

## **Rotor device for a vacuum pump, and vacuum pump**

The invention relates to a vacuum pump rotor device, as well as to a vacuum pump.

Vacuum pumps such as turbomolecular pumps, for example, have a rotor shaft arranged in a pump housing. The rotor shaft typically driven by an electric motor carries at least one rotor element. In a turbomolecular pump a plurality of rotor elements in the form of rotor discs is arranged on the rotor shaft. The rotor shaft is rotatably supported in the pump housing via bearing elements. Further, the vacuum pump has a stator element arranged in the housing. In a turbomolecular pump a plurality of stator elements formed as stator discs are provided. Here, the stator discs and the rotor discs are arranged alternating in the longitudinal direction of the pump or in flow direction of the medium to be pumped.

With rotors constructed from individual rotor discs, the individual rotor elements must be rigidly fastened to the rotor shaft. Correspondingly strong, positionally accurate connections between the rotor shaft and the rotor elements must be ensured under all operational conditions, i.e. in particular under the strong temperature and rotary speed variations that occur. With known multi-part rotors, in particular rotors having a plurality of rotor discs, this is achieved by a considerable oversize of the rotor disc with respect to the rotor shaft for joining purposes. For joining, it is then necessary to strongly cool the rotor shaft and to strongly heat the rotor elements so that it is possible to press the rotor elements onto the shaft. Here, it is in particular necessary to cool the rotor shaft to temperatures in the range of that of liquid nitrogen and, at the same time, to strongly heat the rotor discs in an oven for example by induction. Joining must then be followed by a storage at room temperature until both parts are at room temperature. This takes a relatively long time. Only this considerable oversize and a correspondingly complex joining process can guarantee the required operating safety despite the strongly varying temperatures and rotary speeds. The temperature of the rotor elements, as well as of the rotor shaft reaches up to about 120°C in operation. The maximum rotary speeds are at ca. 1500 r/sec Therefore, it is necessary for joining the rotor elements with the rotor shaft to cool the rotor shaft to about -190°C in liquid nitrogen. Depending on the structural size the cooling time is

about 5 minutes. At the same time the rotor elements must be heated in an oven, e.g. a convection oven, to about 120°C. The corresponding heating time is 1 – 2 hours. The time for heating the structural assembly thoroughly after joining about is 1 – 2 hours to reach room temperature. This known joining method is time-consuming and complex.

Tests have shown that joining a rotor or a disc-shaped rotor element of aluminum onto a rotor shaft of aluminum is not possible at room temperature due to the required oversize. Although the oversize may be selected significantly smaller, since no different thermal expansion coefficients of the rotor element and the shaft exist, fitting by pressing is still not possible at room temperature. Here, a galling or welding of the components to be joined occurs. Therefore, a positionally accurate positioning of a rotor element on the rotor shaft is not possible.

It is an object of the present invention to provide a vacuum pump rotor device which is economic to manufacture, while still providing high operating safety and preferably allowing the components to be joined at room temperature or at only small temperature differences between the components.

The object is solved according to the invention with the features of claim 1.

The rotor device for a vacuum pump of the present invention has a rotor shaft. At least one rotor element is arranged on the rotor shaft. In particular in case of a rotor device of a turbomolecular pump, a plurality of rotor elements in the form of rotor discs are arranged in the longitudinal direction of the rotor shaft.

Tests have shown that it is possible to fit rotors or rotor elements at room temperature and with high operating safety at the same time, if the rotor or the rotor element contains aluminum, titanium and/or CFK and the rotor shaft comprises a chromium-nickel steel (Cr-Ni steel). The use of aluminum, titanium and/or CFK as a material for a rotor or a rotor element is advantageous in that it is possible to achieve the required strength and stability relative to the density of the material that is required in order to reach the high rotary speeds and the great forces and tensions going along therewith. The required properties of the shaft can be achieved with a steel shaft, in particular a stainless steel shaft. In

particular, the shaft comprises Ni-Cr steel with added sulfur and, as is particularly preferred, is made from chromium-nickel steel with added sulfur.

In a preferred embodiment, the rotor or the on rotor element is made of aluminum, an aluminum alloy and/or high-strength aluminum.

It is particularly preferred to use high-strength aluminum with a high tensile strength value of in particular at least 250 N/mm. High-strength aluminum further has the advantage that it has a high fatigue strength also at operating temperatures of 100 – 120°C. It is particularly preferred to use AW-Al Cu 2Mg 1,5 Ni.

Further, it is preferred that the at least one rotor element is made of titanium or a titanium alloy and/or of CFK.

The above described combination of the two components, as provided by the present invention, allows to fit the at least one rotor element on the rotor shaft at room temperature without any galling or welding. Thereby, the manufacturing time can be shortened significantly.

According to the invention a significant reduction of assembly costs can be achieved by the fact that the thermal expansion coefficient of the rotor shaft differs as little as possible from the thermal expansion coefficient of the at least one rotor element. According to the invention a material pair is used that does not tend to gall and which differ only slightly in thermal expansion coefficient, so that less oversize is required for joining than in prior art. As a consequence, the components can be joined at room temperature due to the small required oversize or, at most, the components only need to have a small temperature difference. With such a material pair having slightly different thermal expansion coefficients it is ensured that the operating safety is guaranteed even at great temperature and rotary speed variations. It is particularly preferred that the material pair used is a material pair of in particular high-strength aluminum and stainless steel. Here, it is preferred that the at least one rotor element is made of aluminum and the rotor shaft is made of stainless steel, in particular Cr-Ni steel with added sulfur.

It is particularly suitable to use stainless steel X8CrNiS18-9 with the material number 1.4305 for the rotor shaft.

In particular when using stainless steel X8CrNiS18-9 and aluminum Al, it is possible to join the two components at room temperature, in particular to join them by pressing. This is also possible if in a particularly preferred embodiment the at least one rotor element has an oversize with respect to the rotor shaft for which expansions in the circumferential direction of 0.25% to 0.35% may occur. Due to this oversize, operating safety can be ensured despite the great temperature variations, while at the same time the components can still be joined at room temperature.

In a preferred embodiment in which the rotor device is in particular suited for uses in a turbomolecular pump, a plurality of rotor elements are arranged in particular in the longitudinal direction on the rotor shaft, in particular by pressing. However, a corresponding rotor element may for example also be a disc-shaped carrier of a Holweck stage. This carrier carries the tubular elements of the Holweck stage or is integrally formed therewith. According to the present invention, also such a rotor element or such a rotor element carrier is made from the above mentioned material, in particular aluminum, and is fitted on a stainless steel shaft by pressing.

The rotor elements may be rotor discs, where, possibly, spacer elements are provided in addition between rotor elements or rotor discs. These elements may in particular serve to form an intermediate inlet in a multi-inlet pump.

The invention further relates to a vacuum pump which in particular is a turbomolecular pump. The vacuum pump of the present invention has a rotor device of the present invention as described above, in particular in one of the preferred developments. Further, the vacuum pump has a pump housing in which the rotor shaft is supported by bearing elements. Moreover, a driving device is provided that drives the rotor shaft. Further, at least one stator element is arranged in the pump housing, wherein the stator element may be a stator disc. In this case, in a

turbomolecular pump, a plurality of stator discs is arranged alternating with a plurality of rotor discs.

The invention will be explained in detail hereinafter with reference to a preferred embodiment and to the accompanying drawing.

The Figure shows a greatly simplified schematic sectional view of a turbomolecular pump.

In the greatly simplified illustration of a turbomolecular pump a plurality of rotor elements 12 in the form of rotor discs are arranged on a rotor shaft 10 by being pressed thereon. Stator elements 16 are arranged in a pump housing 14, which in the embodiment illustrated may be stator discs 16.

The rotor shaft 10 is further supported in the pump housing 14 by bearing elements 18, 20 and is driven by a driving device 22.

In the embodiment illustrated a sleeve-like spacer element 24 is further provided between two rotor discs 12. Thereby, an intermediate inlet 26 is formed.

Thus, the vacuum pump schematically illustrated in the drawing draws the medium to be conveyed through a main inlet in the direction of an arrow 28. Further, medium is drawn via the intermediate inlet 26 in the direction of an arrow 30. The two media taken in are conveyed towards an outlet as illustrated by an arrow 32.

According to the invention the rotor shaft 10 is made, in a preferred embodiment, of stainless steel. The individual rotor elements 12 as well as the spacer element 24 are made of aluminum in a preferred embodiment thereof. Fitting the rotor elements 12 and the spacer element 24 is performed by pressing at room temperature. In particular, the individual rotor elements 12 as well as the spacer element 24 show an oversize-related expansion in the circumferential direction of 0.07 % to 0.2%. The pressing force with which the components can be joined at room temperature is in a range from 5 to 50 kN.

## Claims

1. Rotor device for a vacuum pump, comprising  
  
a rotor shaft (10) and  
  
at least one rotor element (12) arranged on the rotor shaft (10),  
  
characterized in that  
  
the at least one rotor element (12) contains aluminum, titanium and/or CFK and the rotor shaft (10) contains chromium-nickel steel wherein the at least one rotor element (12) is arranged in the longitudinal direction of the rotor shaft (10), and wherein materials of the rotor shaft (10) and the at least one rotor element (12) are selected such that the at least one rotor element (12) can be fitted on the rotor shaft (10) at room temperature.
2. Rotor device for a vacuum pump of claim 1, characterized in that the at least one rotor element (12) is made of aluminum, an aluminum alloy and/or high-strength aluminum.
3. Rotor device for a vacuum pump of claim 1, characterized in that the at least one rotor element (12) is made of titanium and/or a titanium alloy.
4. Rotor device for a vacuum pump of claim 1, characterized in that the at least one rotor element (12) is made of CFK.
5. Rotor device for a vacuum pump of one of claims 1-4, characterized in that the rotor shaft (10) contains a chromium-nickel steel with added sulfur, and, in particular, is made of a chromium-nickel steel with added sulfur.
6. Rotor device for a vacuum pump of one of claims 1-5, characterized in that the rotor shaft (10) contains a stainless steel alloy, which in particular is stainless steel X8CrNiS18-9.

7. Rotor device for a vacuum pump of claim 6, characterized in that the rotor elements are formed as rotor discs (12).
8. Rotor device for a vacuum pump of claim 7, characterized in that at least one spacer element (24) is arranged between two of the rotor elements (12).

9. Vacuum pump, in particular a turbomolecular pump, comprising

a rotor device for a vacuum pump, the rotor device comprising a rotor shaft (10) and at least one rotor element (12) arranged on the rotor shaft (10), the rotor shaft (10) being supported in a pump housing (14) by bearing elements (28),

a driving means (22) connected to the rotor shaft (10), and

at least one stator element (16) arranged in the pump housing (14),

characterized in that

the at least one rotor element (12) contains aluminum, titanium and/or CFK and the rotor shaft (10) contains chromium-nickel steel wherein the at least one rotor element (12) is arranged in the longitudinal direction of the rotor shaft (10), and wherein materials of the rotor shaft (10) and the at least one rotor element (12) are selected such that the at least one rotor element (12) can be fitted on the rotor shaft (10) at room temperature.

## **Rotor device for a vacuum pump, and vacuum pump**

### **Abstract**

A rotor device for a vacuum pump comprises a rotor shaft (10) and at least one rotor element (12) on the rotor shaft (10). According to the invention, the at least one rotor element (12) contains aluminum, titanium and/or CFRP, while the rotor shaft (10) contains a chromium-nickel steel. This makes it in particular possible to join the at least one rotor element (12) to the rotor shaft (10) at room temperature using a pressing process.

### **Figure**