United States Patent	12392253
Kind Code	B2
Date of Patent	August 19, 2025
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Method for maintaining a bladed wheel of a high-pressure turbine of a turbomachine

Abstract

A method for maintaining a bladed wheel of a high-pressure turbine of a turbomachine having a disc with cavities, and blades extending radially from a radially internal root mounted in a cavity of the disc, the root being supported on the disc by means of surfaces of the root and of the disc forming bearing surfaces. At least one foil is removably mounted between the root of at least one blade and the disc, at the corresponding bearing surfaces. The method includes measuring a radial clearance between the tip of at least one blade, meaning the radially external end of the blade, and a shroud of the turbomachine situated facing the bladed wheel, and if the radial clearance is greater than a determined value, removing the foil.

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Appl. No.:	**18/842862**
Filed (or PCT Filed):	**March 08, 2023**
PCT No.:	**PCT/FR2023/050308**
PCT Pub. No.:	**WO2023/175256**
PCT Pub. Date:	September 21, 2023

Prior Publication Data

Document Identifier	**Publication Date**
US 20250198299 A1	Jun. 19, 2025

Foreign Application Priority Data

FR	2202428	Mar. 18, 2022

Publication Classification

Int. Cl.: **F01D11/14** (20060101); **F01D5/30** (20060101)

U.S. Cl.:

CPC **F01D11/14** (20130101); **F01D5/3092** (20130101); F05D2300/17 (20130101)

Field of Classification Search

USPC: None

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS

(1) This application is a US National phase Application of PCT/FR2023/050308 filed Mar. 8, 2023, which claims priority to French Patent Application No. 2202428 filed Mar. 18, 2022, both of which are hereby incorporated in their entirety.

TECHNICAL FIELD OF THE INVENTION

(2) The invention relates to a method for maintaining a bladed wheel of a high-pressure turbine of a turbomachine such as an aircraft turbojet or turboprop engine.

BACKGROUND

(3) FIG. **1** represents a dual-flow double-body turbomachine **1**. The axis of the turbomachine is denoted X. In the following, the terms axial and radial are defined in relation to the X axis.

(4) Turbomachine **1** comprises, from upstream to downstream in the direction of the gas flow within turbomachine **1**, a fan **2**, a low-pressure compressor **3**, a high-pressure compressor **4**, a combustion chamber **5**, a high-pressure turbine **6**, and a low-pressure turbine **7**.

(5) The air coming from fan **2** is divided into a primary flow A flowing in a primary flow path **8**, and a secondary flow B flowing in a secondary flow path **9**.

(6) Low-pressure compressor **3**, high-pressure compressor **4**, combustion chamber **5**, high-pressure turbine **6**, and low-pressure turbine **7** are arranged in primary flow path **8**.

(7) High-pressure turbine **6** and high-pressure compressor **4** are coupled in rotation by means of a first shaft **10** so as to form a high-pressure body.

(8) Low-pressure turbine **7**, low-pressure compressor **3**, and fan **2** are coupled in rotation by means of a second shaft (not shown) so as to form a low-pressure body.

(9) As is shown in FIG. **2**, high-pressure turbine **6** conventionally comprises a disk **11** on which blades **12** are mounted. Each blade **12** comprises an airfoil **13** extending radially outwards from a blade root **14** mounted in a cavity **15** of disc **11**.

(10) Tip **16** of blade **12** is formed by the radially external end of blade **12**. Root **14** and airfoil **13** are separated here by a radially internal platform **17**. Root **14** has the general shape of a fir tree, here with four branches or lobes **18**. The shape of cavity **15** is complementary to the shape of root **14**.

(11) Each fir-tree branch or lobe **18** rests against an opposing complementary surface of disk **11**. The surfaces of root **14** and of disk **11** resting against each other are called bearing surfaces **19**. In the embodiment illustrated in FIG. **4**, root **14** has four bearing surfaces **19**, arranged symmetrically relative to a radial midplane P.

(12) Blades **12** are surrounded by an annular shroud **20**. Clearance j is formed between the tips **16** of blades **12** and the shroud **20** surrounding blades **12**.

(13) In order to maximize the efficiency of the turbomachine, it is necessary to limit the flow of gas in the clearances located between the tips of the blades and the shroud.

(14) During operation, this clearance tends to increase over time due to two phenomena.

(15) The first phenomenon is wear of the blade tip, generated by friction between the blade tip and the shroud which faces it.

(16) The second phenomenon is thermal erosion, i.e. oxidation, of the blade tip, due to the high temperatures to which the blade is subjected during operation, in particular in the case of a high-pressure turbine.

(17) The increase in this clearance leads to degraded performance of the turbomachine, and as a result, to an increase in fuel consumption and in the operating temperatures of the turbomachine, further aggravating the oxidation phenomenon.

(18) Currently, when a blade is too worn or too oxidized at its tip, it is replaced and scrapped. Such a maintenance operation is therefore very costly and/or leads to unplanned removal of the turbomachine due to performance limits being reached.

SUMMARY

(19) The invention aims to remedy the above problems in a simple, reliable, and inexpensive manner.
(20) To this end, the invention proposes a method for maintaining a bladed wheel of a high-pressure turbine of a turbomachine, extending along an axis, comprising a disc comprising cavities, and blades extending radially and each comprising an airfoil and a radially internal root, the root of each blade being mounted in a cavity of the disc, said root being supported by the disc by means of surfaces of the root and of the disc which form bearing surfaces, characterized in that at least one foil is removably mounted between the root of at least one blade and the disc, at the corresponding bearing surfaces, said method comprising the following steps: measuring a radial clearance between the tip of at least one blade, meaning the radially external end of the blade, and a shroud of the turbomachine situated facing the bladed wheel, if the radial clearance is greater than a determined value, removing said foil.
(21) The method according to the invention thus aims to determine the state of wear or deformation of the high-pressure turbine by measuring the radial clearance between the blade tip and the shroud, and if the aforementioned radial clearance is too great, removing the foil. Removing the foil then allows reducing the radial clearance between the blade tip and the shroud, so as to return to acceptable performance, at lower cost, without replacing or repairing the blades or the shroud.
(22) At least one foil may be mounted between the root of each blade and the disc, at the corresponding bearing surfaces, all foils being removed if the radial clearance is greater than said determined value.
(23) In this manner, the creation of disparities or “steps” formed by differences in the positioning of the blade tips on the circumference of the turbomachine is avoided. Such steps can generate aerodynamic disturbances impacting the proper functioning of the turbomachine.
(24) The foil may be removably mounted on the blade root.
(25) The foil may be removably mounted on the disc, for example in the cavity or on a tooth of the disc defined between two adjacent cavities.
(26) The foil may comprise a radial abutment surface bearing against a complementary abutment surface of the blade root or of the disc.
(27) Such a feature allows facilitating the correct axial positioning of the foil and also makes it possible to axially retain the foil in position during operation of the turbomachine.
(28) The foil may have a thickness of between 0.1 and 0.9 mm.
(29) The foil may be made of a cobalt-based alloy.
(30) The foil is for example made of an alloy known under the reference MP 159.
(31) The root of the blade may be a root having the general shape of a fir tree.
(32) Each root may have a symmetrical shape relative to a radial midplane.
(33) A single foil may be mounted between the blade root and the disc. This single foil may be inserted between several bearing surfaces of the blade and of the disc.
(34) Several foils may be removably mounted between the root of at least one blade and the disc. In such a case, the foils may be arranged symmetrically relative to the aforementioned radial midplane.
(35) It is also possible to arrange a stack of several foils between the bearing surfaces of the blade root and the bearing surfaces of the disc. In this case, one or more foils may be removed during each maintenance operation.
(36) Each root may have two pairs of bearing surfaces, engaging with two pairs of bearing surfaces of the disc cavity. The root may thus have the shape of a fir tree with four branches or four lobes, such a shape frequently being used in the case of a bladed wheel of a high-pressure turbine. The cavity of course has a shape complementary to that of the root.
(37) The foil may be made by stamping sheet metal or by sintering a metal powder.
(38) The invention also relates to a bladed wheel of a high-pressure turbine comprising a disc comprising cavities, and blades each comprising an airfoil and a root, the root of each blade being

mounted in a cavity of the disc, said root being supported by the disc by means of surfaces of the root and of the disc which form bearing surfaces, characterized in that at least one foil is removably mounted between the root of at least one blade and the disc, at the corresponding bearing surfaces.
(39) The bladed wheel is preferably a rotor bladed wheel.
(40) The foil is formed by a thin metal sheet.
(41) The invention also relates to a turbomachine, characterized in that it comprises a bladed wheel of the aforementioned type.
(42) The turbomachine may be an aircraft turbojet or turboprop engine. The aircraft may be an airplane.

Description

BRIEF DESCRIPTION OF FIGURES
(1) FIG. **1** is a schematic section view of a turbomachine of the prior art;
(2) FIG. **2** is a schematic view of part of a high-pressure turbine of the prior art;
(3) FIG. **3** is a view illustrating the mounting of a blade root in a cavity of a disk of a bladed wheel according to one embodiment of this document;
(4) FIG. **4** is a perspective view of a cavity equipped with a foil, according to the embodiment of FIG. **3**;
(5) FIG. **5** is a perspective view of a blade root equipped with two side foils, according to another embodiment;
(6) FIG. **6** is a perspective view of a blade root equipped with a single foil, according to another embodiment;
(7) FIG. **7** is a view corresponding to FIG. **3**, in which the foil has been removed following a maintenance operation.
DETAILED DESCRIPTION OF THE INVENTION
(8) FIGS. **3** and **4** illustrate a rotor bladed wheel **6** of a high-pressure turbine according to one embodiment.
(9) This embodiment differs from the one illustrated in FIG. **2** in that a foil **21** is removably mounted in each cavity **15** and completely or almost completely covers the internal surface of each of cavities **15** of the bladed wheel. Foil **21** thus has a general U shape and has recesses capable of housing lobes **18** of root **14** of the corresponding blade **12**. Foil **21** thus has surfaces **22** intended to come into contact with the bearing surfaces of root **14** of blade **12**. These surfaces are called the bearing surfaces **22** of foil **21**.
(10) Foil **21** is formed by a metal sheet having a thickness of between 0.1 and 0.9 mm, and made of a cobalt-based alloy.
(11) Root **14** of blade **12** comes to rest against bearing surfaces **22** of foil **21** after assembly in cavity **15**.
(12) One will note that the radial position of tip **16** of blade **12** takes into account the thickness of foil **21** in its specifications, so as to obtain the desired clearance j.
(13) It is also possible to use two foils **21**, located one on either side of midplane P and arranged symmetrically, said foils **21** covering bearing surfaces **19** of cavity **15**. Each foil **21** only covers half, or less, of cavity **15**.
(14) FIGS. **4** and **5** illustrate two embodiments in which foils **21** are removably mounted, not in cavities **15** but on roots **14** of blades **12**.
(15) The assembly formed by blade root **14** and foil(s) **21** is then mounted in the corresponding cavity **15** of disc **11**.
(16) FIG. **5** illustrates one embodiment in particular in which two side foils **21** are mounted on either side of root **14**, symmetrically relative to the radial midplane P. Each foil **21** has a shape

complementary to the lateral side of root **14**, each foil **21** thus covering the two lateral bearing surfaces **19** concerned of root **14** of blade **12**.
(17) FIG. **6** illustrates an embodiment in which a single foil **21** covers the two lateral sides of root **14** of blade **12**, i.e. it covers all of bearing surfaces **19** of root **14**.
(18) Foil **21** has a shape complementary to that of root **14** and comprises a radial wall **23** capable of forming an axial abutment which bears against a radial end surface **24** of root **14**, which may be an upstream surface or a downstream surface of root **14**.
(19) Note that foil **21** does not cover the radially internal end surface **25** of root **14**. In fact, channels in blade **12** for the circulation of cooling air have mouths at end surface **25** and it is necessary that these channels not be blocked. Alternatively, foil **21** may cover said radially internal end surface **25** of root **14** but then comprises orifices or openings lined up with the mouths of said channels, to allow the passage of cooling air.
(20) As indicated above, this document proposes a method for maintaining such a bladed wheel **6** of a high-pressure turbine, said method comprising a step during which the radial clearance j between tip **16** of blade **12** and shroud **20** is measured, and if this radial clearance j is greater than a determined value, foil(s) **21** are removed, as illustrated in FIG. **7**. This has the effect of bringing the blade tip **16** closer to shroud **20**, and therefore reducing the clearance j by the value of the thickness of foil **21**.
(21) It is thus possible to reduce the clearance j in a simple, rapid, and inexpensive fashion, in a manner that improves the performance of the turbomachine and compensates for the aforementioned wear or corrosion phenomena.

Claims

1. A method for maintaining a bladed wheel (**6**) of a high-pressure turbine of a turbomachine, extending along an axis, comprising a disc (**11**) comprising cavities (**15**), and blades (**12**) extending radially and each comprising an airfoil (**13**) having a radially external tip and a radially internal root (**14**), the root (**14**) of each blade (**12**) being mounted in a respective cavity (**15**) of the disc (**11**), said root (**14**) being supported by the disc (**11**) by means of surfaces of the root (**14**) and of the disc (**11**) which form bearing surfaces (**19**), characterized in that at least one foil (**21**) is removably mounted between the root (**14**) of at least one blade (**12**) and the disc (**11**), at the corresponding bearing surfaces (**19**), said method comprising the following steps: measuring a radial clearance (j) between the tip (**16**) of at least one blade (**12**), and a shroud (**20**) of the turbomachine surrounding the bladed wheel, when the radial clearance (j) is greater than a determined value, removing said foil (**21**).
2. The method according to claim 1, wherein the at least one foil (**21**) is mounted between the root (**14**) of each blade (**12**) and the disc (**11**), at the corresponding bearing surfaces (**19**), all foils (**21**) being removed when the radial clearance (j) is greater than said determined value.
3. The method according to claim 2, wherein the foil (**21**) is removably mounted on the blade root (**14**).
4. The method according to claim 2, wherein the foil (**21**) is removably mounted on the disc (**11**), in the cavity (**15**) or on a tooth of the disc (**11**) defined between two adjacent cavities (**15**).
5. The method according to claim 2, wherein the foil (**21**) comprises a radial abutment surface (**23**) bearing against a complementary abutment surface (**24**) of the root (**14**) of the blade (**12**) or of the disc (**11**).
6. The method according to claim 2, wherein the foil (**21**) has a thickness of between 0.1 and 0.9 mm.
7. The method according to claim 2, wherein the foil (**21**) is made of a cobalt-based alloy.
8. The method according to claim 2, wherein the at least one foil comprises several foils and are removably mounted between the root (**14**) of a respective blade of the at least one blade (**12**) and

the disc (**11**).
9. The method according to claim 1, wherein the foil (**21**) is removably mounted on the blade root (**14**).
10. The method according to claim 1, wherein the foil (**21**) is removably mounted on the disc (**11**), in the cavity (**15**) or on a tooth of the disc (**11**) defined between two adjacent cavities (**15**).
11. The method according to claim 1, wherein the foil (**21**) comprises a radial abutment surface (**23**) bearing against a complementary abutment surface (**24**) of the root (**14**) of the blade (**12**) or of the disc (**11**).
12. The method according to claim 1, wherein the foil (**21**) has a thickness of between 0.1 and 0.9 mm.
13. The method according to claim 1, wherein the foil (**21**) is made of a cobalt-based alloy.
14. The method according to claim 1, wherein the at least one foil comprises several foils and are removably mounted between the root (**14**) of a respective blade of the at least one blade (**12**) and the disc (**11**).