

(19)



(11)

EP 3 158 148 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:

21.03.2018 Bulletin 2018/12

(51) Int Cl.:

E04H 9/02 (2006.01)

(86) International application number:

PCT/TR2015/000064

(21) Application number: **15715873.4**

(22) Date of filing: **23.02.2015**

(87) International publication number:

WO 2016/137409 (01.09.2016 Gazette 2016/35)

(54) **A SLIDING BEARING FOR SEISMIC PROTECTION**

GLEITLAGER ZUR ERDBEBENSCHUTZ

APPUI À GLISSIÈRE POUR PROTECTION SISMIQUE

(84) Designated Contracting States:

AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(43) Date of publication of application:

26.04.2017 Bulletin 2017/17

(73) Proprietor: **Tis Teknolojik Izolator Sistemleri**

Sanayi Ticaret

Anonim Sirketi

Cankaya/Ankara (TR)

(72) Inventors:

• **SUYUN, Ahmet**

Cankaya/Ankara (TR)

• **SUCUOGLU, Haluk**

Cankaya/Ankara (TR)

(74) Representative: **Dericioglu Kurt, Ekin**

Ankara Patent Bureau Limited

Bestekar Sokak No: 10

Kavaklidere

06680 Ankara (TR)

(56) References cited:

EP-A1- 2 208 913

WO-A1-2012/114246

WO-A1-2013/191356

Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

EP 3 158 148 B1

Description**Technical Field**

[0001] Embodiments of present invention relate to a sliding bearing for seismic protection of constructions from effects of ground movements like earthquakes. The sliding bearings are intended to be installed between construction and its foundation. The sliding bearings compensate movement of the foundation transferred to the overlying structure. Thus, the structure is protected from forces induced by ground movements.

Background

[0002] Seismic isolation is a concept which isolates a structure from ground movement by transferring reduced ground movement forces to a structure. Sliding bearings is one popular kind of system used for seismic isolation. Sliding bearings provide isolation by two or more hardware such as plates sliding on each other. Damping and energy dissipation is provided by the friction on the sliding surfaces.

[0003] In the state of the art an anti-seismic sliding bearing as described for example in WO 2012/114246 A1, WO 2013/191356 A1 and EP 2 208 913 A1, usually comprises an upper plate and a lower plate, which are joined to the structure to be supported and the foundations of the structure respectively. Plates are sliding over each other to compensate the ground movement forces. It is also known from state of the art; some sliding bearing plates have a respective concave sliding surface and they are separated from each other by an intermediate sliding shoe. The sliding shoe has two convex surfaces mating and be in contact with the concave surfaces of the upper and lower plates, to form an articulation. In the event of a ground movement, some forces such as tremor or shock applied to the sliding bearing and the sliding shoe can slide with a pendulum-like motion relative to at least one of the two plates, thereby protecting the overlying structure from the effects of the ground movements.

[0004] The motion of the sliding depends on several parameters causing some phenomenon like stick-slip. Stick-slip phenomenon is simply a spontaneous jerking motion that can occur while two objects are sliding over each other. Stick-slip can be described as surfaces alternating between sticking to each other and sliding over each other, with a corresponding change in the force of friction. Typically, static friction coefficient between two surfaces is larger than kinetic friction coefficient. If an applied force is large enough to overcome the static friction, then the reduction of the friction to the kinetic friction can cause a sudden jump in the velocity of the movement. To overcome the static friction, the applied force should be equal or higher than "breakaway friction" force. In other words, the breakaway friction force is a minimum force necessary to initiate a motion i.e. sliding.

[0005] At the occurrence of a ground movement like earthquakes, the motion (sliding) of the sliding bearing can start only when forcing action due to the ground motion overcomes the resisting friction force, in other words "breakaway friction" force. The breakaway friction is proportional through the portion of weight of the overlying structure passing through the sliding bearing, to the horizontal acceleration due to the ground motion. If the breakaway friction is large, the structure is affected by a huge horizontal acceleration, a sudden jump in the velocity described in the above, before the seismic isolation becomes effective. Moreover, since change in the direction of the sliding occurs with change in the direction of the contact forces, breakaway friction should be overcomes again through changed direction by the ground motion. Thus, stick-slip phenomenon is also associated, though in general at a less extent, at any changes in the direction of the motion (sliding). So reducing the breakaway friction as close as to the kinetic friction has a crucial role for a sliding bearing to isolate seismic forces effectively.

[0006] In the state of the art, grease or oil inserted between sliding surfaces of the sliding bearings are used to assist the sliding. However, the uses of lubricant agents fail to reduce the breakaway friction at desired level and selection and handling of the lubricant agent is difficult under harsh usage environment outdoors, and maintenance is also a troublesome.

[0007] Another known application to assist the sliding is that the sliding surfaces are coated with a sheet made of a sliding material such as filled or unfilled PTFE. The sliding material should be carefully conducted to achieve enough seismic isolation especially considering stick-slip phenomenon.

[0008] A known sliding material provides a high coefficient of friction which allows dissipation of a large amount of energy following ground movements. Nevertheless, owing to the large coefficient of friction, large forces, causing damage, are transmitted to overlying structure by the bearing before and during motion. The main disadvantage of the known sliding material is that it is not able to deal with the problems caused by stick-slip phenomenon.

[0009] Another known sliding material is an unfilled hard PTFE or UHMWPE. These materials exhibit a relatively low kinetic coefficient of friction which allows the bearing to accommodate the in-service movements of structure. Although use of said thermoplastic materials limits increase of the peak coefficient of friction associated to motion reversals as well as to a change of direction, it does not solve the problem regarding the peak breakaway friction at the starting of the motion.

[0010] Another known sliding material discloses an anti-seismic support, where the friction coefficient between the sliding surfaces is above 10% and is stable notwithstanding the increase in temperature due to sliding at high velocities which typically occurs during strong earthquakes. The sliding material is a plastic resin added with polymeric, synthetic, ceramic or metal filler aiming at increasing the thermal conductivity of the basic resin.

[0011] Other materials that have been recently proposed for use in sliding bearings, like polyamide (PA) are known to be affected by an even more huge increase in breakaway friction, leading to a severe stick-slip problem.

[0012] To reduce the gap between the breakaway and the kinetic coefficient, a sheet of sliding material consisting of a fluorine resin, UHMWPE resin or aromatic polyester resin are used wherein a molecular direction on the sheet surfaces are oriented in a certain direction. This solution minimizes the increase in friction resistance at the starting of the motion. However the effect is achieved only in the direction of the orientation of the molecular chains, and therefore the bearings incorporating sheets of said sliding material are indicated to accommodate service movements in structures like bridges, where the motion occurs mainly along one known direction. On the contrary, said kind of sliding material is not suitable for use in anti-seismic bearings, which are required to accommodate earthquake-induced movements subjected to random patterns of motion with continuous changes of direction.

[0013] Molybdenum disulfide is an inorganic compound that is currently used in bearing technology as solid lubricant to reduce friction between two mating surfaces sliding one onto each other. MoS₂ has been already used as a mineral filler of the PTFE resin, in amounts generally between 5% and 15% by weight, to increase the hardness, stiffness and wear resistance of PTFE. Owing to the excellent self-lubricating behavior of the PTFE resin, the use of MoS₂ to decrease the kinetic coefficient of friction of PTFE is indeed of no interest.

[0014] Technical standards like e.g. the European standard EN 1337-2:2004 "Structural Bearings. Part 2: Sliding Elements" and the US standard "AASHTO LRFD Bridge Design Specification" also acknowledge that today state of the art materials, like PTFE and filled PTFE resins, are characterized by a large increase of the coefficient of friction at the breakaway, that may be ranging from two to four and more times the kinetic coefficient of friction.

[0015] The underlying physical mechanism is known from the literature, e.g. C.M. Pooley; D. Tabor "Friction and Molecular Structure: The Behaviour of Some Thermoplastics", in Proceedings of the Royal Society of London. Series A, Mathematical and Physical Sciences, Vol. 329, No. 1578. (1972), pp. 251-274. Examples of typical plots reporting the friction resistance versus the sliding distance for PTFE - steel mating surfaces are given in Figure 1.

[0016] The huge increase in the coefficient of friction between sliding surfaces occurring at starting and, at less extent, at changing of the direction of motion is also acknowledged as one of the main problems of sliding bearings.

Brief Description of the Drawings

[0017] An exemplary embodiment of the present invention is illustrated by way of example in the accompanying drawings to be more easily understood and uses thereof will be more readily apparent when considered in view of the detailed description, in which like reference numbers indicate the same or similar elements, and the following figures in which:

Figure 1 is examples of typical plots reporting the friction resistance versus the sliding distance for PTFE - steel mating surfaces, X= Friction Force, Y= Sliding Displacement;

Figure 2 is a diagrammatic sectional view of an anti-seismic sliding bearing with sliding material of one embodiment of the invention;

Figure 3 is a close diagrammatic sectional view of an anti-seismic sliding bearing sliding material of one embodiment of the invention;

Figure 4 is an example of the hysteretic horizontal force - deflection curves of the specimen of the sliding bearing (1) in the tests run at 15 MPa average pressure applied to the sheet of sliding material (5).

Figure 5 is an example of the hysteretic horizontal force - deflection curves of the specimen of the sliding bearing (1) in the tests run at 30 MPa average pressure applied to the sheet of sliding material (5).

Figure 6 is an example of the hysteretic horizontal force - deflection curves of the specimen of sliding bearing in the tests run at 45 MPa average pressure applied to the sheet of sliding material (5).

Figure 7 is an example of the hysteretic horizontal force - deflection curve of a specimen of the sliding bearing (1) wherein sheet of the sliding material (5) is made of unfilled PTFE resin.

Figure 8 is an example of the hysteretic horizontal force - deflection curve of a specimen of the sliding bearing (1) wherein the sheet of the sliding material (5) is made of PTFE resin filled with bronze.

Figure 9 is an example of the hysteretic horizontal force - deflection curves of a specimen of the sliding bearing (1) wherein sheet of the sliding material (5) is made of a polyamide resin.

Figure 10 is an example of "Anti-seismic devices (sliding bearing)" from the diagrammatic force - displacement plot in accordance with the European Standard EN 15129:2009.

Detailed Description

[0018] A sliding bearing (1) adapted to provide ground movement protection to a construction, comprising a first plate (2), adapted to be installed to a construction (B), having a first sliding surface (2.1) in a concave form and a second plate (3), adapted to be installed among foundation (A) of the construction, having a second sliding surface (3.1) in a concave form, and a sliding shoe (4) positioned between the first plate (2) and the second plate (3), wherein the sliding shoe (4) has an upper sliding surface (4.1) in a convex form, in contact with the first sliding surface (2.1) and a lower sliding surface (4.2) in a convex form, in contacted with the second sliding surface (3.1), wherein the first plate (2), the second plate (3) and the sliding shoe (4) are capable of sliding with pendulum motion relative to each other in response to a ground movement forces,

sheet of sliding material (5) covers first sliding surface (2.1) and upper sliding surface (4.1) comprising; PTFE resin filled with molybdenum disulfide MoS₂ in a maximum amount of 2.5% by weight of the sliding material (5), The sliding material (5) covers second sliding surface (3.1) and lower sliding surface (4.2), the amount of molybdenum disulfide is 2.0% by weight of said sliding material (5), the PTFE resin is also filled with other solid lubricants to decrease sticking at rest between each sliding surfaces,

the amount of solid lubricants other than molybdenum disulfide is no more than 1.0% by weight of the sliding material (5), the PTFE resin is also filled with bronze,

the amount of the bronze filler is between 15% and 20% by weight of the sliding material (5),

sheet of the sliding material (5) is mounted to the sliding surfaces either as a sheet partially embedded in a corresponding seat formed on the sliding surfaces as a sheet applied using an adhesive or mechanical fastening means and forms the sliding surfaces,

the breakaway value of the coefficient of friction between first sliding surface (2.1) and upper sliding surface (4.1) is less than 7%, when the mutual sliding speed of the said sliding surfaces (2.1, 4.1) is less than 1 mm/s and the contact pressure between the said sliding surfaces (2.1, 4.1) applied to the sliding bearing (1) is at least 15 MPa. the breakaway value of the coefficient of friction between first sliding surface (2.1) and upper sliding surface (4.1), and between second sliding surface (3.1) and lower sliding surface (4.2) are less than 7%, when the mutual sliding speed of the said sliding surfaces (2.1, 4.1 - 3.1, 4.2) is less than 1 mm/s and the contact pressure between the said sliding surfaces (2.1, 4.1 - 3.1, 4.2) applied to the sliding bearing (1) is at least 15 MPa,

the kinetic value of the coefficient of friction between first sliding surface (2.1) and upper sliding surface (4.1) is less than 8%, when the mutual sliding speed of the said sliding surfaces (2.1, 4.1) is less than 200 mm/s and the contact pressure between the said sliding surfaces (2.1, 4.1) applied to the sliding bearing (1) is at least 30 MPa.

the kinetic value of the coefficient of friction between first sliding surface (2.1) and upper sliding surface (4.1), and between second sliding surface (3.1) and lower sliding surface (4.2) are less than 8%, when the mutual sliding speed of the said sliding surfaces (2.1, 4.1 - 3.1, 4.2) is less than 200 mm/s and the contact pressure between the said sliding surfaces (2.1, 4.1 - 3.1, 4.2) applied to the sliding bearing (1) is at least 30 MPa.

[0019] Embodiments of the present invention relates to an anti-seismic sliding bearing can provide ground movement like earthquake protection to a construction by separating the movement of the structure from the movement of its foundation and to protect the overlying construction from tremors and shocks induced by ground movements. Embodiments of the sliding bearing is avoiding substantial increase in forces and accelerations transmitted to the overlying construction over those expected based on the kinetic coefficient of friction developed at sliding surfaces of the sliding bearing during sliding. The sliding bearing is also avoiding the increase in the coefficient of friction between sliding surfaces, causing severe deceleration, occurring at changing of the direction of motion. This makes the motion of the overlying construction smooth and preserves the structure as well as its content by substantial increase of horizontal accelerations, which is particularly advantageous e.g. for hospitals, museums, etc.

[0020] The construction is used herein to designate any kind of civil work and engineering structures including but not limited to buildings, residential buildings, hospitals, bridges (road or railroad bridges), viaducts, and industrial plants, any type of towers, silos and tanks.

[0021] The features and advantages of the present invention will become more apparent from the following detailed description of one practical embodiment, which is given as a non-limiting example with reference to the annexed drawings.

[0022] The sliding bearing (1) is used to support construction and protect the construction in the event of a ground movement.

[0023] One embodiment of the sliding bearing (1) is adapted to be installed among the foundation (A) of a construction and the construction (B) itself. The embodiment of the sliding bearing (1) comprises a first plate (2), adapted to be installed to the construction (B), having a first sliding surface (2.1) and a second plate (3), adapted to be installed among the foundation (A) of the construction, having a second sliding surface (3.1). The first sliding surface (2.1) and the second sliding surface (3.1) are positioned to be in contact with each other and able to slide over each other to compensate the ground movement forces transferred to the construction by transforming the force kinetic energy into heat through friction.

[0024] One preferred embodiment of the sliding bearing (1), shown in Figure 2 and Figure 3, is adapted to be installed among the foundation (A) of a construction, and the construction (B) itself. The embodiment of the sliding bearing (1) comprises a first plate (2), adapted to be installed to the construction (B), having a first sliding surface (2.1) in a concave form and a second plate (3), adapted to be installed among the foundation (A) of the construction, having a second sliding surface (3.1) in a concave form, and a sliding shoe (4) positioned between the first plate (2) and the second plate (3). The sliding shoe (4) has an upper sliding surface (4.1) in a convex form, in contact with the first sliding surface (2.1) and a lower sliding surface (4.2) in a convex form, in contact with the second sliding surface (3.1). In other words, the first plate (2) is located above the sliding shoe (4) and the second (3) plate is located below the sliding shoe (4). The sliding shoe (4) is free to slide, pendulum like motion, between the first plate (2) and the second plate (3) to compensate the ground movement forces (tremors or shocks) transferred to the construction. The upper sliding surface (4.1) is facing away from the lower sliding surface (4.2). The convex upper sliding surface (4.1) matches corresponding the concave first sliding surface (2.1) and the convex lower sliding surface (4.2) matches corresponding the concave second sliding surface (3.1). An articulation joint is formed between the sliding shoe (4) and one of the two concave first plate (2) or second plate (3) and a slip joint is formed between the sliding shoe (4) and the other one of the two concave plates to absorb ground movements. It is also possible to form two slip joint between each matched surfaces.

[0025] Another embodiment of the invention, the lower sliding surface (4.2) preferably has a half spherical shape. The lower sliding surface (4.2) is coupled to the second sliding surface (3.1), thereby forming a ball joint articulation. Particularly, the convex lower sliding surface (4.2) is received in a spherical concavity formed in the concave second sliding surface (3.1). Moreover, the sliding surfaces may also be cylindrical with a substantially horizontal axis of symmetry, in operation.

[0026] The first plate (2) preferably integrally joined, by known fastening means, to the construction to be supported through the other plate surface rather than first sliding surface (2.1). The first plate (2) is preferably made of steel, but may be also made of aluminum alloy or another material.

[0027] Obviously, while reference is expressly made in the drawings and the description to a single configuration (with the articulation joint below the sliding surface), the kinematically opposite configuration (with the articulation joint above the sliding surface) is possible and technically equivalent, and shall be deemed to be implicitly disclosed herein.

[0028] In the preferred embodiment of the sliding bearing (1), the convex upper sliding surface (4.1) and the concave first sliding surface (2.1) have mating curvatures to allow a pendulum motion of the sliding bearing (1). For instance, they may have a spherical shape and hence have the same radius of curvature. Alternatively, other configurations may be envisaged, in which at least one of the two sliding surfaces has a variable radius of curvature, for improved centering of the sliding shoe (4).

[0029] In the Figure 2 and Figure 3, the sliding shoe (4) is shown in its equilibrium position, i.e. centered relative to the first sliding surface (2.1). The sliding shoe (4) is in this equilibrium position before ground movements. Depending on interaction of certain factors, including types and details of the ground movements, the sliding shoe (4) can be recovered in the equilibrium position at the end of the ground movements.

[0030] In one embodiment of the sliding bearing (1) also comprises a sheet of a sliding material (5) that covers the first sliding surface (2.1) and the upper sliding surface (4.1). In one preferred embodiment of the sliding bearing (1), the second sliding surface (3.1) and the lower sliding surface (4.2) are also covered by the sliding material (5).

[0031] Advantageously, the sheet of sliding material (5) can be applied in a shaped seat to cover each sliding surfaces. The seats are situated in the sliding surfaces and sheet of sliding materials (5) can be placed into the seat without any fastening means or adhesives. Advantageously, the sheet of sliding material (5) has a thickness (e.g. a constant thickness) greater than the depth (e.g. a constant depth) of the seat in which it is embedded, thereby projecting out of it.

[0032] In the preferred embodiment of the sliding bearing (1), the sheet of sliding material (5) as used in the sliding bearing (1) has a thickness of 6 to 8 mm and projects out of the sliding surfaces by about 2 to 3 mm, with about 4 to 5 mm thereof being embedded in the sliding surfaces.

[0033] In another embodiment of the sliding bearing (1), the sheet of sliding material (5) may be applied to the sliding surfaces using adhesives or mechanical fastener means, such as screws and/or rivets; in this case, the seat may be omitted.

[0034] At the occurrence of ground movements, the first sliding surface (2.1) and the upper sliding surface (4.1) and also the second sliding surface (3.1) and the lower sliding surface (4.2) start to slide one upon the other as soon as the

forcing action due to the ground motion exceeds the frictional resistance at the breakaway that is very close to the friction force generated during sliding under favour of sliding material (5) which covers each sliding surfaces. Since the first plate (2), the second plate (3) and sliding shoe (4) are free to slide, they are able to move a pendulum like motion and projections of each motions can be independent from each other. Thus, there is no transmission of large horizontal accelerations to the overlying structure (B). The same happens when the direction of motion changes under the effect of ground movements, preventing in such a way the phenomenon of sticking due to the increase of the coefficient of friction.

[0035] In one embodiment of the present invention, the sheet of sliding material (5) comprises polytetrafluoroethylene (PTFE) resin added with molybdenum disulfide (MoS₂) in amounts of less than 2.5% by weight of the sliding material (5). In the preferred embodiment of the invention, the amount of molybdenum disulfide is 2.0% by weight of said sliding material (5), used to mitigate the increase in the coefficient of friction of PTFE at the breakaway with respect to the kinetic value of the coefficient of friction.

[0036] In another embodiment of sliding material (5) also comprises an amount of the bronze filler between 15% and 20% by weight of said sliding material (5).

[0037] In the preferred embodiment of the sliding bearing (1), the sliding material (5) is sintered and/or formed into a sheet by compression molding. After molding, the sheet material is processed to the desired thickness.

[0038] The sliding material (5) composition ratios can differ from each other used on first, second, upper and lower sliding surfaces ((2.1), (3.1), (4.1), (4.2)) in any embodiment of the sliding bearing (1) to increase the effectiveness of anti-seismic protection according to properties such as; construction (B), foundation (A), climate, incline of area where sliding bearing placed, soil, fault line features.

[0039] In the preferred embodiment, in which the sheet of sliding material (5) is made of PTFE resin filled with 2% MoS₂:

(a) The increase in the coefficient of friction at the first starting of motion from rest is less than 20% with respect to the kinetic value of the coefficient of friction, which is insignificant as compared with prior art materials;

The increase in the coefficient of friction at the starting of the motion relative to the kinetic value of the coefficient of friction μ_{kin} is no more than 20% of the value μ_{kin} when the average pressure between the first sliding surface (2.1) and the upper sliding surface (4.1) is 15 MPa or more and the sliding surfaces (16b, 17) are caused to slide at a sliding speed of 1 mm/s or more at a temperature of 20°C or more.

(b) The increase in the coefficient of friction associated to the change of direction of motion is less than 10% with respect to the kinetic value of the coefficient of friction. The sheet of sliding material (5) may be made of PTFE resin filled, in addition to MoS₂ in percentage up to 2.5%, with a polymeric, synthetic, ceramic or metal filler to increase its stiffness and load bearing capacity.

[0040] The sheet of sliding material (5) may be made of PTFE resin filled, in addition to MoS₂ in percentage up to 2.5%, with a solid lubricant to further reduce the sticking phenomenon at the breakaway.

[0041] The sliding bearing (1) is reliable over time, because the effect of avoiding significant increase of the starting friction is achieved without use of lubricant agents like grease or oil, therefore avoiding the problems related to selection and handling of the lubricant agents accounting for the harsh usage environment outdoors, and avoiding the need of maintenance.

[0042] Those skilled in the art will obviously appreciate that a number of changes and variants may be made to the arrangements as described hereinbefore to meet incidental and specific needs, without departure from the scope of the invention, as defined in the following claims.

[0043] The inventors carried out tests on embodiments of the sliding bearing (1) where the sheet of sliding material (5) was made of PTFE resin filled with MoS₂ in a percentage of 2% by weight and bronze in a percentage of 17% by weight of said sliding material (5). The tests consisted in oscillatory tests under imposed displacement and velocity, according to the test conditions illustrated in Table 1, wherein;

[0044] The vertical load is a constant vertical load passing through the sliding bearing (1); The average pressure is the contact pressure acting on the surface of the sheet of sliding material (5) that covers the convex upper sliding surface (4.1) of the sliding shoe (4) and faces the concave first sliding surface (2.1), and is calculated as the ratio between the vertical load and the area of said surface of the sheet of sliding material (5);

[0045] The amplitude is amplitude of the oscillation motion imposed to a specimen of sliding bearing (1) during the test, and is equal to half of the stroke of a cycle of motion (one cycle being composed of two strokes);

[0046] The velocity is relative velocity between the concave first plate (2) and the concave second plate (3) of the specimen of sliding bearing (1).

TABLE 1

vertical load [kN]	average pressure [MPa]	amplitude [m]	velocity [m/s]
796.4	15	0.13	0.001
		0.13	0.050
		0.13	0.100
		0.13	0.200
1592.8	30	0.13	0.001
		0.13	0.050
		0.13	0.100
		0.13	0.200
2389.2	45	0.13	0.001
		0.13	0.050
		0.13	0.100
		0.13	0.200
		0.13	0.500

[0047] In an oscillation test conducted under a vertical load equal to 796.4 kN passing through the sliding bearing (1), corresponding to an average pressure of 15 MPa applied to the sheet of sliding material (5), with the sliding bearing (1) moving at a relative velocity between the concave first plate (2) and the concave second plate (3) of 1 mm/s, or 50 mm/s, or 100 mm/s, or 200 mm/s, with at least 50% of the maximum oscillation amplitude allowed by the sliding bearing (1), the maximum increase in the coefficient of friction at the starting of the motion relative to the kinetic value of the coefficient of friction μ_{kin} is 20%. Figure 4 shows one example of the hysteretic horizontal force - deflection curves of the specimen of the sliding bearing (1) in the tests run at 15 MPa average pressure applied to the sheet of sliding material (5).

[0048] In an oscillation test conducted under a vertical load equal to 1592.8 kN passing through the sliding bearing (1), corresponding to an average pressure of 30 MPa applied to the sheet of sliding material (5), with the sliding bearing (1) moving at a relative velocity between the concave first plate (2) and the concave second plate (3) of 1 mm/s, or 50 mm/s, or 100 mm/s, or 200 mm/s, with at least 50% of the maximum oscillation amplitude allowed by the sliding bearing (1), the maximum increase in the coefficient of friction at the starting of the motion relative to the kinetic value of the coefficient of friction μ_{kin} is 8%. Figure 5 shows one example of the hysteretic horizontal force - deflection curves of the specimen of the sliding bearing (1) in the tests run at 30 MPa average pressure applied to the sheet of sliding material (5).

[0049] In an oscillation test conducted under a vertical load equal to 2389.2 kN passing through the sliding bearing (1), corresponding to an average pressure of 45 MPa applied to the sheet of sliding material (5), with the sliding bearing (1) moving at a relative velocity between the concave first plate (2) and the concave second plate (3) of 1 mm/s, or 50 mm/s, or 100 mm/s, or 200 mm/s, or 500 mm/s with at least 50% of the maximum oscillation amplitude allowed by the sliding bearing (1), the maximum increase in the coefficient of friction at the starting of the motion relative to the kinetic value of the coefficient of friction μ_{kin} is 17%. Figure 6 shows one example of the hysteretic horizontal force - deflection curves of the specimen of sliding bearing in the tests run at 45 MPa average pressure applied to the sheet of sliding material (5).

[0050] Comparative tests were carried out on specimens of the sliding bearings (1) incorporating sheets of sliding materials (5) at the state of the art and available on the market.

[0051] An example of the hysteretic horizontal force - deflection curve of a specimen of the sliding bearing (1) wherein sheet of the sliding material (5) is made of unfilled PTFE resin is shown in Figure 7. The increase in the coefficient of friction at the starting of the motion relative to the kinetic value of the coefficient of friction μ_{kin} is 122%.

[0052] Another example of the hysteretic horizontal force - deflection curve of a specimen of the sliding bearing (1) wherein the sheet of the sliding material (5) is made of PTFE resin filled with bronze is shown in Figure 8. The increase in the coefficient of friction at the starting of the motion relative to the kinetic value of the coefficient of friction μ_{kin} is 78%.

[0053] Another example of the hysteretic horizontal force - deflection curves of a specimen of the sliding bearing (1) wherein sheet of the sliding material (5) is made of a polyamide resin is shown in Figure 9. The increase in the coefficient of friction at the starting of the motion relative to the kinetic value of the coefficient of friction μ_{kin} is 155%.

[0054] In this context the kinetic coefficient of friction μ_{kin} may be determined, in accordance with the European Standard EN 15129:2009 "Anti-seismic devices" from the diagrammatic force - displacement plot (see Figure 10) obtained

in one cycle of a displacement or deflection test as $\mu_{kin} = A/(4 \times V \times d_b)$, where A is the area of the force - displacement loop, V is the vertical load acting through the bearing and d_b is the displacement amplitude.

5 Claims

1. A sliding bearing (1) adapted to provide ground movement protection to a construction, comprising a first plate (2), adapted to be installed to a construction (B), having a first sliding surface (2.1) in a concave form and a second plate (3), adapted to be installed among foundation (A) of the construction, having a second sliding surface (3.1) in a concave form, and a sliding shoe (4) positioned between the first plate (2) and the second plate (3), wherein the sliding shoe (4) has an upper sliding surface (4.1) in a convex form, in contact with the first sliding surface (2.1) and a lower sliding surface (4.2) in a convex form, in contacted with the second sliding surface (3.1), wherein the first plate (2), the second plate (3) and the sliding shoe (4) are capable of sliding with pendulum motion relative to each other in response to a ground movement forces, **and characterized in that** a sheet of sliding material (5) covers first sliding surface (2.1) and upper sliding surface (4.1) comprising; PTFE resin filled with molybdenum disulfide MoS₂ in a maximum amount of 2.5% by weight of the sliding material (5).
2. A sliding bearing (1) as in claim 1, **characterized in that** the sliding material (5) covers second sliding surface (3.1) and lower sliding surface (4.2).
3. A sliding bearing (1) as in claim 1 or 2, **characterized in that** the amount of molybdenum disulfide is 2.0% by weight of the sliding material (5).
4. A sliding bearing (1) as in claim 1 or 2, **characterized in that** the PTFE resin is also filled with other solid lubricants to decrease sticking at rest between each sliding surfaces.
5. A sliding bearing (1) as in claim 1 or 2, **characterized in that** the amount of solid lubricants other than molybdenum disulfide is no more than 1.0% by weight of the sliding material (5).
6. A sliding bearing (1) as in claim 1 or 2, **characterized in that** the PTFE resin is also filled with bronze.
7. A sliding bearing (1) as in claim 6, **characterized in that** the amount of the bronze filler is between 15% and 20% by weight of the sliding material (5).
8. A sliding bearing (1) as in any one of the above claims, **characterized in that** sheet of the sliding material (5) is mounted to the sliding surfaces either as a sheet partially embedded in a corresponding seat formed on the sliding surfaces as a sheet applied using an adhesive or mechanical fastening means and forms the sliding surfaces.
9. A sliding bearing (1) as in any one of the above claims, **characterized in that** the breakaway value of the coefficient of friction between first sliding surface (2.1) and upper sliding surface (4.1) is less than 7%, when the mutual sliding speed of the said sliding surfaces (2.1, 4.1) is less than 1 mm/s and the contact pressure between the said sliding surfaces (2.1, 4.1) applied to the sliding bearing (1) is at least 15 MPa.
10. A sliding bearing (1) as in claims 2-9, **characterized in that** the breakaway value of the coefficient of friction between first sliding surface (2.1) and upper sliding surface (4.1), and between second sliding surface (3.1) and lower sliding surface (4.2) are less than 7%, when the mutual sliding speed of the said sliding surfaces (2.1, 4.1 - 3.1, 4.2) is less than 1 mm/s and the contact pressure between the said sliding surfaces (2.1, 4.1 - 3.1, 4.2) applied to the sliding bearing (1) is at least 15 MPa.
11. A sliding bearing (1) as in any one of the above claims, **characterized in that** the kinetic value of the coefficient of friction between first sliding surface (2.1) and upper sliding surface (4.1) is less than 8%, when the mutual sliding speed of the said sliding surfaces (2.1, 4.1) is less than 200 mm/s and the contact pressure between the said sliding surfaces (2.1, 4.1) applied to the sliding bearing (1) is at least 30 MPa.
12. A sliding bearing (1) as in claims 2-10, **characterized in that** the kinetic value of the coefficient of friction between first sliding surface (2.1) and upper sliding surface (4.1), and between second sliding surface (3.1) and lower sliding surface (4.2) are less than 8%, when the mutual sliding speed of the said sliding surfaces (2.1, 4.1 - 3.1, 4.2) is less than 200 mm/s and the contact pressure between the said sliding surfaces (2.1, 4.1 - 3.1, 4.2) applied to the sliding

bearing (1) is at least 30 MPa.

Patentansprüche

1. Ein Schiebelager (1) angepasst, um zu einer Konstruktion Bodenbewegungsschutz sicherzustellen, bestehend aus einer ersten Platte (2), angepasst zu einer Konstruktion (B) installiert zu werden, hat eine erste Schiebefläche (2.1) in einer konkaven Form und eine zweite Platte (3), angepasst zwischen Grundlage (A) einer Konstruktion installiert zu werden, hat eine zweite Schiebefläche (3.1) in einer konkaven Form, und einen Gleitschuh (4) aufgestellt zwischen einer ersten Platte (2) und zweiten Platte (3), wo der Gleitschuh (4) hat eine obere Schiebefläche (4.1) in einer konvexen Form, im Kontakt mit der ersten Schiebefläche (2.1) und einer unteren Schiebefläche (4.2) in einer konvexen Form, im Kontakt mit der zweiten Schiebefläche (3.1), wo die erste Platte (2), zweite Platte (3) und der Gleitschuh (4) rutschbar sind mit einer Pendelbewegung bezüglich zueinander auf eine Grundbewegungskraft, **und gekennzeichnet dadurch, daß** eine Platte von Schiebematerial (5) bedeckt die erste Schiebefläche (2.1) und obere Schiebefläche (4.1) beinhaltet; PTFE Harz gefüllt mit Molybdändisulfid MoS₂ in einer maximalen Menge von 2.5% nach Gewicht des Rutschmaterials (5).
2. Ein Schiebelager (1) nach Anspruch 1, **dadurch gekennzeichnet, daß** das Rutschmaterial (5) bedeckt zweite Schiebefläche (3.1) und untere Schiebefläche (4.2).
3. Ein Schiebelager (1) nach Anspruch 1 oder 2, **dadurch gekennzeichnet, daß** die Menge von Molybdändisulfid 2.0% ist nach Gewicht des Rutschmaterials (5).
4. Ein Schiebelager (1) nach Anspruch 1 oder 2, **dadurch gekennzeichnet, daß** PTFE Harz auch gefüllt ist mit anderen festen Schmiermitteln, um die Haftung in Ruhelage zwischen jeder Schiebefläche zu vermindern.
5. Ein Schiebelager (1) nach Anspruch 1 oder 2, **dadurch gekennzeichnet, daß** die Menge von festen Schmiermitteln außer Molybdändisulfid nicht höher als 1.0% nach Gewicht des Rutschmaterials (5) ist.
6. Ein Schiebelager (1) nach Anspruch 1 oder 2, **dadurch gekennzeichnet, daß** PTFE Harz auch gefüllt ist mit Bronze.
7. Ein Schiebelager (1) nach Anspruch 6, **dadurch gekennzeichnet, daß** die Menge von Bronzefüller zwischen 15% und 20% ist nach Gewicht des Rutschmaterials (5).
8. Ein Schiebelager (1) nach den vorhergehenden Ansprüche, **dadurch gekennzeichnet, daß** die Platte des Rutschmaterials (5) montiert ist zu den Rutschflächen entweder als seine Platte teilweise eingebettet in einem entsprechenden Sitz gebildet auf den Schiebeflächen als eine Platte angewandt durch Verwendung von einem Klebstoff oder mechanischen Befestigungsmitteln und bildet die Schiebeflächen.
9. Ein Schiebelager (1) nach den vorhergehenden Ansprüche, **dadurch gekennzeichnet, daß** der Trennungswert des Reibungskoeffizient zwischen erster Schiebefläche (2.1) und oberer Schiebefläche (4.1) kleiner ist als 7%, wenn gemeinsame Rutschgeschwindigkeit der besagten Schiebeflächen (2.1, 4.1) kleiner ist als 1 mm/s und der Kontaktdruck zwischen besagten Schiebeflächen (2.1, 4.1) angewandt zum Schiebelager (1) mindestens 15 MPa ist.
10. Ein Schiebelager (1) nach in Ansprüchen 2 bis 9, **dadurch gekennzeichnet, daß** der Trennungswert des Reibungskoeffizient zwischen erster Schiebefläche (2.1) und oberer Schiebefläche (4.1), und zwischen zweiter Schiebefläche (3.1) und unterer Schiebefläche (4.2) kleiner ist als 7%, wenn gemeinsame Rutschgeschwindigkeit der besagten Schiebeflächen (2.1, 4.1 - 3.1, 4.2) kleiner ist als 1 mm/s und der Kontaktdruck zwischen besagten Schiebeflächen (2.1, 4.1-3.1, 4.2) angewandt zum Schiebelager (1) mindestens 15 MPa ist.
11. Ein Schiebelager (1) nach den vorhergehenden Ansprüche, **dadurch gekennzeichnet, daß** der kinetische Wert des Reibungskoeffizient zwischen erster Schiebefläche (2.1) und oberer Schiebefläche (4.1) kleiner ist als 8%, wenn gemeinsame Rutschgeschwindigkeit der besagten Schiebeflächen (2.1, 4.1) kleiner ist als 200 mm/s und der Kontaktdruck zwischen besagten Schiebeflächen (2.1, 4.1) angewandt zum Schiebelager (1) mindestens 30 MPa ist.
12. Ein Schiebelager (1) nach Ansprüche 2 bis 10, **dadurch gekennzeichnet, daß** der kinetische Wert des Reibungskoeffizient zwischen erster Schiebefläche (2.1) und oberer Schiebefläche (4.1), und zwischen zweiter Schiebefläche (3.1) und unterer Schiebefläche (4.2) kleiner ist als 8%, wenn gemeinsame Rutschgeschwindigkeit der besagten

Schiebeflächen (2.1, 4.1 - 3.1, 4.2) kleiner ist als 200 mm/s and der Kontaktdruck zwischen besagten Schiebeflächen (2.1, 4.1 - 3.1, 4.2) angewandt zum Schiebelager (1) mindestens 30 MPa ist.

5 Revendications

1. Palier lisse (1) adapté pour fournir une protection contre le mouvement du sol à une construction, comprenant une première plaque (2), adaptée pour être installée sur une construction (B), ayant une première surface de glissement (2.1) en forme concave et une seconde plaque (3), adaptée à être installée parmi la fondation (A) de la construction, ayant une seconde surface de glissement (3.1) sous une forme concave, et un patin de glissement (4) positionné entre la première plaque (2) et la seconde plaque (3), dans lequel le patin de glissement (4) a une surface de glissement supérieure (4.1) dans une forme convexe, en contact avec la premier surface de glissement (2.1) et une surface de glissement inférieure (4.2) dans une forme convexe, en contact avec la seconde surface de glissement (3.1), dans lequel la première plaque (2), la seconde plaque (3) et le patin de glissement (4) peuvent glisser avec un mouvement de pendule l'un par rapport à l'autre en réponse à des forces de déplacement de sol, et **caractérisé en ce qu'une** feuille coulissante matériau (5) couvre la première surface de glissement (2.1) et la surface de glissement supérieure (4.1) comprenant; résine de PTFE remplie de disulfure de molybdène MoS₂ dans une quantité maximale de 2,5% en poids du matériau de glissement (5).
2. Palier lisse (1) selon la revendication 1, **caractérisé en ce que** le matériau de glissement (5) recouvre la seconde surface de glissement (3.1) et la surface de glissement inférieure (4.2).
3. Palier lisse (1) selon la revendication 1 ou 2, **caractérisé en ce que** la quantité de bisulfure de molybdène est de 2,0% en poids du matériau de glissement (5).
4. Palier lisse (1) selon la revendication 1 ou 2, **caractérisé en ce que** la résine PTFE est également remplie d'autres lubrifiants solides pour diminuer le collage au repos entre chaque surface de glissement.
5. Palier lisse (1) selon la revendication 1 ou 2, **caractérisé en ce que** la quantité de lubrifiants solides autres que le bisulfure de molybdène ne dépasse pas 1,0% en poids du matériau de glissement (5).
6. Palier lisse (1) selon la revendication 1 ou 2, **caractérisé en ce que** la résine PTFE est également remplie de bronze.
7. Palier lisse (1) selon la revendication 6, **caractérisé en ce que** la quantité de l'apport de type bronze est comprise entre 15% et 20% en poids du matériau de glissement (5).
8. Palier lisse (1) selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la feuille de matériau coulissant (5) est montée sur les surfaces de glissement soit sous la forme d'une feuille partiellement encastrée dans un siège correspondant formé sur les surfaces de glissement appliqué à l'aide d'un moyen de fixation adhésif ou mécanique et forme les surfaces de glissement.
9. Palier lisse (1) selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la valeur de rupture du coefficient de frottement entre la première surface de glissement (2.1) et la surface de glissement supérieure (4.1) est inférieure à 7% lorsque la vitesse desdites surfaces de glissement (2.1, 4.1) est inférieure à 1 mm / s et la pression de contact entre lesdites surfaces de glissement (2.1, 4.1) appliquée sur le palier lisse (1) est d'au moins 15 MPa.
10. Palier lisse (1) selon les revendications 2-9, **caractérisé en ce que** la valeur de rupture du coefficient de frottement entre la première surface de glissement (2.1) et la surface de glissement supérieure (4.1) et entre la seconde surface de glissement (3.1) et la surface de glissement inférieure (4.2) est inférieure à 7%, lorsque la vitesse de glissement mutuel desdites surfaces de glissement (2.1, 4.1 - 3.1, 4.2) est inférieure à 1 mm / s et la pression de contact entre lesdites surfaces de glissement (2.1, 4.1-3.1, 4.2) appliquées au palier lisse (1) est d'au moins 15 MPa.
11. Palier lisse (1) selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la valeur cinétique du coefficient de frottement entre la première surface de glissement (2.1) et la surface de glissement supérieure (4.1) est inférieure à 8%, lorsque la vitesse de coulissement mutuel desdites surfaces de glissement (2.1, 4.1) est inférieure à 200 coups / s et la pression de contact entre lesdites surfaces de glissement (2.1, 4.1) appliquée au

EP 3 158 148 B1

palier lisse (1) est d'au moins 30 MPa .

12. Palier lisse (1) selon les revendications 2-10, **caractérisé en ce que** la valeur cinétique du coefficient de frottement entre la première surface de glissement (2.1) et la surface de glissement supérieure (4.1) et entre la seconde surface de glissement (3.1) et la surface de glissement inférieure (4.2) est inférieure à 8%, lorsque la vitesse de coulissement mutuel desdites surfaces de glissement (2.1, 4.1 - 3.1, 4.2) est inférieure à 200 mm / s et la pression de contact entre lesdites surfaces de glissement (2.1, 4.1 - 3.1, 4.2) appliquée au palier lisse (1) est d'au moins 30 MPa.

5

10

15

20

25

30

35

40

45

50

55

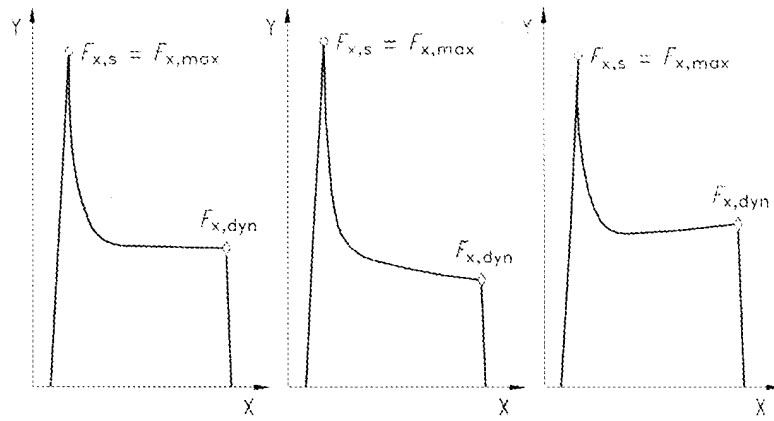


Figure 1

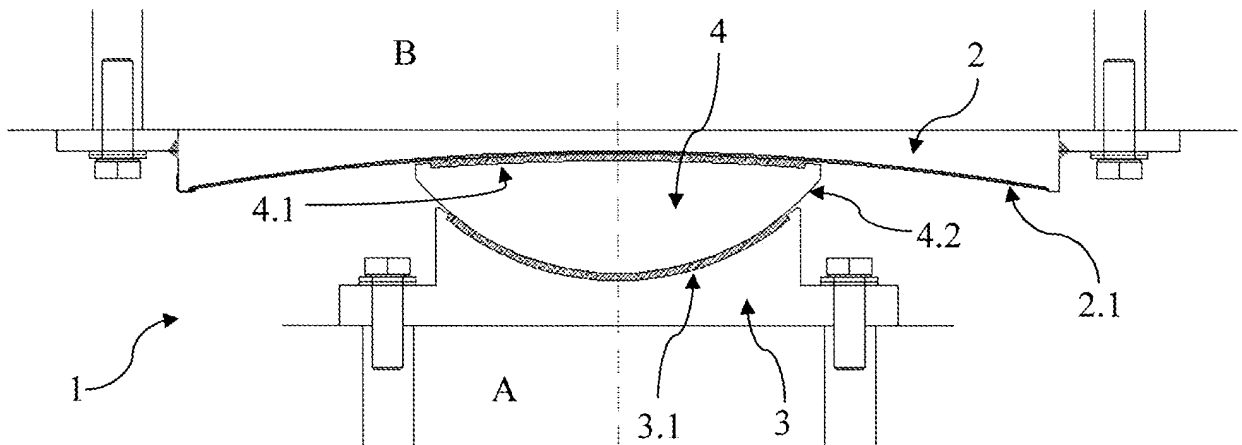


Figure 2

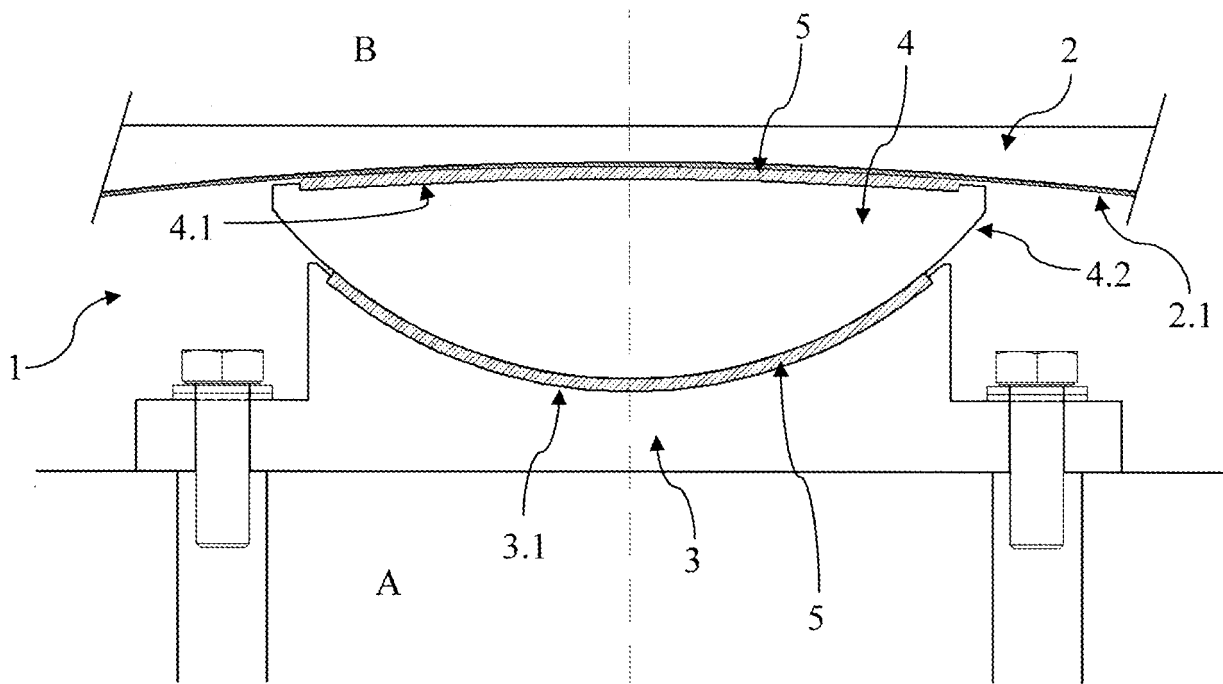


Figure 3

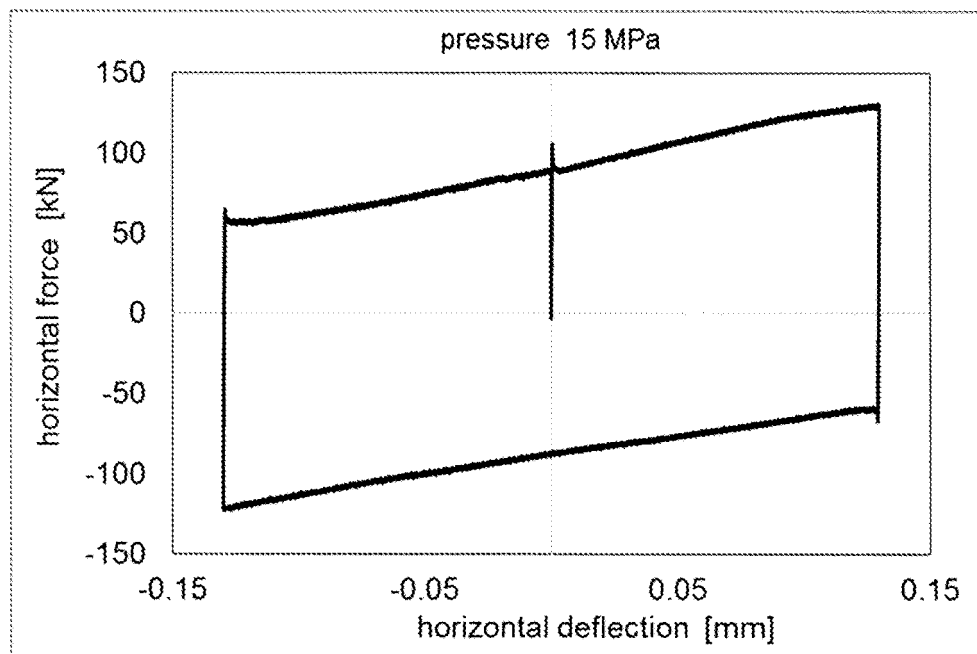


Figure 4

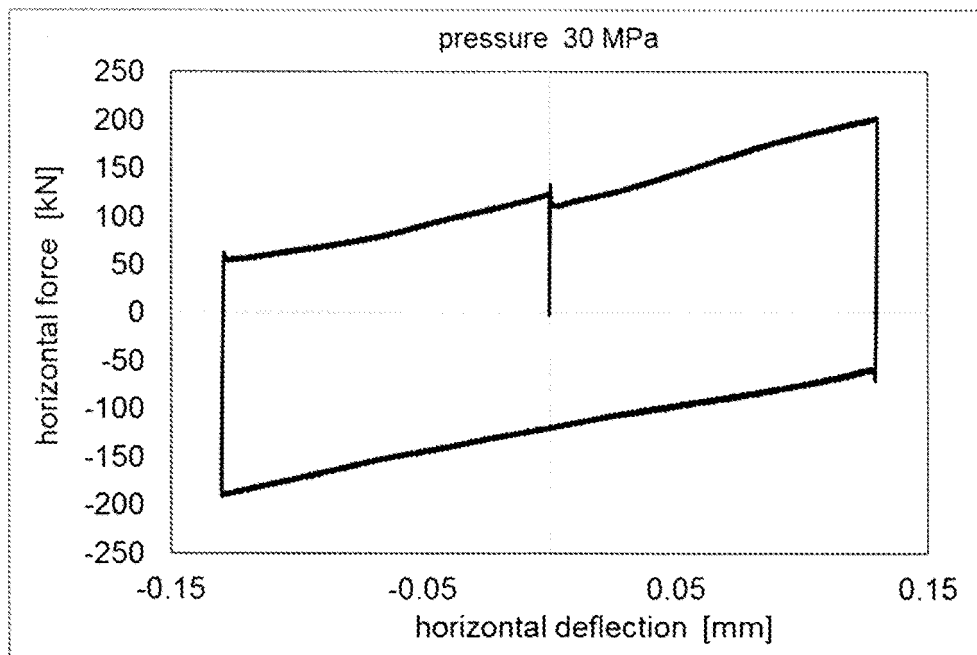


Figure 5

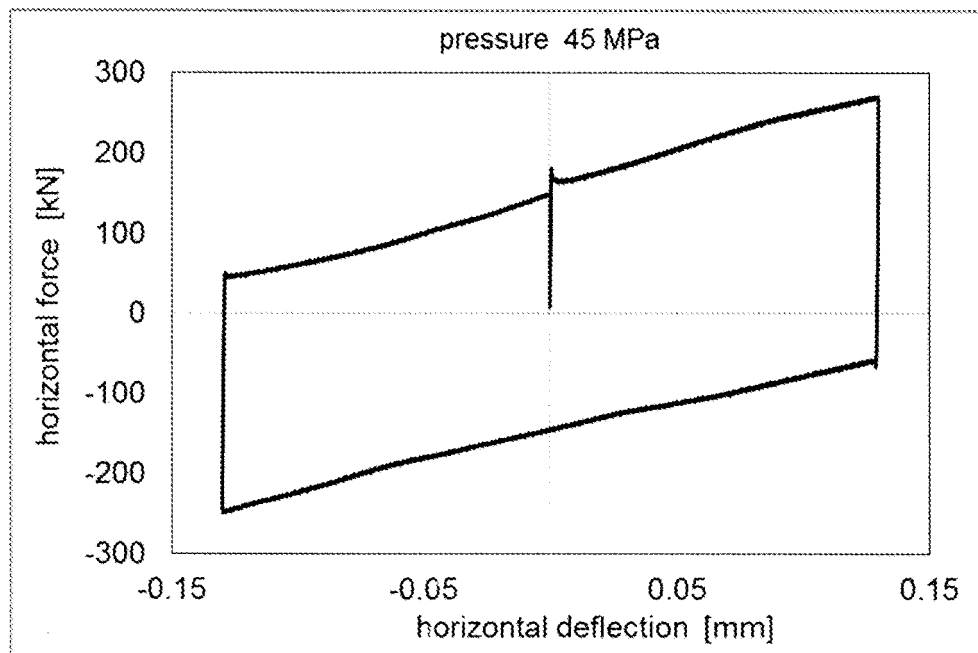
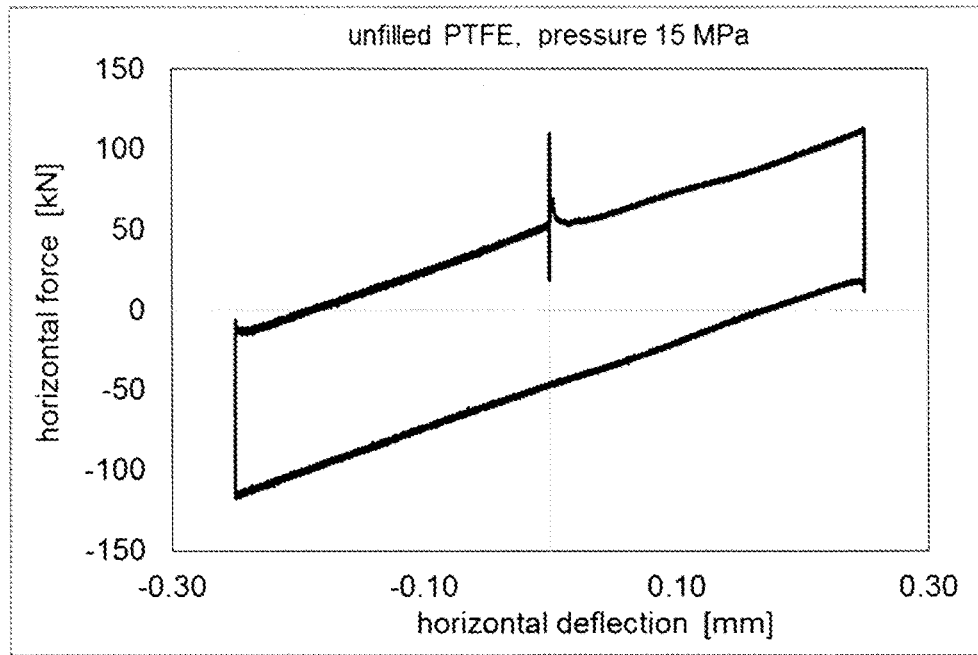
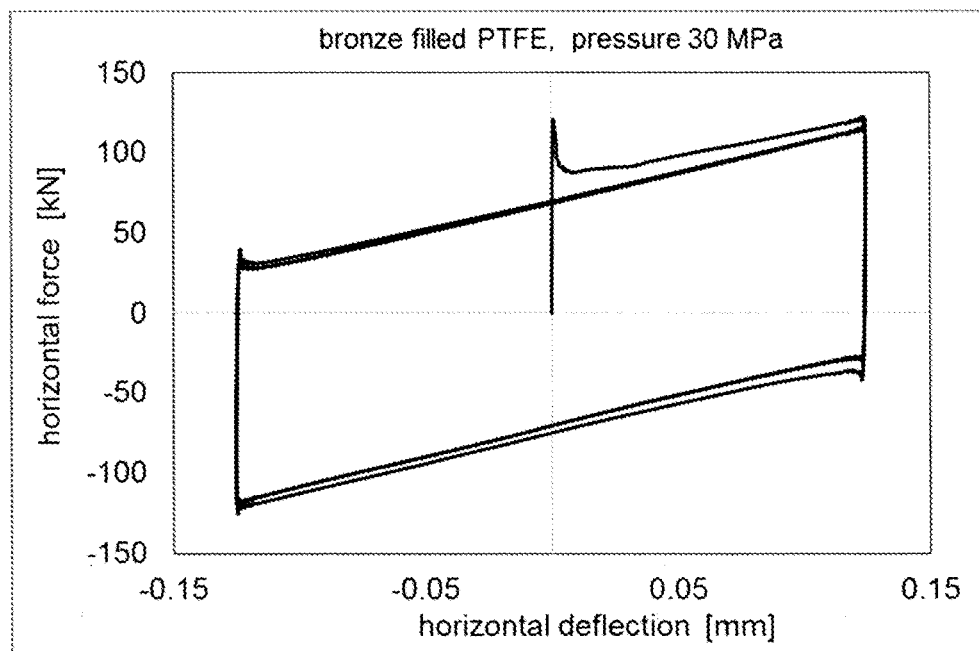


Figure 6

**Figure 7****Figure 8**

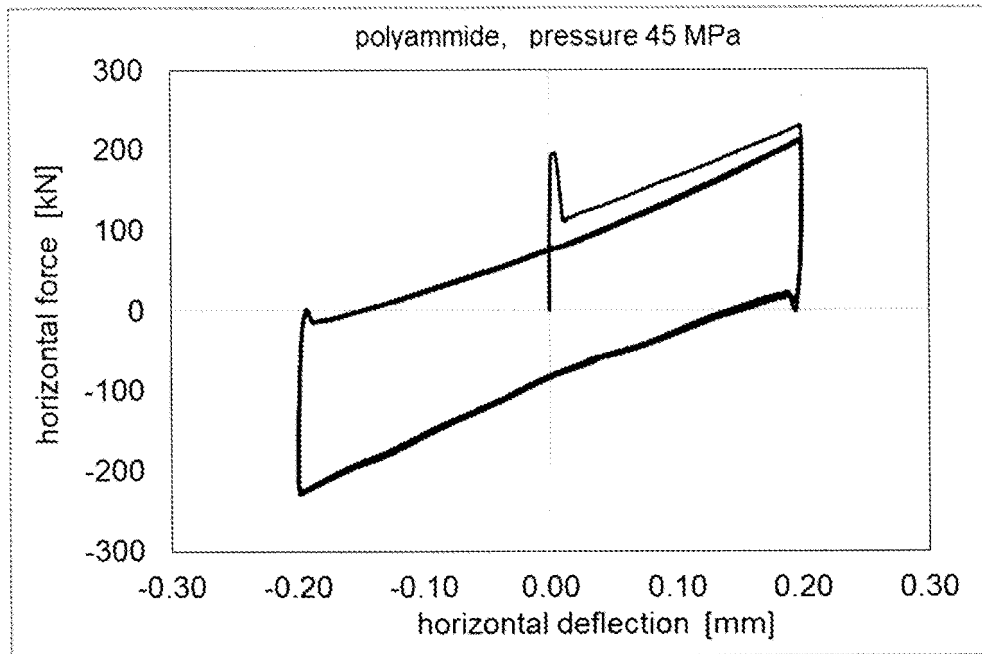


Figure 9

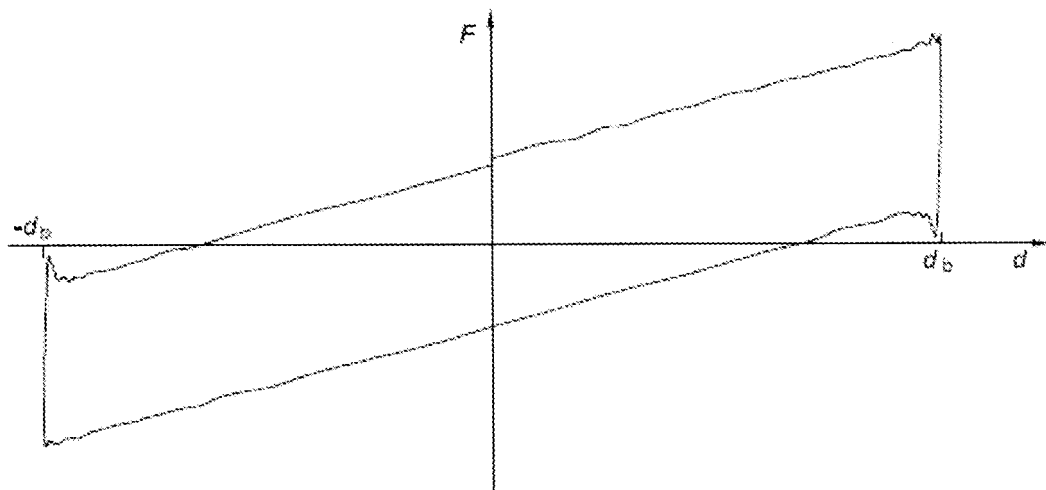


Figure 10

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- WO 2012114246 A1 [0003]
- WO 2013191356 A1 [0003]
- EP 2208913 A1 [0003]

Non-patent literature cited in the description

- **C.M. POOLEY ; D. TABOR.** Friction and Molecular Structure: The Behaviour of Some Thermoplastics. *Proceedings of the Royal Society of London. Series A, Mathematical and Physical Sciences*, 1972, vol. 329 (1578), 251-274 [0015]