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(54) Title: CONNECTING ROD FOR AN INTERNAL COMBUSTION ENGINE WITH ADJUSTABLE COMPRESSION RATIO

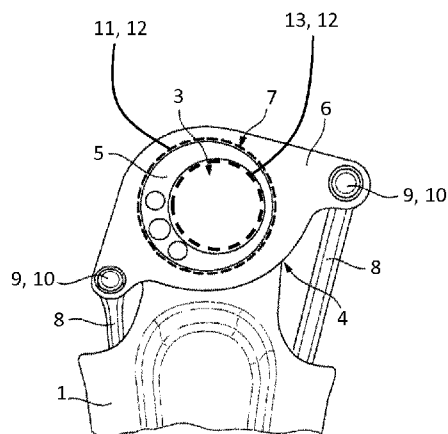


Fig. 2

(57) Abstract: The present invention refers to a connecting rod (1) for an internal combustion engine with an adjustable compression ratio comprising a crank pin bearing eye (2) for connecting the connecting rod (1) to a crank shaft of the internal combustion engine, a connecting rod bearing eye (3) for connecting said connecting rod (1) to a cylinder piston of said internal combustion engine and an eccentric element adjustment device (4) for adjusting the distance between said crank pin bearing eye (2) and said connecting rod bearing eye (3), wherein said eccentric element adjustment device (4) comprises an eccentric element (5) including said connecting rod bearing eye (3), an eccentric element lever (6) and eccentric element rods (8) engaging the eccentric element lever (6), wherein said eccentric element rods (8) are loaded with a force generated by hydraulic pressure in hydraulic cavities (9), wherein an outer surface (11) of the eccentric element (5) and/or an inner surface (12) at the border of the connecting rod bearing eye (3) is provided with a texture (10).



DESCRIPTION**Title**

Connecting rod for an internal combustion engine with adjustable compression ratio

Background

Internal combustion engines with adjustable compression ratio are commonly known from the prior art.

By way of example, prior art documents DE 10 2012 020 999 A1, DE 10 2013 014 090 A1 and DE 10 2005 055 199 A1 disclose internal combustion engines with a cylinder and a crank shaft coupled with each other by means of a connecting rod having an adjustable effective length e.g. in order to increase fuel efficiency of the internal combustion engines under varying loads.

The connecting rod comprises a crank pin bearing eye for connecting the connecting rod to the crank shaft on the one hand and a connecting rod bearing eye for connecting the connecting rod to a cylinder piston by using a piston pin on the other hand. In order to adjust the effective length of the connecting rod, the connecting rod comprises an eccentrical element adjustment device for adjusting the effective distance between the crank pin bearing eye and the connecting rod bearing eye. For this purpose, the eccentrical element adjustment device comprises an eccentrical element including the connecting rod bearing eye, an eccentrical element lever non-rotatably connected to the eccentrical element and two eccentrical element rods engaging the eccentrical element lever. The eccentrical element rods are operatively connected to hydraulic cavities in the body of the connecting rod in order to generate a force onto the eccentrical element rods generated by hydraulic pressure. The eccentric element lever comprises a through bore in which the eccentrical is mounted.

Consequently, the eccentrical element comprises an outer surface being in mechanical contact with the inner wall of the through hole of the eccentric element lever and the through hole of connecting rod bearing eye. Furthermore, the eccentrical element comprises an inner surface at the connecting rod bearing eye being in mechanical contact with the outer surface of the piston pin.

The eccentrical element may be subjected to an increased wear and friction due to the above mentioned mechanical contacts. Disadvantageously, the foregoing leads to a decreased lifetime of the eccentrical element and therefore of the whole connecting rod.

A solution is to provide a Diamond like Carbon (DLC) coating on the components, but a DLC coating is comparatively expensive and would therefore increase the components cost.

Summary of invention

It is therefore an object of the present invention to provide a connecting rod for an internal combustion engine machine with an adjustable compression ratio and a corresponding combustion engine machine with less wear at the contact surfaces of the eccentrical element and an extended lifetime which is more cost-efficient.

The object of the present invention is achieved by a connecting rod for an internal combustion engine with an adjustable compression ratio comprising a crank pin bearing eye for connecting the connecting rod to a crank shaft of the internal combustion engine, a connecting rod bearing eye for connecting the connecting rod to a cylinder piston of the internal combustion engine and an eccentrical element adjustment device for adjusting the distance between the crank pin bearing eye and the connecting rod bearing eye, wherein the eccentrical element adjustment device comprises an eccentrical element including the connecting rod bearing eye, an eccentrical element lever and eccentrical element rods engaging the eccentrical element lever, wherein the eccentrical element rods are loaded with a force generated by hydraulic pressure in hydraulic cavities, wherein an outer surface of the eccentric element and/or an inner surface at the connecting rod bearing eye is provided with a texture.

According to the present invention, it is thereby advantageously possible to provide less mechanical wear and friction at the inner and/or outer surfaces of the eccentrical element due to a better lubrication effect, so that an improved lifetime can be achieved. The better lubrication effect arises from the textured surfaces as the texture leads to a stabilized lubrication film in the lubrication gap between both components. Furthermore, heat in the contact zone between the inner surface of the eccentrical element and the outer surface of the piston pin which connects the eccentrical element to the cylinder piston or between the inner surface of the connecting rod bearing eye and the outer surface of the eccentrical element will be reduced due to the better lubrication effect.

According to a preferred embodiment of the present invention, the said texture comprises laser-structured surface. This has the advantage that the texture can be provided on the eccentric element in a comparatively simple and cost-efficient manner. The texture and in particular said laser-structured surface comprises a plurality of melt craters generated during the laser treatment.

According to a preferred embodiment of the present invention, the texture comprises a plurality of dimples each providing a potential lubrication reservoir. Advantageously, the volume of the dimples and the dimple density allow the eccentric element to support higher pressures due to the compression of oil in the dimples. Furthermore, a dry contact between the surfaces of the components is avoided due to the better lubrication, so that wear is reduced. Preferably, the dimples have a diameter between 50 to 110 micrometers and preferably of around 74 micrometers. Particularly preferably, the dimples have a depth between 3 to 10 micrometers and preferably of around 5 micrometers.

According to a preferred embodiment of the present invention, said texture comprises mechanical-structured surface, more preferably produced by lapping or grinding.

According to a preferred embodiment of the present invention, the outer surface of the eccentric element and/or the inner surface at the connecting rod bearing eye is provided with a coating. The coating preferably comprises a carbon-based coating, e.g. Diamond like Carbon (DLC) coating. The coating is applied e.g. by physical or chemical vapour deposition (PVD or CVD), plasma spray or the like.

Another subject of the present invention is an internal combustion engine with an adjustable compression ratio comprising at least one cylinder and a crank shaft at which at least one connecting rod engages, characterized in that the at least one connecting rod is a connecting rod according to the present invention.

These and other characteristics, features and advantages of the present invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings, which illustrate, by way of example, the principles of the invention. The description is given for the sake of example only, without limiting the scope of the invention. The reference figures quoted below refer to the attached drawings.

Brief description of the drawings

Figure 1 illustrates schematically an exemplary connecting rod for an internal combustion engine having an adjustable compression ratio as known from the prior art

Figure 2 illustrates schematically a detailed view of a connecting rod for an internal combustion engine with an adjustable compression ratio according to an exemplary embodiment of the present invention.

Figure 3 shows a detailed view of the eccentrical element for the connecting rod according to the exemplary embodiment of the present invention

Detailed description

The present invention will be described with respect to particular embodiments and with reference to certain drawings but the invention is not limited thereto but only by the claims. The drawings described are only schematic and are non-limiting. In the drawings, the size of some of the elements may be exaggerated and not drawn on scale for illustrative purposes.

Where an indefinite or definite article is used when referring to a singular noun, e.g. “a”, “an”, “the”, this includes a plural of that noun unless something else is specifically stated.

Furthermore, the terms first, second, third and the like in the description and in the claims are used for distinguishing between similar elements and not necessarily for describing a sequential or chronological order. It is to be understood that the terms so used are interchangeable under appropriate circumstances and that the embodiments of the invention described herein are capable of operation in other sequences than described or illustrated herein.

In **figure 1**, an exemplary connecting rod for an internal combustion engine having an adjustable compression ratio as known from the prior art is shown.

The connecting rod 1 is provided for connecting a crank shaft (not shown) of the internal combustion engine with a cylinder piston (not shown) of the internal combustion engine. For this approach, the connecting rod 1 comprises a crank pin bearing eye 2 for connecting the connecting rod 1 to the crank shaft and a connecting rod bearing eye 3 for connecting the connecting rod 1 to the cylinder piston.

The internal combustion engine has an adjustment mechanism to adjust the compression ratio inside the cylinder. This is achieved by adjusting the effective length l_{eff} of the connect-

ing rod 1. In order to adjust the effective length l_{eff} of the connecting rod 1, the connecting rod 1 comprises an eccentrical element adjustment device 4 for adjusting the distance between the connecting rod bearing eye 3 and the crank pin bearing eye 2.

The eccentrical element adjustment device 4 comprises an eccentrical element 5 including the connecting rod bearing eye 3. The eccentrical element 5 is non-rotatable connected to a single-piece or multi-piece eccentrical element lever 6. The eccentrical element lever 6 comprises a through bore 7 in which the eccentrical element 5 is mounted. The connecting rod bearing eye 3 is located outside the rotational center of the eccentrical element 5, so that rotating the eccentrical element 5 varies the distance between the connecting rod bearing eye 3 and the crank pin bearing eye 2. The eccentrical element lever 6 is torque-proof and non-rotatable to the eccentrical element 5, so that the eccentrical element 5 can be rotated by turning the eccentrical element lever 6. For this approach, the eccentrical element lever 6 comprises two fixation points 9 provided on opposite sides of the eccentrical element lever 6. In each fixation point 9 one end of an eccentrical element rod 8 is mounted by means of a bolt 10. The other end of the eccentrical element rod 8 is operatively connected to a hydraulic cavity (not shown) provided in the body of the connecting rod 1. The hydraulic cavity is filled with oil in order to generate a force onto the eccentrical element rods 8 generated by hydraulic pressure, as known from the prior art. The function of the hydraulic system and the eccentrical element rods 8 rotating eccentrical element lever 6 explained e.g. in prior art document DE 10 2013 014 090 A1.

In **figure 2**, a detailed view of a connecting rod 1 for an internal combustion engine with an adjustable compression ratio according to an exemplary embodiment of the present invention is illustrated.

The connecting rod 1 according to the present invention substantially corresponds to the connecting rod 1, shown in figure 1, whereas the circumferential outer surface 11 of the eccentrical element 5 is provided with a texture 12. The same applies to the inner surface 13 of the eccentrical element 5 which is the border of the connecting rod bearing eye 3. The inner surface 13 of the eccentrical element 5 is also provided with a texture 12.

In both cases, the texture 12 is formed by a plurality of dimples, wherein each dimple works as a potential lubrication reservoir. The dimples can be melt craters produced by laser treatment of the inner and outer surfaces 11, 13. It is conceivable that the dimples have a diameter between 50 to 110 micrometers, preferably around 74 micrometers and that the dimples have a depth between 3 to 10 micrometers, preferably around 5 micrometers.

In **figure 3**, a detailed view of the eccentrical element 5 for the connecting rod 1 according to the exemplary embodiment of the present invention is shown. It can be seen from figure 3 that the circumferential outer surface 11 of the eccentrical element 5 is provided with a texture 12 in the form of a plurality of dimples and that also the inner surface 13 of the eccentrical element 5 is provided with a texture 12 in the form of a plurality of dimples.

Preferably, the outer surface 11 of the eccentric element 5 and the inner surface 13 at the connecting rod bearing eye 3 is provided with a coating, e.g. a Diamond like Carbon (DLC) coating applied e.g. by physical or chemical vapour deposition (PVD or CVD).

Reference signs

- 1 connecting rod
- 2 crank pin bearing eye
- 3 connecting rod bearing eye
- 4 eccentric element adjustment device
- 5 eccentric element
- 6 eccentric element lever
- 7 through bore
- 8 eccentric element rod
- 9 fixation point
- 10 bolt
- 11 outer surface of the eccentric element
- 12 texture
- 13 inner surface of the eccentric element

PATENT CLAIMS

1. Connecting rod (1) for an internal combustion engine with an adjustable compression ratio comprising a crank pin bearing eye (2) for connecting the connecting rod (1) to a crank shaft of the internal combustion engine, a connecting rod bearing eye (3) for connecting said connecting rod (1) to a cylinder piston of said internal combustion engine and an eccentrical element adjustment device (4) for adjusting the distance between said crank pin bearing eye (2) and said connecting rod bearing eye (3), wherein said eccentrical element adjustment device (4) comprises an eccentrical element (5) including said connecting rod bearing eye (3), an eccentrical element lever (6) and eccentrical element rods (8) engaging the eccentrical element lever (6), wherein said eccentrical element rods (8) are actuated with a force generated by hydraulic pressure in hydraulic cavities (9), characterized in that an outer surface (11) of the eccentric element (5) and/or an inner surface (13) of the connecting rod bearing eye (3) is provided with a texture (12).
2. Connecting rod (1) according to claim 1, wherein said texture (12) comprises a laser-structured surface.
3. Connecting rod (1) according to claim 2, wherein said laser-structured surface comprises a plurality of craters.
4. Connecting rod (1) according to one of the preceding claims, wherein the texture (12) comprises a plurality of dimples each providing a potential lubricant reservoir.
5. Connecting rod (1) according to one of the preceding claims, wherein the dimples have a diameter between 50 to 110 micrometers and preferably of around 74 micrometers.
6. Connecting rod (1) according to one of the preceding claims, wherein the dimples have a depth between 3 to 10 micrometers and preferably of around 5 micrometers.
7. Connecting rod (1) according to claim 1, wherein said texture (12) comprises a mechanical-structured surface, more preferably produced by lapping or grinding.
8. Connecting rod (1) according to one of the preceding claims, wherein the outer surface (11) of the eccentric element (5) and/or the inner surface (13) of the connecting rod bearing eye (3) is provided with a coating.

9. Internal combustion engine with an adjustable compression ratio comprising at least one cylinder and a crank shaft at which at least one connecting rod (1) engages, characterized in that the at least one connecting rod (1) is a connecting rod (1) according to one of the preceding claims.

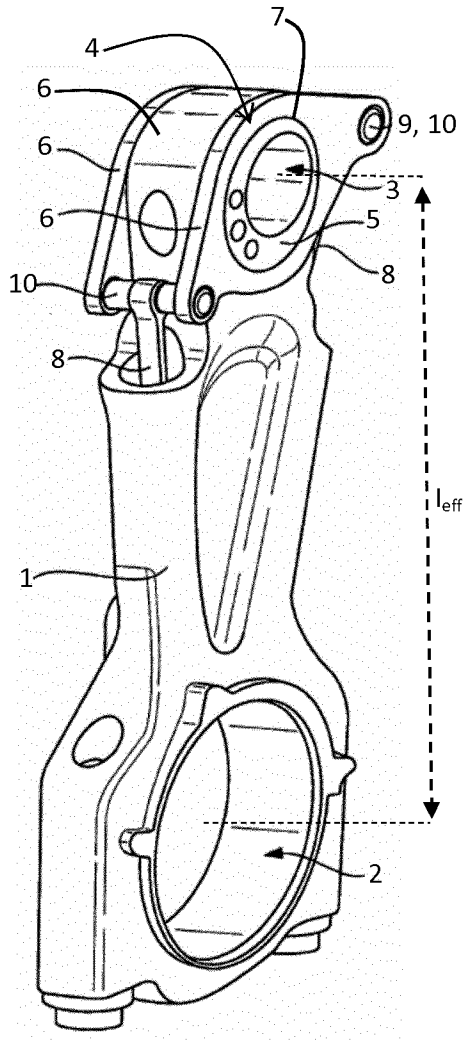


Fig. 1

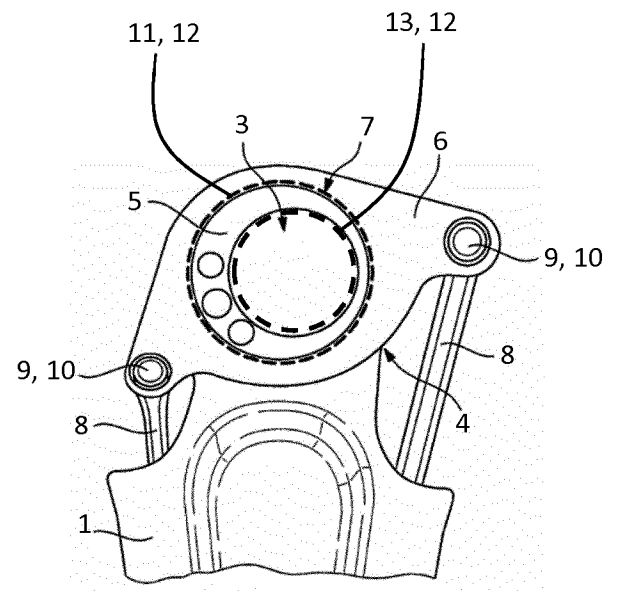


Fig. 2

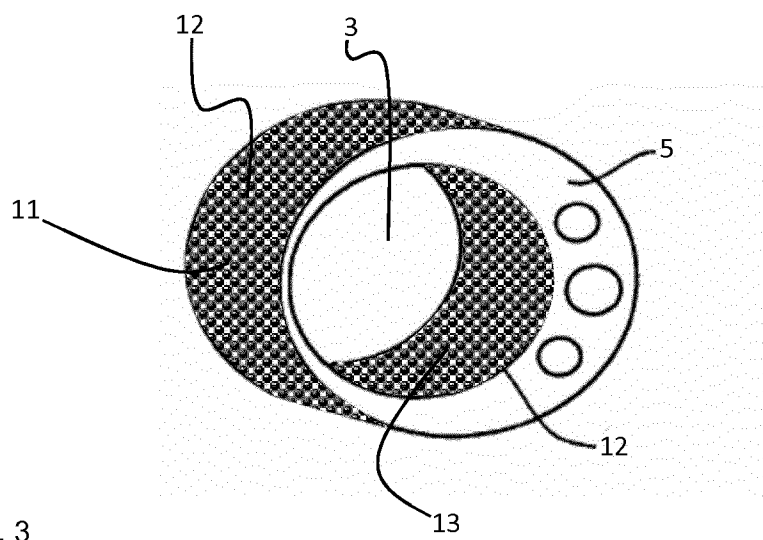


Fig. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/062280

A. CLASSIFICATION OF SUBJECT MATTER
INV. F02B75/04 F16C7/06
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)
F02B F16C

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 2014 103585 B3 (HILITE GERMANY GMBH [DE]) 3 September 2015 (2015-09-03) paragraph [0022] - paragraph [0026]; figures 1-5	1-9
X	DE 10 2013 223746 B3 (SCHAEFFLER TECHNOLOGIES GMBH [DE]) 8 January 2015 (2015-01-08) paragraph [0008] - paragraph [0013]; figures 1,7,9	1,4,7-9
X	DE 10 2013 224270 B3 (SCHAEFFLER TECHNOLOGIES GMBH [DE]) 8 January 2015 (2015-01-08) paragraph [0030]; figures 3,4,5	1,4,7,9
	-/--	



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

10 August 2017

Date of mailing of the international search report

24/08/2017

Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

International application No

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 10 2012 020999 A1 (FEV GMBH [DE]) 30 January 2014 (2014-01-30) cited in the application paragraph [0080]; figure 34 -----	1-9

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2017/062280

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 102014103585 B3	03-09-2015	NONE	
DE 102013223746 B3	08-01-2015	DE 102013223746 B3 WO 2015074649 A1	08-01-2015 28-05-2015
DE 102013224270 B3	08-01-2015	NONE	
DE 102012020999 A1	30-01-2014	CN 104797797 A DE 102012020999 A1 US 2015260094 A1 WO 2014019683 A1	22-07-2015 30-01-2014 17-09-2015 06-02-2014