

DESCRIPTION

TITLE: TOOL FOR MACHINING AN ABRADABLE ANNULAR LAYER OF A FAN CASING OF AN AIRCRAFT TURBINE ENGINE AND MACHINING METHOD USING SUCH A TOOL

5 Technical field of the invention

This invention relates to a tool for machining an abradable annular layer of a fan casing of an aircraft turbine engine, and to a machining method using such a tool.

Technical background

10 The technical background comprises the documents WO-A1-2016/2023141, GB-A-2 240 735, EP-A1-3 017 898 and WO-A1-2023/062302. The main function of a fan casing assembled on an aircraft turbine engine is to ensure the retention in the event of debris ingestion or fan vane loss.

Some of the secondary functions of a fan casing are to ensure the mechanical continuity in forces and moments between an air inlet handle and an intermediate casing shell, to allow the attachment
15 of the duct panels, such as the upstream acoustic shell, the cartridge of the abradable layer support and the downstream acoustic panel.

Other functions of the fan casing are to allow the attachment of the equipment and supports, to meet the specifications to fire and leakage and to allow the continuity of the electrical current for lightning protection.

20 For example, on a turbine engine, up to eighteen fan vanes can be installed opposite the abradable layer. This abradable layer, often made of solid colored porous material, crumbles during operation to ensure an optimum aerodynamic duct thanks to the fan vanes that come into contact with the layer.

When not in operation, a certain amount of clearance is required to ensure that the fan vanes can
25 be mounted in the fan casing.

During operation, the inertia of the fan disc, which includes all the fan vanes, causes the disc to move apart to take up the assembly clearance and also to create an optimum aerodynamic duct. To create this aerodynamic duct, the fan vanes come into contact with the abradable layer and crush it as required.

30 During operation, some abradable porous material may become detached from the rest of the surface as it crumbles.

This is not the only source of crumbling of the abradable layer as, during operation, the fan may suck in foreign bodies, which can damage the abradable surface.

These missing surfaces or asperities, of the order of a few micrometres, on one face of the sequentially abradable layer opposite the vanes must be reconditioned to avoid loss of performance, cosmetic problems or the risk of further degradation if they are not brought back into conformity.

5 In order to recondition the abradable annular layer, it is known to dismantle the casing on which the abradable layer is located in its entirety in order to position it in an environment (e.g. a workshop) allowing the abradable layer to be machined and reconditioned. Dismantling the casing, transporting it to the workshop and then carrying out the reverse operations are inefficient and costly, and require the presence of a specialist workshop close to the casing.

10 As a result, there is a need to improve the efficiency and repeatability of machining an abradable layer of an aircraft turbine engine fan casing.

The Applicant has already proposed a tool for machining an abradable annular layer of a fan casing in the document FR-A1-3 117 390.

The invention is an improvement on this type of tool and in particular improves the machining
15 quality.

Summary of the invention

The invention therefore proposes a tool for machining an abradable annular layer of a fan casing of an aircraft turbine engine, this tool being configured so as to be at least partly housed in said casing
20 and comprising:

- a central centring body configured to be attached to a fan disk of the turbine engine, so as to be movable in rotation about an axis of rotation of the fan disk,
 - a machining tool connected to the central body and comprising at least one machining means configured to come into contact with the abradable layer, and
 - 25 - a first motor for driving said machining means in rotation,
- characterized in that the central body comprises or carries a copy cam which comprises a cam profile which is a function of a desired surface profile for the abradable layer after machining, the machining tool being movable relative to the copy cam and being configured to follow the cam profile so that the machining means machines the abradable layer in accordance with the cam
30 profile.

The tool, thanks in particular to its central body, can therefore be positioned directly inside the fan casing, whatever the position of the casing. The tool according to the invention enables the abradable layer to be machined with precision thanks to the copy cam, which is selected according

to its cam profile. The abradable layer will be machined according to this cam profile, which significantly improves machining quality and, in particular, the dimensional and geometric conformity of the abradable layer after machining.

In this application, the term "surface profile" refers to the profile (i.e., the general shape) of a surface in cross-section. The surface considered is the internal annular surface of the abradable layer and the profile of this surface is therefore the general shape of this surface when considering a cross-section of this abradable layer.

The tool, according to the invention, may comprise one or more of the characteristics below, taken alone with each other or in combination with each other:

- 10 - the machining means is a ball end mill;
- the tool comprises a second motor for driving the machining tool in rotation about said axis of rotation;
- said, or each motor, is a brushless electric motor;
- the copy cam is removably and interchangeably mounted on the central body;
- 15 - the copy cam comprises a flat plate wherein an elongated through slot is formed, this slot comprising a longitudinal edge which defines the desired surface profile, i.e. an axial sectional shape of an internal annular surface of the abradable layer; the use of a slot is advantageous as it enables better guidance;
- the plate has a generally parallelepiped shape;
- 20 - the flat plate extends in a plane passing through the axis of rotation;
- the machining tool comprises a follower, such as a roller, which is engaged in the slot and which cooperates by sliding or rolling with said longitudinal edge; the follower being engaged in the slot, it cannot move away from the longitudinal guide edge, which ensures optimum guidance;
- the copy cam is clamped to the central body by mounting brackets and/or clamping screws;
- 25 - said machining means is housed in a cover for protecting and containing chips and dust, this cover being carried by the tool;
- the cover is connected by a hose to a suction pump for chips and dust;
- the tool also comprises a measuring tool connected to the central body and comprising at least one probe configured to bear on said layer, this measuring tool being, for example,
- 30 diametrically opposed to the machining tool with respect to said axis of rotation;
- the central body is equipped with position-adjustable balancing weights so as to limit the force required to drive the central body in rotation about the axis of rotation;

- the tool also comprises formwork extensions configured to be mounted on either side of the abradable layer and to be clamped axially against the abradable layer;
 - the slot is slightly wider than the diameter of the follower or pebble, i.e. the width is approximately 101 to 120% of the diameter.
- 5 The invention also relates to a method for machining an abradable annular layer of a fan casing of an aircraft turbine engine, by means of a tool according to one of the preceding claims, comprising the steps consisting of:
- a) determining the desired surface profile for the abradable layer after machining,
 - b) selecting a copy cam comprising a cam profile which corresponds to this surface profile,
 - 10 and and removably mounting it on the central body, and
 - c) machining the abradable layer according to the cam profile.

Brief description of the figures

Further characteristics and advantages of the invention will become apparent from the following detailed description, for the understanding of which reference is made to the appended drawings wherein:

- [Fig. 1] Figure 1 is a schematic representation of an axial cross-section of a fan of an aircraft turbine engine,
- [Fig. 2] Figure 2 is a schematic representation of a perspective view of a fan casing,
- 20 [Fig. 3] Figure 3 is a schematic representation of a side view of a fan casing and machining tool according to the invention,
- [Fig. 4] Figure 4 is a schematic representation of an axial cross-sectional view of a machining tool according to the invention inserted into part of a fan disk,
- [Fig. 5] Figure 5 is a schematic representation of a perspective view of a central body of the machining tool according to the invention,
- 25 [Fig. 6] Figure 6 is a schematic representation of an axial cross-sectional view of the extensions of the machining tool according to the invention, and
- [Fig. 7] Figure 7 is a schematic representation of a perspective view of a machining tool and a copy cam of the machining tool according to the invention,
- 30 [Fig. 8] Figure 8 is a schematic representation of another perspective view of the machining tool and the copy cam of the machining tool according to the invention,
- [Fig. 9] Figure 9 is a schematic representation of another perspective view of the copy cam of the machining tool according to the invention,

[Fig. 10] Figure 10 is a schematic representation of a cross-sectional perspective view of the copy cam of the machining tool according to the invention,

[Fig. 11] Figure 11 is a schematic representation of another perspective and cross-sectional view of part of the machining tool according to the invention, and

5 [Fig. 12] Figure 12 is a schematic perspective representation of the masses of machining tool according to the invention of the copy cam of the tool.

Detailed description of the invention

Figure 1 is a partial representation of a fan of an aircraft turbine engine.

10 In a conventional way, a turbine engine comprises from upstream to downstream, i.e. in the direction of flow of the gas flows, a fan, one or more compressors, a combustion chamber, one or more turbines, and a nozzle for the ejection of the combustion gases leaving the turbine or the turbines.

The fan 1 comprises a vane disk 2 which is surrounded by a fan casing 3, also known as a retention casing because of its function of retaining the vanes in the event of their breakage, or in the event of debris entering the fan.

As can be seen from Figure 2, the fan casing 3 has a generally cylindrical shape with an axis of revolution A.

It comprises an annular securing flange 3' at each of its axial ends. These flanges 3' are used to fix the casing 3 to the annular walls of the nacelle of the turbine engine or to the shell of an intermediate casing downstream.

As shown in this figure 2, a layer of abradable material 10b is present inside the fan casing 3 by being of revolution in the fan casing 3.

The fan casing 3 therefore extends around the fan vane disk 2. It therefore comprises an internal cylindrical surface which is provided with an annular layer 10b of abradable material.

The annular layer 10b of abradable material, hereinafter referred to as the abradable layer 10b, extends around and at a short radial distance from one 2a of the vanes, sequentially as the vane disc 2 rotates. The vanes 2a can rub against the abradable layer 10b in operation and successively and wear it down by friction.

30 This allows to optimize the radial clearances between the vanes 2a and the surrounding fan casing 3 and thus to limit the gas leakage at the radially external tips or ends of the vanes, and thus to optimize the performance of the turbine engine.

The abrasable layer 10b can be supported by a solid or honeycomb structure support cartridge 4. This cartridge 4 is usually riveted or screwed to the fan casing 3.

A machining tool 20 according to the invention is shown in Figure 3 (outside the casing 3) and Figure 4 (inside the casing 3). Such a tool 20 is configured to machine the abrasable layer 10b of the casing 3 of the fan 1 with the aim in particular of reconditioning this abrasable layer 10b.

To this end, the tool 20 comprises:

- a central body 30 for centring, or even fixing, to the fan disk 2 of the turbine engine, this central body 30 being intended to be rotatable about the axis A of rotation of the fan disk 2,
- a machining tool 50 connected to the central body 30 and comprising at least one machining means, such as a rotary cutter 51, configured to come into contact with the abrasable layer 10b, and
- a first motor 52 for driving the milling cutter 51 in rotation.

The tool 20 may also include a measuring tool 40 connected to the central body 30 and comprising at least one probe 41 configured to bear on the abrasable layer 10b, this measuring tool being mobile in rotation about the axis A on the central body 30.

The tool 20 may also include a second motor 32 for rotating at least the measuring 40 and machining 50 tools about the axis A. Alternatively, this rotation could be carried out manually by an operator about the axis A.

The machining 50 and measuring 40 tools and the central body 30, for example, are connected by a shaft 90. The shaft extends radially by a dimension substantially less than that of an internal diameter of the casing 3 to allow axial insertion of the tool 20 into the casing 3. In particular, the machining 50 and the measuring 40 tools are substantially diametrically opposed with respect to the axis A.

The tool 20 can be brought inside the casing 3 by means of a carriage 60, such as that described in the document WO-A1-2023/062302 for example. The tool 20 may have a weight between 100 and 150 kg.

Once the tool 20 is centered with respect to the casing 3, it is inserted along axis A into the casing 3. Once the tool 20 has been inserted inside the casing 3, it is secured to the fan disk 2 by means of a securing means 31 comprising the central body 30.

The tool 20 also includes displacement means 58 for moving the machining tool 50 in translation with respect to the shaft 90, i.e. radially. These movement means 58 enable the milling cutter 51 to be positioned in contact with the abrasable layer so that the depth of cut can be adjusted and machining carried out.

At least one of the first 52 and second 32 motors is electric and preferably brushless to reduce noise pollution during operation and improve operator comfort during machining.

Each of the first 52 and second 32 motors can be controlled separately. As a result, they can rotate at two different speeds. It is then possible to rotate the measuring tool 40 and the machining tool
5 50 completely with the probe in contact with the abradable layer to measure its thickness without rotating the milling cutter 51.

The milling cutter 51 can be housed in a cover 53 for protecting and containing chips and dust, this cover 53 being carried by the machining tool 50.

The cover 53 is connected by a hose 54 to a suction pump (not shown) for chips and dust. The
10 hoover can be used to prevent dust being sucked up by operators. The cover 53 is transparent, for example, so that the milling cutter 51 and the abradable layer 10b can be seen during machining. Figures 5 and following show various parts of a more specific embodiment of the tool 20 according to the invention.

Figure 5 shows the central body 30 of this tool, which has a generally annular shape and is carried
15 here by the aforementioned carriage 60.

Figure 6 shows formwork extensions 62, 64 designed to be mounted on either side of the abradable layer 10b and to be clamped axially against the abradable layer 10b.

These extensions 62, 64 are used to recondition the abradable layer 10b after it has been machined. The extensions 62, 64 create a formwork for applying the new abradable material.

20 A straight spatula 66 is guided in or on the sockets 62, 64 to apply a new abradable with a controlled excess thickness.

Figures 7 to 9 show that the central body 30 comprises or carries a copy cam 70 which comprises a cam profile 72 which is a function of a desired surface profile for the abradable layer 10b after machining.

25 The machining tool 50 is movable relative to the copy cam 70 and is configured to follow the cam profile 72 so that the milling cutter 51 machines the abradable layer 10b according to the cam profile 72.

The copying cam 70 is preferably removably mounted on the central body 30 so that the copy cam 70 can be selected according to its cam profile 72 and so adapt the cam profile 72 to the fan casing
30 3 to be machined. The abradable layers 10b of the fan casings of several engines or references of the same engine may have different surface profiles. The number of copy cams 70 available is preferably equal to the number of different surface profiles of these fan casings 3. It is therefore

understood that an operator must select the copy cam 70 having the desired surface profile for the abradable layer 10b, and mount this copy cam on the tool 20.

The copy cam 70 can be clamped to the central body 30 by mounting brackets 74 and/or clamping screws 76.

- 5 In the example shown, the copy cam 70 comprises a flat plate 80 in which an elongated through slot 82 is formed. A slot in the sense of the invention has the particularity of being surrounded and delimited by a continuous peripheral edge. The slot is therefore formed at a distance from the edges of the plate 80. The slot 82 comprises a longitudinal edge 84 which defines the desired surface profile, i.e. an axial cross-sectional shape of an internal annular surface of the abradable
10 layer 10b.

The plate 80, for example, has a generally parallelepiped shape. The plate 80 preferably extends in a plane passing through the axis of rotation A.

The machining tool 50 may comprise a follower 91, such as a roller, which is engaged in the slot 82 and cooperates by sliding or rolling with the longitudinal edge 84 of the slot 82.

- 15 The slot 82 is preferably slightly wider than the diameter of the follower or roller.

Figure 11 shows a micrometric adjustment system 92 for setting the depths of machining passes, and a positioning system 93 using conical surfaces and retaining screws.

Figure 12 shows that the central body 30 can be equipped with position-adjustable balancing weights 94 to limit the force required to rotate the central body 30 about the axis of rotation A.

- 20 When not in use, the tool 20 can be stored in a crate which can also be used to transport it.

The present invention also relates to a method for machining an abradable annular layer 10b of a casing 3 of the fan 1 of an aircraft turbine engine, by means of the tool 20 described above, comprising the steps consisting of:

- a) determining the desired surface profile for the abradable layer 10b after machining,
- 25 b) selecting a copy cam 70 comprising a cam profile which corresponds to this surface profile and removably mounting it on the central body, and
- c) machining the abradable layer 10b according to the cam profile.

During machining, the duct of the casing can be protected by shrouds or similar, such as those described in the document WO-A1-2023/062302 for example.

- 30 The invention offers a number of advantages, including:

- improved ergonomics for the operators, particularly in terms of noise levels,
- a dimensional conformity of the abradable layer 41b, which can be detected directly during machining by the probe 4 701,

- faster reconditioning times to minimize engine downtime as much as possible,
 - greater repeatability of reconditioning,
 - a high level of safety for the operators,
 - adaptability of the tool to different surface profile configurations, thanks to the
- 5 interchangeability of the copy cam, etc.

CLAIMS

1. A tool (20) for machining an abradable annular layer (10b) of a casing (3) of a fan (1) of an aircraft turbine engine, this tool (20) being configured so as to be at least partly housed in said casing (3) and comprising:
 - 5 - a central centring body (30) configured to be attached to a fan disk (2) of the turbine engine, so as to be movable in rotation about an axis of rotation (A) of the fan disk (2),
 - a machining tool (50) connected to the central body (30) and comprising at least one machining means (51) configured to come into contact with the abradable layer, and
 - a first motor (52) for driving said machining means (51) in rotation,
- 10 characterized in that the central body (30) comprises or carries a copy cam (70) which comprises a cam profile (72) which is a function of a desired surface profile for the abradable layer (10b) after machining, the machining tool (50) being movable relative to the copy cam (70) and being configured to follow the cam profile (72) so that the machining means (51) machines the abradable layer (10b) in accordance with the cam profile (72),
- 15 and in that the copy cam (70) comprises a flat plate (80) wherein an elongated through slot (82) is formed, this slot (82) comprising a longitudinal edge (84) which defines the desired surface profile, the machining tool (51) comprising a follower (91) which is engaged in the slot (82) and which cooperates by sliding or rolling with said longitudinal edge (84).
- 20 2. The tool (20) according to claim 1, wherein the machining means is a ball end mill (51).
3. The tool (20) according to claim 1 or 2, wherein it comprises a second motor (32) for driving the machining tool (50) in rotation about said axis of rotation (A).
- 25 4. The tool (20) according to one of the preceding claims, wherein said or each motor (32, 52) is a brushless electric motor.
5. The tool (20) according to one of the preceding claims, wherein the copy cam (70) is removably and interchangeably mounted on the central body (30).
- 30 6. The tool (20) according to one of the preceding claims, wherein the plate (80) has a generally parallelepiped shape.

7. The tool (20) according to one of the preceding claims, wherein the flat plate (80) extends in a plane passing through the axis of rotation.
8. The tool (20) according to one of the preceding claims, wherein the follower (91) is a roller.
- 5 9. The tool (20) according to one of claims 5 to 8, wherein the copy cam (70) is clamped to the central body (30) by means of mounting brackets (74) and/or clamping screws (76).
- 10 10. The tool (20) according to one of the preceding claims, wherein said machining means (51) is housed in a cover (53) for protecting and containing chips and dust, this cover (53) being carried by the machining tool (50).
11. The tool (20) according to claim 10, wherein the cover (53) is connected by a hose (54) to a suction pump for chips and dust.
- 15 12. The tool (20) according to one of the preceding claims, wherein it further comprises a measuring tool (40) connected to the central body (30) and comprising at least one probe (41) configured to bear on said layer (10b), this measuring tool (40) being, for example, diametrically opposite the machining tool with respect to said axis of rotation (A).
- 20 13. The tool (20) according to one of the preceding claims, wherein the central body (30) is equipped with balancing weights (94) which are adjustable in position so as to limit the force required to drive the central body in rotation about the axis of rotation (A).
- 25 14. The tool (20) according to one of the preceding claims, wherein it further comprises formwork extensions (62, 64) configured to be mounted on either side of the abradable layer (10b) and to be clamped axially against the abradable layer (10b).
- 30 15. A method of machining an abradable annular layer (10b) of a casing (3) of a fan (1) of an aircraft turbine engine, by means of a tool (20) according to one of the preceding claims, comprising the steps consisting of:
 - a) determining the desired surface profile for the abradable layer (10b) after machining,

- b) selecting a copy cam (70) comprising a cam profile (72) which corresponds to that surface profile, and removably mounting it on the central body (30), and
- c) machining the abradable layer (10b) according to the cam profile (72).