

METHOD AND DEVICE FOR SENSING A CLEARANCE

The present invention relates to a method of sensing the clearance between an object and a surface that lies adjacent thereto, and of generating a
5 signal representative of the magnitude of said clearance for adjusting the clearance to a desired magnitude with the aid of an adjusting device controlled in dependence on said signal.

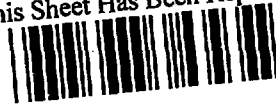
The invention also relates to an arrangement by means of which the method can be carried out.

10 Clearances ranging from some tenths of a millimetre up to several millimetres can be measured in many ways. The measuring process applied, however, immediately becomes more complicated when it is effected in order to generate a signal that controls a setting device for adjusting the clearance. This is particularly true of measuring processes that are effected in a troublesome
15 atmosphere, such as in the case of regenerative rotary heat-exchangers that operate in a corrosive atmosphere contaminated with soot for instance, and under high, varying pressure and temperature conditions.

In an application of this nature, the clearance between moving sector plates or seals and a rotor surface must be held constant, said rotor being
20 through-passed axially by air and combustion gases for instance.

As will be evident from US 3 246 686, mobile mechanical sensors have been tested, although ambient conditions have been found too troublesome with respect to bearings and journals among other things.

The same applies to the devices disclosed in US 3 232 335, these
25 devices including on the one hand a sliding shoe that slides against the rotor and on the other hand an inductive component and a compressed-air jet for contactless sensing of a clearance. Dirtying of the slide shoe and its bearings makes the use of this solution impossible in practice. A corrosive atmosphere and high temperatures make the use of an inductive device impossible in
30 practice and the markedly varying pressure conditions in particular have a pronounced effect on measuring processes that use a jet of compressed air.



Sliding shoes made of ceramics and carbon or graphite have been proposed in recent years. However, these shoes result in higher friction and in problems relating to lubrication of contacting surfaces, subsequent adjustment of clearances, among other things. The use of air cushions has been proposed as an alternative to sliding shoes. The use of air cushions, however, introduces complications, partly as a result of the greatly varying pressure conditions. A sensing device that includes fibre optics for infrared light beams has also been proposed (US 4 306 612). Such sensing devices are troubled by corrosion, dirt contamination, etc., and do not therefore provide a satisfactory solution.

The object of the invention is to provide a method and an arrangement of the kind defined in the introduction that will enable clearance ranging from some tenths of a millimetre to several millimetres to be measured simply and positively in all relevant ambient conditions.

This object is achieved with the method comprising the method steps set forth in claim 1 and with the arrangement that has the characteristic features set forth in claim 2

The invention is based on the understanding that a whistle pipe, organ pipe or flute can be tuned to an exact resonance frequency and that the so-called end correction and the resonance frequency will change markedly when an object is brought into the close vicinity of a sound-emitting opening of the pipe or flute, while a change in the length of the pipe or flute will cause the resonance frequency to change in accordance with the change in length. Trials have shown that a frequency change of 50 Hz can correspond to a change in clearance of from 2 to 3 mm. Since frequencies of some few Hz can be measured readily, it will be understood that the invention affords an accuracy that has not earlier been achieved. The only driving force required to operate the pipe is a weak compress-air flow. One particular advantage afforded by the invention is that the frequency is highly insensitive to external or ambient conditions, which although affecting the strength of the sound that is generated have no effect on the resonance frequency.

The invention will now be described in more detail with reference to exemplifying embodiments of the invention and with reference to the

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accompanying schematic drawings, of which Figure 1 shows part of an air-preheater from above; Figure 2 is a partly sectioned side view of a sector-plate mounted arrangement for contactless measuring of the clearance to a rotor; Figure 3 is a longitudinal section view of an open pipe included in the arrangement shown in Figure 2; Figure 4 is a graph that shows measured frequency as a function of clearance; and Figure 5 is a partly sectioned side view of another embodiment of the invention.

Figure 1 shows a typical rotary regenerative heat exchanger which is intended for preheating combustion air with the aid of exhaust gases and which includes a stationary housing 1 and a rotor 2 that has a regenerator mass and is mounted for rotation in the housing 1. Two axially movable sector plates 3, 4 are mounted on bearings above and beneath the rotor and close to its end surface. The sector plates 3, 4 separate a gas side 5 from an air side 6, wherewith although gas and air is able to enter the clearance beneath respective sector plates 3, 4 due to rotation of the rotor, no direct leakage need occur from one side to the other provided that the clearance between the sector plates 3, 4 and the ends of rotor can be kept small in spite of the fact that the ends of the rotor will never be completely flat.

The outer ends of the sector plates 3, 4 are guided by sensing devices 7 that coact with a circular flange 8 extending around the rotor circumference at the top and at the bottom of the rotor 2, as evident from Figure 2.

The sensing devices 7 consist of a compressed-air operated pipe 9, of the whistle pipe, flute or organ pipe kind, that has been tuned to a specific frequency. Each pipe 7 is attached to a lug 10 that projects out from each side of a respective sector plate 3, 4 immediately above the upper rotor flange 8 and immediately beneath the lower rotor flange (not shown). The bottom part of the pipe 9 is threaded and screwed into a hole provided in the lug 10, and locked with a lock nut 11.

The sector plates 3, 4 are set by means of a setting device 12 which is fixedly attached to the housing and has an adjuster rod 13 connected to a respective sector plate, said sector plates being set with the underside about 2 mm from the rotor end and the flange 8.

The pipe 9 has the well-known form shown in Figure 3, including a straight tube in which a so-called mouth opening 15 has been made. A block 16 that includes an air passageway 17 is inserted edge to edge with the upper edge of the opening 15. Provided at the upper end of the pipe 9 is a nozzle 18 that includes a compressed-air passageway 19 that opens into a nipple 20 which is connected to a hose 21 that leads to a source (not shown) of compressed-air.

A sleeve 22 is mounted around part of the pipe 9 and the nozzle 18 and functions as an attachment means for a hose lead 23 that communicates with the sleeve interior, where the mouth opening 15 is located, by means of passageways not shown. The hose lead 23 has a transit or lead-through 24 for the hose 21 and is connected to a microphone 25 which, in turn, is connected to a frequency measuring device 26 that includes a necessary filter and amplifier. The frequency measuring device is designed to control the setting device 12 so that if the clearance S between the underside of respective sector plates 3, 4 and the rotor flange 8 should decrease, the frequency measuring device 26 will deliver a first signal that causes the setting device 12 to lift the sector plate 3, 4 slightly. If the clearance S should increase, the frequency measuring device will deliver a second signal that causes the setting device 12 to lower the sector plate 3, 4 slightly.

This function of the sensing device 7 is based on the fact that when a surface approaches the end surface 14 of the pipe 9, the end correction of the resonance tube will be affected within a distance equal to 0.6 times the end diameter of said tube, therewith resulting in an increase in the resonance frequency or a decrease in the resonance frequency if the distance should decrease.

Figure 4 shows how the frequency is changed when the distance A between the end surface 14 of the pipe 9 and the rotor flange 8 is changed between 1 mm and 6 mm in a certain case.

Figure 5 shows a modified version of the sensing device. In this case, the bottom part of the pipe 9 has the form of a bore 30 drilled in a carbon or graphite block 31 and forming a continuation of the bore in the pipe 9. The block

31 is arranged to slide on the flange 8 and the pipe 9 therefore forms a closed pipe with the singularity of initially being tuned to a resonance frequency that is dependent on the length of the pipe 9. When wear occurs on the block 31, the pipe 9 will have a shorter length and the frequency therefore increase. The frequency is measured in the same way as that described with reference to Figure 2 and when the frequency has increased by a value corresponding to 2 mm for instance, the sensing device causes a block-actuating setting device 32 attached to the sector plate 3, 4 to move the block 31 down through 2 mm for instance. This procedure is repeated until the block 31 has been almost completely consumed and must be replaced.

In this embodiment it is possible to utilize the fact that if for some reason the block 31 should become distanced from the flange 8, the frequency will be increased by a full octave so as to produce a pronounced signal.

It will be understood that the invention is not restricted to the illustrated and described embodiments thereof and that modifications can be made within the scope of the inventive concept as defined in the following claims. This applies particularly to the measuring equipment. The mouth opening 15 of the pipe 9 may be used to measure the clearance, instead of the end 14 of the pipe 9. When required, pressure and temperature variations can be compensated for in a known manner. By placing the sensing devices 7 on outwardly projecting peripheral fastener lugs 10, essentially constant pressure and temperature conditions can be achieved in normal operation of a regenerative rotary heat exchanger, by virtue of the sensing devices 7 therewith being located on the air side 6 and the gas side 5 respectively.



Claims

1. A method of sensing the clearance (S) between an object (3, 4) and an object-adjacent surface (8), and of generating a signal which is representative of the magnitude of said clearance and which is used in the adjustment of the clearance to a desired magnitude by means of a setting device (12, 32) that is controlled in dependence of said signal, **characterized** by providing the object (3, 4) with at least one compressed-air operated pipe (9) that includes a resonance tube that has been tuned to a specific frequency and that includes an opening (14, 15) which is placed adjacent said surface (8) such that the resonance frequency of the pipe (9) will change in dependence on the magnitude of the clearance (S), and by indicating and utilizing said frequency to control the setting device (12, 32).

2. An arrangement for carrying out the method of sensing the clearance (S) between an object (3, 4) and an object-adjacent surface (8) in accordance with Claim 1, **characterized** in that the object (3, 4) is provided with at least one pipe (9) which is operated by compressed-air taken from a compressed-air source and which includes a resonance tube that has been tuned to a specific frequency and that includes at least one sound-emitting opening (14, 15); in that the pipe (9) is positioned with the sound-emitting opening located adjacent said surface (8) so that the resonance frequency of the pipe will be dependent on the magnitude of the clearance (S); and in that a setting device (12, 32) for setting said clearance is adapted to be controlled by a device (25, 26) that indicates the frequency of the pipe (9).

3. An arrangement according to Claim 2, **characterized** in that the pipe (9) is a straight open pipe which is mounted on the object (3, 4) at right angles to said surface (8) with a clearance (A) between the surface (8) and the end surface (14) of the pipe (9).

4. An arrangement according to Claim 2, **characterized** in that the pipe (9) is a straight open pipe which is mounted on the object (3, 4) and is axially displaceable by means of the setting device (32), with one end (31) of the pipe lying against the surface (8) which therewith closes the end (31) of said pipe (9).



- 5 An arrangement according to any one of Claims 1 - 4, wherein the object is a sector plate (3, 4) on a regenerative rotary heat exchanger, and said surface to which the clearance shall be measured is comprised of a peripheral flange (8) on the rotor of said heat exchanger, characterized in that the sector plate (3, 4) is provided on at least one of its sides with a part (10) which projects out peripherally opposite the rotor flange (8) and which carries the sensing device (7) provided with a resonance tube.