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(54) **Title:** TEXTURIZED SEAL

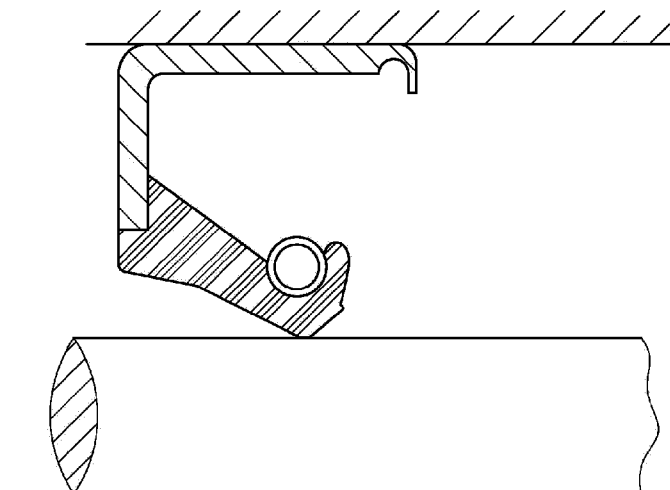


Figure 1

(57) **Abstract:** The present invention relates to an elastomeric sealing element and to a method of manufacturing an elastomeric sealing element (20) having a contact surface (25) that is provided with a surface texture. According to the invention the contact surface (25) is provided with a wear-resistant coating and the surface texture is introduced into the coating.

Texturized Seal

Technical field

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The present invention relates to the field of dynamic seals, for sealing a gap between relatively moving components. More specifically, the present invention relates to an elastomeric seal having a texturized contact surface, and to a method for manufacturing the seal.

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Background

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Seals are used to prevent leakage between two environments and/or to prevent the ingress of particulate contaminants from one environment to another. In a dynamic seal, the seal has a surface that is in sliding contact with a moving counterface, and provides dynamic sealing. When the counterface is stationary, the seal provides static sealing.

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One example of a dynamic seal is an oil seal, which may be mounted between a shaft and the bore of a bearing housing. Typically, the oil seal has an elastomeric sealing element with at least one lip that bears against the shaft surface. To ensure static and dynamic tightness, the seal lip must remain in contact with the counterface. Therefore, friction occurs during dynamic conditions. The friction generates heat, leading to energy losses. The friction also leads to wear of the elastomeric material, which will ultimately cause a loss of sealing function.

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To reduce friction, lubrication of the contact interface is important. During dynamic conditions, a thin elasto-hydrodynamic oil film builds up between the seal lip and the moving counterface. The oil film reduces the frictional forces. Therefore, one way of reducing friction in a dynamic seal is to ensure that the contact interface remains well lubricated.

A number of solutions have been proposed. For example, the movable counterface may be provided with a texture that facilitates hydrodynamic pumping of the lubricant (oil) in the direction of the seal lip. One such texture is disclosed in US3572730, whereby triangular asperities are provided on a rotatable counterface, to improve reverse pumping. It is also possible to provide such a texture on the seal lip.

In addition, a hydrodynamic pumping action is obtainable by means of helical ribs on a contact surface or surfaces of a seal lip. In US 6276691, for example, helical ribs are provided at both the oil side of a seal lip and at the air side. The main function of the helices is to prevent leakage, by pumping oil to the oil side of the seal. The air-side helices pump the oil towards the seal lip, which therefore has the additional effect of keeping the lip contact interface supplied with lubricant.

Dynamic seals are also used in reciprocating applications, and it has been suggested to provide the contact surface of such seals with a surface texture. A variety of textures are proposed in the technical paper "Effects of Surface Dimples on Friction Coefficient of Reciprocating Model Lip Seals", published in Koyo Engineering Journal English Edition No. 164E. The results of the tests show that friction coefficient can be reduced by providing micro-dimples in the contact surface of a silicon rubber seal. The reduction is attributed to improved oil-film formation.

Thus, the provision of a functional texture on a seal lip can have several benefits in terms of improving lubrication and/or reducing leakage. A drawback, however, of texturizing a relatively soft material such as a rubber, is that the texture will wear off relatively quickly. Even if friction is minimized by the methods described above, some friction and wear is inevitable, particularly if the lip is preloaded to ensure that contact with the counterface is maintained. Preloading is common practice when a low-viscous fluid is being retained. Also, in shaft seals, the lip is generally preloaded to compensate for shaft-to-bore misalignment and/or dynamic run-out.

One solution for reducing wear is to provide a wear-inhibiting coating on the surface texture. In US 2004/0113366, for example, a PTFE coating is suggested. A disadvantage of providing a coating on a texturized surface, however, is that the coating will lessen the texture. Indentations become less deep and protrusions become less high. The coating must therefore be provided in a thin layer, which increases the likelihood that the coating will get worn off. Also, when the texturized surface comprises e.g. micro-dimples, even a thin coating layer will clog the dimples, drastically impairing the functionality of the surface texture.

Consequently, there is room for improvement.

Summary

The present inventors have discovered that it is possible to provide the contact surface of an elastomeric sealing element with a wear-resistant surface texture, by introducing the texture into a wear-resistant coating that is applied on the contact surface.

In this way, the coating may be applied in a thickness that provides long-lasting resistance to wear, while the beneficial effects of the surface texture are reliably obtained, without any unpredictable clogging.

The present invention provides a method of manufacturing a coated elastomeric sealing element, the method comprising steps of;

- providing an elastomeric sealing element having a contact surface which, in use, is adapted to bear against a moveable counterface;
- providing a coating material on at least the contact surface; and
- processing the coating material to provide a textured coating on the contact surface.

Preferred elastomers for the sealing element include acrylate rubber, fluoro rubber, nitrile rubber, hydrogenated nitrile rubber, or mixtures of two or more

thereof. Preferably, the contact surface of the elastomeric sealing element, prior to application of the coating, is substantially smooth. This allows standard moulds to be used in the manufacture of the elastomeric sealing element.

- 5 In the step of coating, the coating material preferably comprises a polymeric material such as polyurethane or polytetrafluoroethylene. To provide increased wear resistance, the coating material suitably has a hardness of between 90 Shore A and 25 Shore D. Furthermore, the coating material is provided in a thickness that is sufficient to accommodate the height/depth of the texturing features to be
10 provided. The texturing features are distinct from mere surface roughness. They are deeper and may be specifically arranged on the surface to provide the beneficial effects.

Typically, the coating thickness lies between 0.05 and 1.00 mm. The thickness can
15 be measured by techniques known in the art and is measured from the contact surface of the elastomeric seal to an upper surface of the coating, which upper surface will bear against the counterface.

The texturing features may comprise indentations in the upper surface of the
20 coating. The indentations may be grooves or dimples with a depth of between 5 and 150 microns. An appropriate thickness for the coating is then 0.1 to 0.3 mm.

The dimples may be spherical, cylindrical, square, rectangular, triangular, hexagonal, or any other suitable shape. In some examples, the dimples are
25 provided in a predetermined array. The predetermined array may be a regular array, adapted to enhance oil film formation. The predetermined array may also be irregular, so as to provide a desired pressure differential across the contact interface, to promote pumping in a desired direction. The indentations may also be provided with a non-predetermined distribution.

30 Additionally or alternatively, the texturing features may comprise protrusions, whereby an upper surface of the protrusions coincides with the upper surface of

the coating. The protrusions may be formed by ridges, such as helical ribs. The ribs typically have a height of between 0.05 and 0.3 mm, whereby the coating may be provided in a thickness of 0.25 – 0.7 mm.

- 5 The protrusions may also be provided in a regular or irregular predetermined array, or with a non-predetermined distribution, as described above with reference to indentations. Likewise, the protrusions may be spherical in shape, or cylindrical, triangular, square, rectangular, etc. Typically, the protrusions in the array have a height of 5 to 150 microns and the coating is suitably provided in a
10 thickness of 0.15 to 0.35 mm.

In a first embodiment of the method according to the invention, the step of processing is carried out after a layer of coating material has been applied.

- 15 In some examples of the first embodiment, the texturing features as described above are created by removing material from the coating layer. Accordingly, the step of processing may comprise laser etching or machining the texturing features into the coating material.

- 20 In a further example, the coating material comprises a soluble filler and the step of processing comprises the dissolving soluble filler. For example, the soluble filler may contain sodium chloride crystals, which are removed to leave indentations in the surface of the coating, when they are washed (dissolved) away.

- 25 A deformation process may also be used to create the desired surface texture in the coating material. In one example, the step of processing comprises stamping the texturing features into the coating material.

- 30 Additionally or alternatively, the coating material may comprise a blowing agent. Blowing agents are used to produce bubbles in the coating material. If the bubble is formed close to the surface then it may be used to provide a void or dimple in the surface. If the bubble is below the surface then it may form a dome on the

surface of the coating layer. Blowing agents include physical blowing agents such as CFCs, HCFCs, hydrocarbons (e.g. pentane, isopentane, and cyclopentane) and solid or liquid CO₂. The bubble/foam-making process often requires heat initiation. Suitably, the step of processing comprises initiating the blowing agent.

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Chemical blowing agents such as isocyanate and water (which react to release CO₂) are especially useful for forming expanded polyurethanes. Other examples include azo-, hydrazine and other nitrogen-based materials and sodium bicarbonate.

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In one example, the blowing material may be distributed throughout the coating material and only selectively activated or initiated. In this way, the bubbles only form surface texture in a desired distribution on the coated surface.

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Where the material forming the coating is a polymeric material, it may be necessary to cure the coating material. In a still further example, the curing treatment may be selectively applied to the coating material. In this way, uncured material can be removed from the surface to provide a surface texture in a desired distribution on the coated surface.

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When curing is required, curing may be initiated before the step of processing the coating to create a surface texture. Thus the coating material can be hardened while the texture is formed. Preferably, if the step of processing comprises deformation and/or machining of the coating material, these operations are performed before curing is complete. In particular, stamping is suitably carried out while the coating is still uncured or only partially cured.

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In a second embodiment of the invention, the step of processing the coating to provide a textured coating is performed as part of the step of providing the coating material on the seal contact surface.

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In one example of the second embodiment, the step of processing comprises providing a non-bonding agent on one or more portions of the contact surface, prior to application of the coating material. Thus a textured coating is created in that at least the portions of the contact surface provided with the non-bonding agent have a reduced amount of coating material thereon.

In a further example of the second embodiment, the step of processing comprises masking one or more portions of the contact surface, prior to application of the coating material. The mask(s) used suitably constitute a "negative" of the desired surface texture.

The present invention also provides an elastomeric sealing element having a substantially smooth contact surface provided with a coating layer, wherein the coating layer has a surface texture comprising a plurality of dimples, protrusions, ribs and/or grooves.

The elastomeric sealing element may be adapted for use in a rotary seal, such as a shaft seal or a seal for a rolling element bearing, or may be adapted for use in a reciprocating seal. Such seals are well known in the art. Furthermore, an elastomeric sealing element according to the invention may be adapted for use in combination with a variety of lubricants such as oil, grease or water, depending on the application.

Brief description of the drawings

The present invention will now be described further with reference to the accompanying drawings, provided by way of example, in which:

Figure 1 shows a cross-section of part of a seal according to the invention. Figure 2 is a flowchart of a method according to the invention, used in the manufacture of the seal in Figure 1.

Detailed Description

Figure 1 shows an example of a shaft seal 10 comprising a metal casing 15 to which an elastomeric sealing lip 20 has been bonded. The seal is mounted in an annular gap between the bore of a bearing housing 30 and a shaft 35, whereby the sealing lip 20 has a contact surface 25 which bears against a counterface on the shaft 35. To ensure that the lip remains in contact with the shaft, the lip is preloaded with a garter spring 40. Furthermore, an interface between the contact surface 25 and the shaft 35 is lubricated with a grease (not shown).

The contact surface 25 is provided with a wear-resistant coating material and has a surface texture comprising texturing features. According to the invention, the texturing features are provided only in the coating material.

In the example of Figure 1, the texturing features provided on the contact surface are dimples. The dimples have a diameter of approximately 30 microns, a depth of 10 microns, and have an essentially cylindrical geometry. The dimples are provided in a regular array and cover approximately 20 percent of the contact surface area. The dimpled texture promotes the formation of a thicker oil film under elasto-hydrodynamic sealing conditions; i.e. when the lip contact surface 25 is in sliding contact with the shaft 35.

A method of manufacturing the seal of Figure 1 will now be explained, with further reference to the flowchart of Figure 2.

In a first step 210, the elastomeric sealing lip 20 is moulded from nitrile rubber in a standard mould. The standard mould has substantially smooth surfaces which are not adapted to create any kind of surface texture on a surface of the lip. The rubber lip is then cured.

In a second step 220, a polymer coating material comprising polyurethane is applied to a predetermined surface of the elastomeric lip 20, which predetermined

surface will serve as the lip contact surface 25 in use of the seal. The coating is sprayed onto the predetermined surface in a thickness of approximately 0.25 mm. The coating is then cured.

- 5 In a third step 230, the described array of micro-dimples are laser etched into the coated contact surface 25. A short-pulse Nd: YAG laser may be used, at a spot size of 30 microns.

10 After the coated contact surface 25 has been texturized, the seal 10 is further assembled as known in the art; i.e. the lip 20 is bonded to the metal casing 15 and the garter spring is fitted. Alternatively, the coated contact surface can be texturized after the elastomeric lip 20 has been bonded to the casing 15 and the garter spring 40 has been installed.

15 In use of the seal, the dimpled surface texture on the contact surface provides low friction under dynamic sealing conditions, as is known from conventional texturized seals. Unlike such conventional seals, a seal according to the invention has significantly greater wear resistance and is able to provide the beneficial functionality for a considerably greater duration.

20 A number of aspects/embodiments of the invention have been described. It is to be understood that each aspect/embodiment may be combined with any other aspect/embodiment. The invention may thus be varied within the scope of the accompanying patent claims.

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Claims:

1. A method for manufacturing a coated elastomeric sealing element, the method comprising steps of;
 - providing an elastomeric sealing element (20) having a contact surface (25) which, in use, is adapted to bear against a moveable counterface (35);
 - providing a coating material on at least the contact surface (25); and
 - processing the coating material to provide a textured coating on the contact surface (25).
2. The method according to claim 1, wherein the coating material comprises a polymeric material.
3. The method according to any of the proceeding claims, wherein the textured coating on the contact surface of the elastomeric sealing element has a mean thickness of from 0.1 to 1mm.
4. The method according to any preceding claim, wherein the step of processing is performed after the step of providing the coating material.
5. The method according to claim 4 wherein the step of processing comprises:
 - (i) laser etching a surface texture into the coating material; and/or
 - (ii) machining a surface texture into the coating material; and/or
 - (ii) stamping a surface texture into the coating material.
6. The method according to any preceding claim, wherein the coating material comprises a blowing agent and the step of processing comprises initiating the blowing agent.
7. The method according to claim 6, wherein initiating the blowing agent is carried out in a predetermined pattern on the coating material.

8. The method according to any preceding claim, wherein the coating material comprises a soluble filler and the step of processing comprises dissolving the soluble filler.

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9. The method according to any of claims 1 to 3, wherein the step of processing is performed simultaneously with the step of providing the coating material on the contact surface (25).

10 10. The method according to claim 9 wherein the step of processing comprises:

(i) providing a non-bonding agent onto one or more portions of the contact surface; such that when the coating material is applied on the contact surface, at least the portions of the contact surface provided with the non-bonding agent have a reduced amount of coating material thereon; and/or

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(ii) masking at least portions of the contact surface, such that unmasked portions have an increased amount of coating thereon.

11. The method according to any preceding claim, wherein the textured coating comprises a plurality of indentations and/or protrusions.

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12. The method according to any preceding claim, wherein the plurality of indentations and/or protrusions are formed in a predetermined array.

13. An elastomeric sealing element (20) having a contact surface (25) provided with:

25

(i) a wear-resistant coating, and

(ii) surface texturing features

characterized in that,

the surface texturing features are provided only in the wear-resistant coating.

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14. The elastomeric sealing element of claim 13, wherein the surface texturing features comprise dimples, protrusions, ribs and/or grooves.

15. A seal comprising an elastomeric sealing element (20) according to claim 14.

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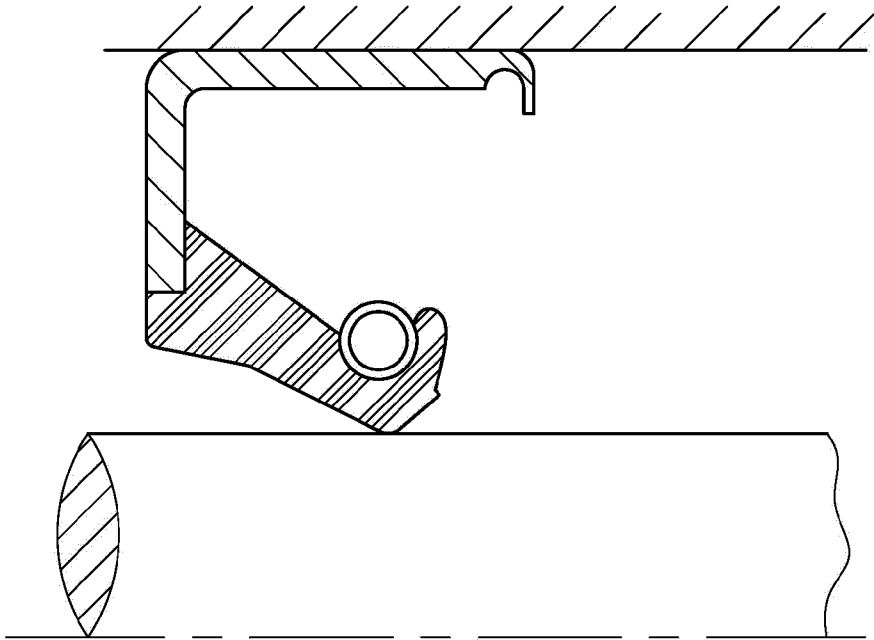


Figure 1

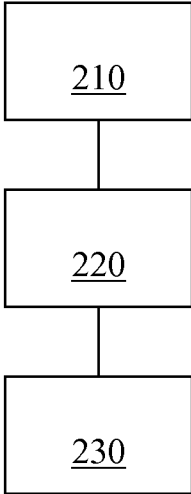


Figure 2

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/058492

A. CLASSIFICATION OF SUBJECT MATTER
INV. F16J15/32
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F16J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 10 2008 039805 A1 (KACO GMBH & CO KG [DE]) 25 February 2010 (2010-02-25) paragraphs [0005], [0006], [0017], [0024] - [0027] claims 2,3,5,11,21,22 figures 1-6	1-5,9-15
X	US 4 239 243 A (BAINARD DEAN R [US] ET AL) 16 December 1980 (1980-12-16) column 2, lines 24-28 column 2, lines 37-66 column 3, lines 16-19 figures 2-3	1-5, 11-15



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 102008039805 A1	25-02-2010	NONE	
US 4239243 A	16-12-1980	NONE	