechanism, in particular based on a resonant spring-mass system, for maintaining the oscillating movement of its components. The linear compressor in question provides a resonant oscillating arrangement responsible for attenuation of vibration imposed on their outer housing.

Background of the Invention

Briefly, linear compressors consist of a piston which is responsible for admission and compression of the working fluid, coupled to a linear motor. The linear motor is responsible for imposing the linear oscillatory motion to the piston, which is responsible for the compression of the fluid. Compressors that make use of a linear motor on their drive have the advantage of occupying a substantially small volume compared to the compressors driven by a conventional rotary motor.

The use of a compact compressor is regarded as preferred and as the volume occupied by a compressor which is driven by a linear motor is significantly lower than the volume occupied by a compressor driven by a rotary engine, various solutions arose to seek the increase of the performance of the compressors driven by linear motors, the so-called linear compressors.

Based on the resolution of this drawback, linear compressors began to emerge provided with means focused on minimizing the force that the linear motor needs to perform in each cycle. One of these solutions reside in the use of a physical principle to conserve energy of the system, using the alternative movement of the linear motor and extending it in such a way that the effort made by the linear motor is aided by the inertia of the system. The resonance phenomenon is used.

The resonance is the tendency (or facility) that a body has to oscillate with large amplitudes at certain frequencies, called natural frequency or resonant frequency.

Once a force is imposed at a frequency near the natural frequency of a body, there is a gradual accumulation of mechanical energy, resulting in the increase of the amplitude of oscillation of the system.

Thus, solutions appeared which comprise a linear motor mounted under supports comprising springs, which have the function of accumulating the energy delivered by the engine. In addition to the accumulation of energy, these springs have the function of transmitting the movement of the motor to the piston. These springs are commonly called as resonant springs.

The use the resonant of springs helps linear motor to work and reduces the effort required to move the set, resulting in lower electricity consumption of the linear motor that

drives the system, due to the fact that most part of the energy required to move the piston is already stored in the spring resonant.

A first example of linear compressor provided with resonant springs is described in the document US 2006/005700, which discloses a linear compressor provided with an assembly of resonant springs, associated with the piston, which is in turn associated with the movable core of a linear motor. Said assembly of resonant springs consists of two pairs of springs, each pair disposed in a face of a plate associated with the piston. Thus, when performing the linear movement of the piston in one direction, the pair of springs arranged in the respective face of the plate acts on the assembly and moves it in the opposite direction when they reach a certain level of openness, reducing the effort that the motor needs to operate in alternating manner. This embodiment has, however, the inconvenience of using a large amount of springs, which complicates the mounting of the assembly. Furthermore, this embodiment prevents the minimization of the compressor assembly, preventing its application in small devices.

A second example of a linear compressor provided with resonator springs is described in document PI 0601645-6, which discloses a minimized compressor, comprising a single resonant spring associating a linear motor and a piston, and give it a reciprocating motion performed by the linear motor. This embodiment, while enabling a more compact arrangement of the linear compressor, has the disadvantage of not providing the existence of any deviation in the position between the piston and the linear motor, since each component is disposed at one end of the resonant spring. Furthermore, such a constructive arrangement, to use a single spring arranged along the entire length of the compressor, without any guiding element, results in undesirable efforts of the piston and of the motor, which may preclude their correct functioning.

A third example of the linear compressors provided with resonant springs is illustrated schematically in Figure 1 with a resonant linear compressor CL, according to the state of the art, comprising a piston P mounted within a cylinder CM and associated with a first end of a resonant spring MR, which has its second end associated with a movable portion (moving magnet) PM of a linear motor. The resonant spring MR has a neutral portion PN associated to the housing C of the compressor by a fastening means MF. Therefore, it should be noted that the linear compressor CL of the state of the art employs the piston P being mounted on a first end PE of the housing C, and the motor mounted on a second end SE of the housing C, that is, each component in one of the ends of the compressor. These components are intermediated by the resonant spring MR, however, this motor and piston arrangement is not favorable due to the resulting vibration in the compressor housing, since the forces generated by the engine and the forces generated by the compression of gas in the cylinder are in phase, that is, in the same direction, and therefore they are added,

resulting in a greater force on the housing.

Thus, it is noted that the current state of the art lacks a resonant compressor comprising a constructive simplified arrangement which can be minimized and, moreover, provided with means to reduce vibration of the housing.

5 Objectives of the Invention

It is one of the objectives of the present invention to provide a linear compressor based on resonant oscillating mechanism capable of attenuating the vibration that said resonant oscillating mechanism applies to its carcass. In this sense, then it is another objective of the present invention to provide a linear compressor whose resonant oscillation
10 arrangement is able to promote the cancellation (even partially) of the forces generated by the motor and of the forces generated by compression of the gas in the cylinder.

It is another objective of the present invention to provide a linear compressor based on resonant oscillating mechanism whose resonant oscillating arrangement reduces the amplitude of the resultant forces (movement) imposed on its housing.

15 Summary of the Invention

The objectives of the present invention are fully achieved by the linear compressor shown herein, which comprises an oscillating arrangement essentially comprising at least one linear motor (defined by a movable portion and a fixed portion), at least one resonant spring and at least one piston. The oscillating arrangement further comprises at least one
20 balancing body.

According to the concepts of the present invention, the movable portion of the linear motor is cooperatively associated with the piston defining a piston-drive assembly.

In this sense, the piston - motor is functionally associated to one of the ends of the resonant spring, while at least one balancing body is functionally associated with the
25 opposite end of the resonant spring.

Thus, the mentioned balancing body is capable of exerting an oscillatory movement, which can be synchronized to the resonant oscillatory motion of the motor piston assembly, or, synchronously opposite to the resonant oscillatory motion of the piston - motor assembly.

Brief Description of Figures

30 The present invention will be described in detail based on the figures listed below.

Figure 1 illustrates a schematic view of the assembly of the resonant linear compressor belonging to the current state of the art.

Figure 2 illustrates a schematic view of the assembly of the resonant linear compressor that is object of the present invention.

35 Detailed Description of Figures

According to the main concept of the present invention, there is shown a linear compressor based on resonant oscillating mechanism (driven by a linear motor and which

makes use of a resonant spring to assist its operation through the accumulation of energy resulting in an increased oscillation amplitude), where the resonant arrangement itself is capable of minimizing the unbalanced forces from the gas compression in the cylinder and the oscillating operation of the motor. With this, the vibration that the resonant arrangement
5 applies to the housing of the linear compressor is attenuated.

Figure 2 shows a schematic (cross-sectional) view of the preferred construction of the linear compressor 1, which is designed in accordance with the concepts and objectives of the present invention.

Thus, the preferred construction of a linear compressor 1 comprising an oscillating
10 arrangement essentially comprising a linear motor 2, a resonant spring 3, a piston 4, and a balancing body 5. Notably, the linear compressor 1 also comprises a cylinder 6 and other elements conventionally existing in compressors (for example, as a head assembly 7 and connections 8 for suction and discharge of the working fluid). Preferably, the linear compressor 1 is also integrated by a housing 9 which has the function of accommodating all
15 components that form the mentioned linear compressor 1.

The linear motor 2 comprises, in general, a fixed portion 21 (stator or back iron) and a movable portion 22 (cursor / magnet). The linear motor 2 is, therefore, a conventional linear motor.

According to the present invention, the fixed portion 21 of the linear motor 2 is fixed
20 to the casing 9 of the linear compressor, or any intermediate element (not shown) also fixed to the frame 9 of the linear compressor 1. Since the movable portion 22 of the linear motor 2 is cooperatively associated with the piston 4 defining a piston - motor assembly.

The resonant spring 3 includes a physically resilient body, that is, capable of suffering physical "deformation" when subjected to an external force and capable of returning
25 to its original "form" when free of external force.

Preferably, the resonant spring 3 is a substantially helical tubular metal body defining two distal ends 31 and 32. The resonant spring 3 further comprises a neutral point 33 (where vibrations or deformations are much smaller than the ends 31 and 32) arranged in the middle of its length. Said neutral point 33 allows the resonant spring 3 to be attached to
30 the casing 9 of the linear compressor 1, or any intermediate element (not shown) also attached to the housing 9 of the linear compressor 1.

The piston 4 is one conventionally piston used in linear compressors, that is, it comprises a piston defined by an essentially cylindrical body with an open end and one closed end (working end).

35 The balancing body 5, as induced by its nomenclature, consists of a body with a specific mass. Preferably, the balancing body 5 has a mass similar to the mass of the piston - motor assembly.

The cylinder 6, the head 7 and the connections 8 for suction and discharge of working fluid comprise conventional components already belonging to the current state of the art, therefore, already known to those skilled versed in the art.

5 The housing 9 which provides attachment means 91 to the neutral point 33 of the resonant spring 3 (or to any intermediate element disposed between said resonant spring 3 and the housing 9) also comprises a conventional housing already belonging to the current state of the art.

10 According to the main concepts of the present invention, the oscillating arrangement is especially detached from other oscillatory arrangements of the same type and belonging to the current state of the art due to the fact that the piston - motor assembly (defined by the cooperative association between the movable portion 22 of the linear motor 2 and the piston 4) is functionally associated with the end 31 of the resonant spring 3, while the balancing body 5 is functionally associated with the end 32 of the resonant spring 3.

15 In this sense, the movement of the movable portion 22 of the linear motor 2 is integral and directly transmitted to the piston, thereby moving the piston - motor assembly, and consequently, the end 31 of the resonant spring 3. This movement is transmitted to the end 32 of the resonant spring 3 and, consequently, to the balancing body 5.

Thus, each component of the oscillating arrangement described herein has its particular function, namely:

20 The piston - motor assembly (defined by the cooperative association between the movable portion 22 of the linear motor 2 and the piston 4) serves to impose movement on the resonant spring 3 and function of compressing, effectively, the working fluid.

The resonant spring 3 has a function to amplify the oscillating movement, by accumulating mechanical energy.

25 The balancing body 5 has the task of balancing the system, so that the forces generated by piston - motor assembly (at the time of compression of the working fluid) are annulled (by the forces generated by the movement of the balancing body itself).

30 Thus, the main objective of the present invention (attenuate the vibration that the resonant oscillating mechanism requires the compressor housing by canceling (even partially) the forces generated by the motor and the forces generated by compression of the gas in the cylinder) is successfully achieved.

35 It is also worth mentioning that, as the piston - motor assembly, the balancing body 5 performs an axial, linear and oscillating movement inside the housing 9 of the linear compressor 1. This movement can be synchronized or synchronously opposite to the resonant oscillatory movement of said piston - motor assembly.

Having described an example of a preferred embodiment of the present invention, it should be understood that the scope of the same includes other possible physical variations,

which are limited solely by the wording of the claims, with the inclusion of the possible equivalent means.

CLAIMS

1. Linear compressor, comprising a oscillating arrangement fundamentally formed by at least one linear motor (2) defined by a movable portion (22) and a fixed portion (21), at least one resonant spring (3) and at least one piston (4); the compressor being especially

5 CHARACTERIZED in that:

the oscillating arrangement comprises at least one balancing body (5);

the movable portion (22) of the linear motor (2) is cooperatively associated with the piston (4) defining a piston - motor assembly;

10 the piston - motor assembly is functionally associated with the end (31) of the resonant spring (3); and

at least one balancing body (5) is functionally associated with the end (32) of the resonant spring (3).

2. Linear compressor according to claim 1, CHARACTERIZED in that the balancing body (5) is capable of having an oscillatory movement.

15 3. Linear compressor according to claim 2, CHARACTERIZED in that the balancing body (5) is capable of performing a resonant oscillating movement synchronized with resonant oscillatory movement of the piston - motor assembly.

20 4. Linear compressor according to claim 2, CHARACTERIZED in that the balancing body (5) is capable of performing a resonant oscillating movement synchronously opposite to the resonant oscillatory movement of the piston - motor assembly.