

### **Method for cutting machining of turbine blades**

The invention relates to a method for cutting machining of turbine blades on a multi-axis machine tool, wherein the turbine blade is held by a rotatable blade-root clamping device  
5 a rotatable blade-tip clamping device and is machined by means of a tool which is chucked in a tool spindle.

In such methods, the elastic bending of the turbine blade which is caused by cutting  
10 forces is a known problem. This bending detrimentally affects the accuracy of the machining and can lead to vibrations in the turbine blade, as a result of which the surface quality in the machined profile sections is impaired.

A solution of the above-mentioned problem is known from document EP261896 B1, in  
15 which the turbine blade during the machining is supported in certain sections by means of a back stay which can travel along the blade axis. This back stay has a number of plungers which can move along their axis and are pressed against the turbine blade in order to support this. This back stay requires a relatively large amount of space all around the turbine blade, requires additional drives, detrimentally affects the accessibility  
20 to the turbine blade and can obstruct the falling of chips. Moreover, during a change of the profile section which is to be machined the back stay has to be circumvented by the tool, which necessitates a considerable programming cost and involves a certain risk of collision anyway. Moreover, the finish-machined blade surface can be damaged by the plungers, for example by these leaving behind impressions.

25 Documents CH693610A5 and WO2015/157166A1 show devices with clamping jaws which are adapted to the blade profile, but the workpiece has to be reclamped there in order to be able to machine all the profile sections.

30 Starting from this prior art, the invention is based on the object of proposing a method for cutting machining of turbine blades, in which the turbine blade is machined in a single chucking, wherein in the region of the blade tip the chucking is such that a bending of the turbine blade as a consequence of cutting forces is reduced and vibrations are damped.

35 This object is achieved according to the invention by a first profile section which is adjacent to the blade tip being machined first of all by the tool, by the tool then being removed and the tool spindle grabbing an additional clamping device which has clamping

jaws adapted to the first profile section, by the additional clamping device being positioned on the blade-tip clamping device in such a way that the clamping jaws rest in the first profile section, and by the tool spindle grabbing a tool and machining the remaining profile section with it.

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This embodiment according to the invention of the method has the following advantages. The space between the blade-root clamping device and the additional clamping device remains free during the machining of the remaining profile section so that the turbine blade remains accessible for the tool and the chips can fall down freely. As a result of this accessibility, there is no risk of collision for the tool and the programming of the machining is simpler compared with the known prior art. Furthermore, the machine tool does not need an additional axis for handling the additional clamping device and finally care is taken of the surface of the blade profile as a result of the adapted clamping jaws.

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15 Particular types of embodiment of the invention are described in the dependent claims.

Exemplary embodiments of the invention are explained below with reference to the attached drawings. In the drawings

20 Figure 1 shows a perspective view of the region of the blade-tip clamping device of a machine tool after the machining of a first profile section and

Figure 2 shows a view corresponding to Figure 1 after attaching the additional clamping device.

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The two drawing figures show in perspective views a region of a machine tool during the machining of the turbine blade 1, with a rotatably drivable blade-tip clamping device 2. The axis and the drive of this blade-tip clamping device 2 are accommodated in a housing 3. Provision is made for a blade-root clamping device which is disposed opposite the blade-tip clamping device 2 and for a tool axis which is oriented at an angle to the longitudinal axis of the turbine blade 1, but are not shown in the figures. It is shown in Figure 1 that a first profile section 4 which is adjacent to the blade tip has already been machined by the tool. This machining does not necessarily have to be finish-machining. It is only important that the profile section provides a defined, stable contact surface for the clamping jaws mentioned below.

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An additional clamping device 5, consisting of two parts 5.1 and 5.2, for stabilising said first profile section 4 is mounted on the housing 3 later application in the view according to Figure 1 for. Each part 5.1, 5.2 of the additional clamping device 5 is equipped with a clamping jaw 6.1, 6.2, the clamping face of which is adapted to the already machined  
5 first profile section 4. The clamping jaws 6.1 and 6.2 do not have to butt against the section 4 in a full-faced manner but can have interrupted contact sections. Each part 5.1, 5.2 of the additional clamping device 5 also has an upwardly projecting manipulating pin 7 which can be grabbed by the tool spindle after the tool, for example a miller, which was previously chucked in this has been deposited in a tool magazine.

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In the view according to Figure 2, the two parts 5.1 and 5.2 of the additional clamping device 5 have been brought into their position on the blade tip by the tool spindle and clamped tight. In the process, the first part 5.1 was first of all grabbed by its manipulating pin 7 by the tool spindle and by means of a zero-point clamping device  
15 fixed on the blade-tip clamping device 2 for example on the suction side of the turbine blade 1 and the turbine blade was then rotated by 180 degrees. After that, the second part 5.2 was fixed by means of the tool spindle in a similar manner on the pressure side of the turbine blade. The manipulating pins 7 are hollow and enable the operation of the additional clamping device 5 for example by means of a pressurised fluid, for example  
20 compressed air, which is fed through the tool spindle. In this case, the additional clamping device 5 is released under pressure and clamped if it is unpressurised.

Compared with the prior art which is known from document EP2618961B1 mentioned in the introduction, the previously described method is managed with significantly lower  
25 costs and practically without maintenance. Also, the programming is less complex and allows a fixed, fully automatic positioning of the tool without risk of collision, even in the event of variable blank sizes.

**List of designations**

|    |     |                                          |
|----|-----|------------------------------------------|
|    | 1   | Turbine blade                            |
| 5  | 2   | Blade-tip clamping device                |
|    | 3   | Housing                                  |
|    | 4   | First profile section                    |
|    | 5   | Additional clamping device               |
|    | 5.1 | Part of the additional clamping device 5 |
| 10 | 5.2 | Part of the additional clamping device 5 |
|    | 6.1 | Clamping jaw                             |
|    | 6.2 | Clamping jaw                             |
|    | 7   | Manipulating pin                         |

## Patent claims

1. Method for cutting machining of turbine blades (1) on a multi-axis machine tool, wherein the turbine blade (1) is held by a rotatable blade-root clamping device and a  
5 rotatable blade-tip clamping device (2) and is machined by means of a tool which is  
chucked in a tool spindle, characterised in that a first profile section (4) which is adjacent  
to the blade tip is first of all machined by the tool, in that the tool is then removed and the  
tool spindle grabs an additional clamping device (5) which has clamping jaws (6.1, 6.2)  
adapted to the first profile section (4), in that the additional clamping device (5) is  
10 positioned on the blade-tip clamping device (2) in such a way that the clamping jaws  
(6.1, 6.2) rest in the first profile section (4), in that the tool spindle grabs a tool and  
machines the remaining profile section with it.
2. Method according to Claim 1, characterised in that the additional clamping device (5)  
15 is fastened on the blade-tip clamping device (2) by means of a zero-point clamping  
system.
3. Method according to one of the preceding claims, characterised in that the clamping  
jaws (6.1, 6.2) are arranged in the additional clamping device (5) in an exchangeable  
20 manner.
4. Method according to one of the preceding claims, characterised in that the additional  
clamping device consists of two parts (5.1, 5.2), of which each has a clamping jaw (6.1,  
6.2).  
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5. Method according to Claim 4, characterised in that the first part (5.1) of the additional  
clamping device (5) is first of all attached on the suction side or the pressure side of the  
machined profile section (4), in that the turbine blade (1) is rotated by 180 degrees and  
then the second part (5.2) of the additional clamping device (5) is attached on the  
30 pressure side or the suction side of the machined profile section (4).
6. Method according to Claim 5, characterised in that a manipulating pin (7) is arranged  
on each part (5.1, 5.2) of the additional clamping device (5) for grabbing the part (5.1,  
5.2) by means of the tool spindle.  
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7. Method according to Claim 6, characterised in that the manipulating pin (7) is hollow.

8. Method according to Claim 7, characterised in that the additional clamping device (5) is clamped or released by means of a pressurised fluid which is fed through the tool spindle.

- 5 9. Machine tool for cutting machining of turbine blades (1), wherein the machine tool has a rotatable blade-root clamping device and a rotatable blade-tip clamping device (2) for holding a turbine blade (1), wherein the machine tool furthermore has a tool spindle for the chucking of a tool, characterised in that the machine tool has an additional clamping device (5) which consists of two parts (5.1, 5.2) which in each case are equipped with  
10 one or more clamping jaws (6.1, 6.2), and wherein the two parts (5.1, 5.2) can be independently positioned and fastened to the blade-tip clamping device (2).

10. Machine tool for cutting machining of turbine blades (1) according to Claim 9, characterised in that a manipulating pin (7) is provided on each part (5.1, 5.2) of the  
15 additional clamping device (5) for grabbing the part (5.1, 5.2).

11. Machine tool for cutting machining of turbine blades (1) according to either of Claims 9 and 10, characterised in that the additional clamping device (5) is clamped or released by means of a pressurised fluid which is fed through the tool spindle.  
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12. Machine tool for cutting machining of turbine blades (1) according to any one of preceding Claims 9 to 11, characterised in that the additional clamping device (5) can be fastened on the blade-tip clamping device (2), by means of a zero-point clamping system.  
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13. Machine tool for cutting machining of turbine blades (1) according to any one of preceding Claims 9 to 12, characterised in that when not in use, the additional clamping device (5) is stowed on another part of the machine tool.