

## Cantilever slide for installing and removing a rotor block

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### DESCRIPTION

#### Technical field

5 The invention relates to the field of rotary machines. It relates to an assembly/disassembly tool and to a method for moving a rotor block in a housing along the axis of rotation of the rotor contained in the rotor block.

Assembly/disassembly tools of this kind are used with exhaust turbochargers of pressure-charged internal combustion engines or comparable rotary machines, in which the rotor block can weigh over one hundred kilograms up to several tons.

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#### Prior art

Exhaust turbochargers are used to pressure-charge large internal combustion engines. These drive marine shipping or large emergency generating equipment.

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In order to service the exhaust turbocharger at intervals of several thousand working hours, the rotating parts must be removed from the housing. To do this in the case of conventional exhaust turbochargers, the multi-part housings must be removed and then the rotor must be lifted out of the housing in an axial direction by means of a crane. More specifically, the general practice for the disassembly of an exhaust turbocharger is to remove the compressor housing in order to be able to attach a boom of the crane above the center of gravity of the rotor block.

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In addition to the rotating parts of the shaft and of the turbine and compressor wheels connected to the shaft, the rotor block of an exhaust turbocharger also comprises the bearing parts, i.e. axial and radial bearings and internal bearing housing parts. This rotor block is also referred to as a cartridge. In the case of servicing, there is the possibility of completely replacing a cartridge of an exhaust turbocharger. This reduces the downtime of the exhaust turbocharger and hence of the internal combustion engine pressure-charged by means of the exhaust turbocharger. The effort required for the removal and reinsertion of the cartridge can be further reduced if the number of housing parts that has to be removed is as small as possible. It would be desirable, for example,

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not to have to remove the outer compressor housing, which is firmly integrated into the pipe system of the internal combustion engine by means of its large air outlet branch, and the entire turbine housing during the servicing work. Thus, it would only be necessary to remove the inner compressor housing, situated on the inlet side, in order to be able to pull the rotor block through the axial opening thereby exposed out of the compressor housing and the bearing housing and the gas outlet housing situated behind.

Various devices and methods for pulling and/or inserting rotors, rotor blocks or bearing components out of a housing are described in the prior art.

EP2610439A1, for example, discloses an apparatus for disassembling a turbine bearing or a segment thereof in a stationary turbomachine having a housing which can be divided in two. This apparatus comprises means for supporting the rotor to relieve the weight of the bearing parts to be removed. The apparatus furthermore comprises rail-type supports, along which the bearing parts to be removed can be moved.

JP10-220399 discloses an apparatus for disassembling a rotor of a pump, in which extension pieces are mounted on the shaft stubs, which extension pieces are mounted movably on a support and with the aid of which the rotor can be pushed out of the housing to enable it then to be lifted by a crane.

US2011/0052426A1 discloses an apparatus for disassembling a rotor of a large compressor, which comprises a bilateral support for the rotor, wherein extension elements are provided on the rear side of the rotor in order to ensure support while the rotor is being pushed out of the housing. The apparatus furthermore comprises rail elements, along which the rotor to be removed can be moved.

## Brief description of the invention

The object of the present invention consists in providing a tool and a method which enables a rotor block to be removed from a housing surrounding the rotor block along the axis of rotation of the rotor contained in the rotor block.

According to the invention, this is achieved with a lifting apparatus which has a cantilever, which is fastened on a vertical stop, i.e. an axial end, of the housing and on

which a structure which can be moved along the cantilever and is likewise secured on a vertical stop, i.e. an axial end of the rotor block, is arranged.

The linear motion of the structure on the cantilever is accomplished by means of linear guidance (rails) and is optionally equipped with ball bearings.

- 5 As an option, the structure of the lifting apparatus is arranged on a carriage, wherein the support for the structure is in two parts and comprises a tilting rod and a vertical fastener, thereby allowing the structure to tilt relative to the position of the cantilever.

- As an option, a trapezoidal-threaded spindle, which can be moved either by hand or by a battery-operated screwdriver, can be provided as a drive for the movement along the  
10 cantilever.

As an option, the height and tilt of the rotor block can be adjusted by means of threaded screws.

- The lifting apparatus according to the invention does not have further supports and requires only the installation space of the filter muffler. In particular, the installation  
15 space above the housing of the exhaust turbocharger is not used during the removal and reinsertion of the rotor block, thereby ensuring that insulation, pipes etc. are not compromised.

Further advantages are obtained from the dependent claims.

## Brief description of the drawings

Embodiments of the lifting apparatus according to the invention are explained below by means of the drawings, in which

5 Figure 1 shows a schematic illustration of a section, taken along the shaft axis (A), through an exhaust turbocharger, wherein the exhaust turbocharger comprises a rotor block which can be pulled out of the housing towards the compressor side in an axial direction,

10 Figure 2 shows an isometric view of an exhaust turbocharger according to figure 1 with an attached lifting apparatus according to the invention in accordance with a first embodiment and a rotor block pulled partway out of the housing,

Figure 3 shows a schematic illustration of a section, taken along the shaft axis, through the exhaust turbocharger together with the lifting apparatus according to figure 2,

15 Figure 4 shows a schematic illustration of an enlarged section through the lifting apparatus according to figures 2 and 3,

Figure 5 shows a lateral view of an exhaust turbocharger according to figure 1 with an attached lifting apparatus according to the invention in accordance with a second embodiment and a rotor block pulled partway out of the housing,

Figure 6 shows an oblique view of the arrangement according to figure 5,

20 Figure 7 shows an isometric view of the structure of the lifting apparatus, and

Figure 8 shows an isometric view of the cantilever of the lifting apparatus and the mounting bracket for fastening the cantilever on the housing of an exhaust turbocharger.

## Embodiment of the invention

Figures 1 and 2 show an exhaust turbocharger of the kind typically used for pressure-charging large internal combustion engines. It comprises an exhaust turbine with axial inflow and a radial compressor.

- 5 The housing of the exhaust turbocharger is composed essentially of five housing parts. The outer bearing housing 13 is arranged axially in the center. In general, the bearing housing stands on a bracket arranged on the internal combustion engine.

The gas outlet housing 12 is fastened on the bearing housing on the turbine side, and the gas inlet housing 11 is in turn fastened on said outlet housing. The gas inlet housing  
10 11 carries the hot exhaust gas flow from the gas inlet to the rotor blades of the turbine wheel 21, wherein the flow duct through the gas inlet housing is redirected from the circular-tube form at the gas inlet into an annular-tube form in the inlet flow region of the turbine blades. The gas outlet housing 12 has a large, spiral collecting chamber and opens into the gas outlet, from where the exhaust gases are directed to the exhaust  
15 system or to a downstream second turbine stage, for example.

The outer compressor housing 14 adjoins the outer bearing housing 13 on the compressor side. The outer compressor housing essentially comprises a spiral collecting chamber, which opens into the air outlet. Like the gas inlet and the gas outlet on the turbine side, the air outlet of the compressor is permanently connected to the  
20 pipe system of the internal combustion engine and there should generally be no need to undo the respective flange fastenings. The fifth housing part, the inner compressor housing, is not shown in figures 1 and 2. On the one hand, the inner compressor housing is fastened on the outer compressor housing 14 by means of the fastening bolts 142 and, on the other hand, it represents the connection to the air inlet.

- 25 The air inlet can be implemented either by an attached filter muffler or by a tubular intake branch. This connection is the only one in the case of servicing which has to be removed at regular intervals. On the one hand, the filter muffler itself has to be serviced at regular intervals and, on the other hand, the opening exposed by the removed inner compressor housing forms the service hatch through which the rotor block of the  
30 exhaust turbocharger can be pulled out of the housing.

As the illustration suggests, the center of gravity of the rotor block 2, which comprises not only the actual rotor with the turbine wheel 21, shaft and compressor wheel 22 but

also the inner bearing region 23, is situated axially somewhere in the region of the bearing housing. In order to be able to lift the rotor out of the housing opening using a crane acting directly on the rotor block, the outer compressor housing 14 would therefore likewise have to be detached from the outer bearing housing 13. The intention is to eliminate this additional effort using the assembly and disassembly tool according to the invention described below.

Figure 2, figure 3 and figure 4 show a first embodiment of the lifting apparatus 4 according to the invention in use. Figure 5 and figure 6 show a second embodiment of the lifting apparatus 4 according to the invention in use. The individual components of the second embodiment of the lifting apparatus 4 are shown in detail in figure 7 and figure 8.

In both embodiments, the lifting apparatus 4 comprises two main components, a cantilever 5 and a structure 6 which can be moved on the latter. In general terms, a cantilever (also known in the literature as a cantilever beam or cantilever arm) is a horizontal beam supported at one end which carries a load. The cantilever beam has a single support. The cantilever beam can generally be subjected to shear, bending and torsional stress, and the support fixes all six degrees of freedom (forces and moments). In the present case of the cantilever 5 of the lifting apparatus 4 according to the invention, the horizontal beam is a supporting frame 51, and a mounting plate 56 at one end of the supporting frame serves as a support on the outer compressor housing 14. The compressor housing has fastening holes 141 arranged in a manner distributed along the circumference to receive the fastening bolts 142, which are shown in figure 1. The fastening holes are made in a vertical surface of the outer compressor housing, thus forming a vertical stop which is used to fasten the inner compressor housing and, in the case of assembly/disassembly, the cantilever beam 5 of the lifting apparatus 4 according to the invention.

For simplified mounting of the cantilever beam on the outer compressor housing 14 and especially to ensure the transferability of the cantilever beam for exhaust turbochargers of different overall sizes, a mounting bracket 7 can be provided between the mounting plate 56 of the cantilever and the vertical stop of the compressor housing. As an option, however, the cantilever could also be screwed directly onto the outer compressor housing. The mounting bracket 7 is screwed onto the vertical stop of the outer compressor housing using fastening means 72, wherein the abovementioned fastening

holes 141 are advantageously used. As an option, holes provided specifically for this purpose could also be used to fasten the mounting bracket 7. Fastening holes 71 for receiving fastening means 561 of the mounting plate 56 of the cantilever beam 5 are made in the mounting bracket 7. As an option, the mounting plate of the cantilever beam could also be connected to the mounting bracket in some other way, e.g. by means of a positive plug-in connection.

The structure 6, the second component of the lifting apparatus, comprises an assembly 61 of sectional bars, which serves to accept and transmit forces to the cantilever. The basic task of the structure of the lifting apparatus according to the invention is to grip the rotor block in order to move it along the extent of the supporting frame of the cantilever and relative to the housing. For this purpose, the structure 6 is mounted on a carriage 53, which in turn can be moved on rails 52 along the supporting frame 51. As an option, the carriage 53 can be guided along the rails 52 of the cantilever by means of a trapezoidal-thread spindle, which is moved either by hand by means of a spindle wheel 54 with a crank 541 or by a battery-operated screwdriver. This allows continuous slow movement of the structure and of the rotor block fastened thereon.

In a simple form, the structure itself could be guided directly along a rail on the cantilever as long as the transmission of forces and moments is ensured. However, this means that there are no possibilities for correction in respect of the height and angular position of the rotor relative to the housing. In order to allow precisely for this point, the structure according to the invention comprises not only the points of engagement on the rotor block and the support on the carriage but also means for tilting the assembly of sectional bars 61 and for aligning the assembly of sectional bars 61 relative to the rotor block 2.

In the simplest, first embodiment, the assembly of sectional bars 61 comprises an L-shaped basic framework formed by the two sectional bars 611 and 613, which is supplemented by the threaded rod 631 of the fastening point 63 to form a C-shaped main support. This main support is fastened at two points, provided for this purpose, on the rotor block, wherein the two fastening points are advantageously spaced apart vertically from one another. In the present case, the two fastening points 63 and 66 are situated at approximately the same radial height above and below the compressor wheel. In the region of the lower fastening point, a mounting plate is arranged on the free end of the sectional bar 611 and can be fastened directly on the vertical stop 26 of

the rotor block by means of fastening means 661. In the region of the upper fastening point, the threaded rod 631 is screwed directly into a corresponding hole 32 in the rotor block. On the rotor block, the fastening points can either be arranged on the inner bearing housing 23 itself directly or via a cover plate, which covers any irregularities, e.g. a baffle device in the diffuser region. The openings for the fastening screws 31 by means of which the rotor block is fixed on the outer bearing housing 13 are used to receive the threaded rod 631 of the upper fastening point. The C-shaped basic framework mentioned is provided in the region of intersection of the two sectional bars 611 and 613 with a tilting rod 62, which is rotatably mounted in a fixture 532 on the carriage 53 of the cantilever 5. The inserted tilting rod 62 is secured in the fixture 532 against falling out during the operation of the lifting apparatus by a retaining bolt. The tilting rod allows a tilting movement of the assembly of sectional bars 61 and the rotor block fastened thereon. In order to be able to adjust the extent of the tilting movement to a particular angular position, a vertical fastening 64 of the structure 6 on the carriage is provided at a distance from the tilting rod. The vertical fastening 64 essentially comprises a threaded rod 642 having a nut 643, a horizontal stop 644 having a hole for receiving the threaded rod and a connecting pin 641, which is mounted on the threaded rod, is arranged in a fixture 531 provided for this purpose on the carriage 53 and is likewise secured against falling out during operation. The hole for receiving the threaded rod in the horizontal stop 644 is arranged at a distance from the vertically extending sectional bar 613 of the basic framework. In the first embodiment, the horizontal stop is connected to the basic framework directly and, in the second embodiment, for improved force transmission in the case of relatively heavy rotor blocks, in a fixed manner via a plurality of sectional bars 612, 614, 615 and 616. The horizontal stop 644, which is spaced apart from the vertically extending sectional bar 613 of the basic framework, can be positioned at a greater or lesser distance from the anchoring on the carriage, connecting pin 641, by turning the nut 643, thereby making it possible to achieve a corresponding adjustment of the extent of the tilting movement and a particular angular position of the assembly of sectional bars 62 and of the rotor block fastened thereon relative to the cantilever. According to the second embodiment, the plurality of sectional bars 612, 614, 615 and 616 ensure a high stability of the structure 6, which can be advantageous for instance in the case of relatively large and heavy rotor blocks.

In the region of the upper fastening point, the structure comprises a second possibility of adjusting the angular position of the rotor block fastened on the structure. In addition to the lock nut 633 for screwing the threaded rod 631 into the rotor block 2, the threaded rod 631 has another nut 632 for adjusting the alignment of the structure relative to the rotor block. This nut rests on a vertical stop 634. By rotating the nut 632 on the threaded rod 631, the axial spacing between the vertical stop 634 and the rotor block can be adjusted. When this spacing changes, it has an effect on the angular position of the rotor block relative to the assembly of sectional bars. If the two adjusting options are superimposed, there is the possibility of raising the rotor block in height, supplementing the possibility of adapting the angular position. Tilting the assembly of sectional bars 61 about the axis of the tilting rod 62 leads to a changed angular position of the rotor block fastened on the structure. By changing the spacing between the vertical stop 634 and the rotor block, the modified angular position can be corrected again, thereby resulting in a height adjustment.

As it is pulled out of the housing, the rotor block can thus be adjusted in terms of height and angular position by rotating the two nuts 632 and 643. Owing to the high weight of the rotor, this is a great advantage, especially during installation, since otherwise there would be the risk of the rotor resting at least partially on the housing and damage occurring.

In the case of disassembly, the rotor block is pushed out (pressed out) of the centering seat in the outer bearing housing by means of press-off screws 635. For this purpose, the press-off screws 635, which are provided specifically for this purpose, are screwed through the hole 32 until the seating length in the region of two mutually matched seats 132 (indicated by way of example in figure 3) on the outer bearing housing 13 and 231 on the inner bearing housing 23 has been traversed.

To ensure that this axial movement can take place with the lifting apparatus already assembled, a freewheel is provided for this mentioned seating length between a spindle nut 57 mounted on the threaded rod 55 and the carriage 53, as illustrated in detail in figure 4. The spindle nut 57 is moved along the threaded rod by rotating the threaded rod. The spindle nut has a groove-shaped freewheel region 571, in which a projection 533 of the carriage is arranged with the ability for free movement between two axial stops. To damp the free movement of the carriage relative to the spindle nut 57 which is possible within the axial stops, a spring 535 is mounted on the threaded rod axially

between the spindle nut and an axial stop 534 of the carriage. As soon as the spring 535 of the freewheel has been completely compressed, the threaded rod 55 can be rotated by rotating the spindle wheel, and the movable carriage 53 is taken along.

## List of reference signs

- 11 Gas inlet housing of the exhaust turbine
- 12 Gas outlet housing of the exhaust turbine
- 13 Outer bearing housing
- 132 Centering seat on the outer bearing housing
- 14 Outer compressor housing
- 141 Fastening holes
- 142 Fastening bolts
- 2 Rotor block
- 21 Turbine wheel
- 22 Compressor wheel
- 23 Inner bearing housing
- 231 Centering seat on the inner bearing housing
- 25 Cover for compressor wheel
- 26 Vertical stop with holes for receiving fastening means
- 31 Fastening means for fastening the rotor block on the bearing housing
- 32 Hole in the rotor block
- 4 Lifting apparatus (comprising 5 and 6)
- 5 Cantilever for lifting apparatus, comprising:
  - 51 Supporting frame
  - 52 Rail
  - 53 Carriage
  - 531 Fixture for vertical fastening of the structure
  - 532 Fixture for the tilting rod of the structure
  - 533 Projection on the carriage for guidance in the freewheel region of the spindle nut 57
  - 534 Axial stop on the carriage
  - 535 Spring
  - 54 Spindle wheel
  - 541 Crank
  - 55 Threaded rod (spindle)
  - 56 Mounting plate of the cantilever for fastening on the mounting bracket
  - 561 Fastening means
  - 57 Spindle nut

- 571 Groove-shaped freewheel region
- 6 Structure of the lifting apparatus, comprising:
  - 61 Assembly of sectional bars (611, 612, 613, 614, 615, 616)
  - 62 Tilting rod of the structure
  - 63 Fastening point (horizontal fastening of the structure)
  - 631 Threaded rod
  - 632 Nut for adjusting the alignment of the rotor block relative to the assembly of sectional bars
  - 633 Lock nut for screwing the threaded rod into the rotor block
  - 634 Vertical stop
  - 635 Press-off screw
  - 64 Vertical fastening of the structure
  - 641 Connecting pin for vertical fastening of the structure on the cantilever
  - 642 Threaded rod
  - 644 Horizontal stop
  - 643 Nut for adjusting the alignment of the assembly of sectional bars relative to the cantilever
  - 66 Fastening point (mounting plate of the structure for fastening on the rotor block)
  - 661 Fastening means
- 7 Mounting bracket
- 71 Holes in the mounting bracket for receiving fastening means
- 72 Fastening means

## PATENT CLAIMS

1. A lifting apparatus (4) for moving a rotor block, which is arranged in a housing of an exhaust turbocharger, along the axis of rotation of the rotor contained in the rotor block, wherein the lifting apparatus has a cantilever (5), which is provided for fastening on a vertical stop of the housing surrounding the rotor block, wherein  
5 the cantilever (5) comprises a supporting frame (51) with rails (52) arranged thereon and a carriage (53) guided on the rails, wherein the mounting devices (531, 532) for fastening a structure (6) that can be fastened on a vertical stop of the rotor block are arranged on the carriage, allowing the structure (6) to be moved with the aid of the  
10 carriage along the rails arranged on the supporting frame of the cantilever.
2. The lifting apparatus as claimed in claim 1, wherein the carriage (53) is connected to a spindle nut (57), which is arranged on a threaded rod (55), making it possible to move the spindle nut and thus the carriage along the threaded rod (53) by rotating the threaded rod, wherein a spindle wheel (54) is preferably provided for rotating the  
15 threaded rod (55).
3. The lifting apparatus as claimed in claim 2, wherein a connection with play in the direction of the threaded rod is provided between the spindle nut (57) and the carriage (53), allowing the carriage to be moved along the threaded rod relative to the spindle nut within the range of the play, even when the threaded rod is not being  
20 rotated.
4. The lifting apparatus as claimed in one of claims 1 to 3, wherein the structure comprises at least two vertically spaced fastening points (63, 66) for fastening the structure on the rotor block to be moved in the axial direction in the housing by means of the lifting apparatus, and wherein the at least two fastening points are  
25 connected to the carriage by means of sectional bars (611,..., 616).
5. The lifting apparatus as claimed in claim 4, wherein the at least two vertically spaced fastening points (63, 66) are connected by means of the sectional bars to a tilting rod (62) and a vertical fastener (64), wherein these are each arranged in a horizontally spaced manner at different distances from the at least two vertically spaced  
30 fastening points (63, 66), and wherein the structure is fastened by means of the

tilting rod (62) and the vertical fastener (64) on mounting devices (531, 532) of the carriage, which are likewise spaced apart horizontally.

6. The lifting apparatus as claimed in one of claims 4 or 5, wherein at least one of the at least two vertically spaced fastening points (63, 66) comprises means for adjusting the alignment of the structure relative to a rotor block fastened on the structure, wherein these means preferably comprise a threaded rod (631) and a nut (632).
7. The lifting apparatus as claimed in one of claims 4 to 6, wherein the vertical fastener comprises means for adjusting the alignment of the structure (6) relative to the cantilever (5), wherein these means preferably comprise a threaded rod (642) and a nut (643), and the angular position of the structure around the axis of the tilting rod can be adjusted by means of the nut and the threaded rod.
8. The lifting apparatus as claimed in one of claims 1 to 7, wherein a mounting bracket (7) is provided for fastening the cantilever on a vertical stop of the housing.
9. A method for moving a rotor block, which is arranged in a housing of an exhaust turbocharger, along the axis of rotation of the rotor, which is contained in the rotor block, in said housing by means of a lifting apparatus (4) as claimed in one of claims 1 to 8, comprising the following steps:
  - fastening the cantilever (5) of the lifting apparatus on a vertical stop of the housing (14),
  - fastening the structure (6) of the lifting apparatus on the rotor block,
  - moving the structure along the cantilever.