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[Suite sur la page suivante]

(54) Title: HYDRAULIC MACHINE INCLUDING MEANS FOR INJECTING A FLOW DRAWN FROM A MAIN FLOW

(54) Titre : MACHINE HYDRAULIQUE COMPRENANT DES MOYENS D'INJECTION D'UN ÉCOULEMENT PRÉLEVÉ D'UN ÉCOULEMENT PRINCIPAL

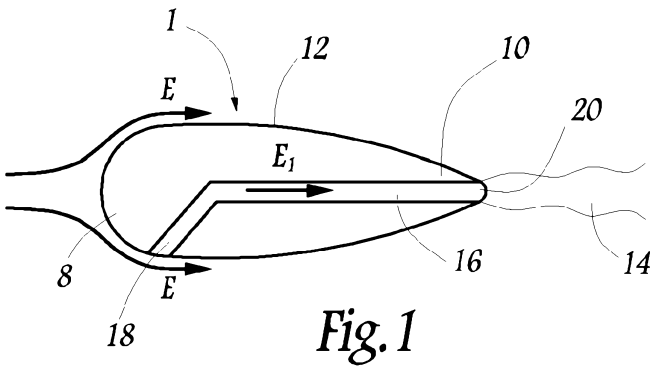

Fig. 1

(57) Abstract: The invention relates to a hydraulic machine through which a main flow (E) of water passes, including at least one turbine blade profile (1) having an upstream end (8) and a downstream end (10), with at least a turbulent zone, reduced-pressure zone or cavitation zone (14) being formed close to said downstream end. The machine also includes means for injecting a flow (E_1, E_2) drawn from the main flow into the aforementioned zone (14). The injection means include a channel (16) for drawing said flow (E_1, E_2) from the main flow (E) and discharging same at the downstream end (10) substantially in the direction of the main flow (E).

[Suite sur la page suivante]

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(57) Abrégé : Cette machine traversée par un écoulement (E) principal d'eau comprend au moins un profil d'aubage (1) d'une turbine, présentant une extrémité amont (8) et une extrémité aval (10), au voisinage de laquelle se forme au moins une zone tourbillonnaire ou une zone de pression réduite ou une zone de cavitation (14), la machine comprenant des moyens d'injection d'un écoulement prélevé (E_1, E_2) dudit écoulement principal dans ladite zone (14). Les moyens d'injection comprenant une conduite (16) prélevant l'écoulement (E_1, E_2) de l'écoulement principal (E) et le faisant déboucher dans l'extrémité aval (10) sensiblement selon la direction de l'écoulement principal (E).

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Hydraulic machine including means for injecting a flow drawn from a main flow

The present invention relates to a hydraulic machine of the type traversed by a main flow of water, comprising at least one blade profile of a turbine, having an upstream end and a downstream end, in the vicinity of which is formed at least one eddy zone or a reduced-pressure zone or a cavitation zone, the machine comprising means of injecting a flow tapped from said main flow, not modified relative to the main flow, in said eddy or reduced-pressure or cavitation zone so as to locally modify the main flow or increase the pressure in this zone.

Such a hydraulic machine is used, for example, in a plant for producing hydroelectricity. The machine is installed in the path of the current or is supplied with water from a reservoir into which one or more water courses are discharged.

In these hydraulic machines, there are zones in which the main flow traversing the machine is disturbed and forms eddies or exhibits a reduced pressure or cavitation zones, because of the configuration of the machine. Such zones disrupt the general performance of the hydraulic machine because they reduce the efficiency of action of the main flow in the hydraulic machine or cause problems of operation of the hydraulic machine.

The document US-1 942 995 describes a hydraulic machine of the abovementioned type, making it possible to inject a flow tapped from the main flow in the cavitation zone being formed along the blades of the turbine wheel.

However, the outlet orifices for the tapped flow are arranged to inject the flow in a direction roughly

perpendicular to the direction of the main flow. Such orifices do not make it possible to eliminate the eddy zones that are formed in the trail of the blades and also disturb the general performance of the hydraulic machine.

Embodiments of the invention may alleviate these drawbacks by making it possible to eradicate the eddy zones that are formed in the trail of any blade profile.

Accordingly, the invention relates to a hydraulic machine of the aforementioned type, in which the injection means comprising a duct drawing the flow from the main flow and making it open into the downstream end substantially in the direction of the main flow.

The injection of a flow tapped from the main flow into the downstream end of the blade profile makes it possible to modify the main flow in the eddy zone that is formed immediately downstream of the blade profile in the trail of the latter. The eddy zone is thus eliminated, which makes it possible to effectively make good the lack of performance in the action of the main flow in this zone, which enhances the performance and the behaviour of the hydraulic machine.

In a first aspect, a hydraulic machine is disclosed. The hydraulic machine is traversed by a main flow of water and comprises at least one blade profile of a turbine, having an upstream end and a downstream end, in the vicinity of which is formed at least one eddy zone or a reduced-pressure zone or a cavitation zone. The machine further comprises means of injecting a flow tapped from the main flow, not modified relative to the main flow, in said eddy or reduced-pressure or cavitation zone so as to locally modify the main flow or increase the pressure in this zone. The means of

injection of the flow comprises a duct opening into the downstream end substantially in the direction of the main flow.

According to embodiments of the hydraulic machine:

- the duct may comprise an inlet drawing the flow from the main flow upstream of the blade profile and an outlet opening into the eddy or reduced-pressure or cavitation zone,
- the injection means may comprise a valve placed in the path of the tapped flow, the said valve may be able to be moved between an open position in which it allows the tapped flow to pass from the main flow and a closed position in which it prevents the passage of the tapped flow,
- the movement of the valve may be controlled by suitable control means,
- the blade profile may be at least one blade of a plurality of blades of a Francis turbine wheel, said blades may be arranged between a ceiling and a belt, the flow may be tapped from the ceiling or from the belt by means of openings formed in said ceiling or in said belt, said flow opening into the downstream end of the at least one blade.

Other aspects and advantages of the invention will appear during the following description, given as an example and made with reference to the appended drawings in which:

- Fig. 1 is a schematic representation in section from the top of a blade profile of a turbine according to an embodiment of the invention,
- Fig. 2 is a partial schematic representation in section of a Francis turbine according to an embodiment of the invention,
- Fig. 3 is a schematic representation seen from above of the Francis turbine rotor of Fig. 2

The embodiment of the invention described below applies particularly to hydraulic machines of the Francis turbine type. Since these machines are known, they will not be described in detail in the present description. The invention also applies to other types of hydraulic machines in which problems of the formation of eddy, reduced-pressure or cavitation zones occur.

In the description, the terms "upstream" and "downstream" are defined with respect to the direction of flow of the main flow E traversing the hydraulic machine.

With reference to Fig. 1, a member of a hydraulic machine of the blade profile 1 type of a turbine is described. Such a blade profile 1 is for example a fixed guide vane, a wicket gate or a turbine blade. The blade profile 1 shown in Fig. 1 is a fixed guide vane.

The function of fixed guide vanes and wicket gates is to guide a main flow E which traverses the rotor 4 of the turbine sweeping against the blades 6, which rotates the rotor 4 about a vertical axis Z-Z'.

The blade profile 1 has an upstream end 8 and a downstream end 10 connected together by side walls 12 swept by the main flow E. Whether it be a fixed guide vane, a wicket gate or a turbine blade, an eddy and/or reduced-pressure zone 14 is created in the vicinity of the downstream end 10, particularly immediately downstream of the downstream end 10, which can cause vibrations in the hydraulic machine.

The blade profile 1 comprises at least one duct 16 extending inside the profile between an inlet opening 18 and an outlet opening 20. The inlet opening 18 is placed in the vicinity of the upstream end 8 and emerges for example in one of the side walls 12 of the

blade profile 1. A portion E_1 of the main flow E sweeping the side walls 12 is therefore tapped off in the duct 16 via the inlet opening 18 and is conveyed to the outlet opening 20. According to another embodiment, the duct 16 taps the flow E_1 on the outside of the blade profile 1 and conveys this flow to the outlet opening 20.

The outlet opening 20 emerges in the downstream end 10. Therefore, the tapped flow E_1 from the main flow E travels in the duct 16 and is injected into the zone 14 via the outlet opening 20. The effect of this is to modify the properties of the flow E in the zone 14 and thereby to prevent the vibration phenomena.

In the case of a blade 6, there is also a problem of the creation of cavitations on the profile of the blades 6 of the rotor 4 in a zone in the vicinity of the inlet edges or upstream end 8 and/or of the outlet edges or downstream end 10 of the blades. In order to alleviate this drawback, the blade 6, shown in Fig. 2, comprises other ducts (not shown) extending inside the blade between an inlet opening 22 and an outlet opening 24, 26. The inlet openings 22 of the ducts are placed in the vicinity of the upstream end 8 of the blade 6 so as to tap off a flow from the main flow E upstream of the blade. The outlet openings 24, 26 of the ducts are arranged to inject the tapped flow on the side walls of the blades 6 in the vicinity of the upstream end 8 and/or of the downstream end 10 of the blade 6. The effect of the tapped and injected flow is to locally modify the main flow E and thereby to prevent the phenomena of forming cavitation on the profile of the blades. Certain ducts therefore comprise an outlet opening 24 leading into a side wall of the blade 6 in the vicinity of the upstream end 8 in order to prevent the phenomena of forming cavitation on the blades in the vicinity of the upstream end 8. Other ducts

comprise an outlet opening 26 opening into a side wall of the blade 6 in the vicinity of the downstream end 10 in order to prevent the phenomena of forming cavitation on the blades in the vicinity of the upstream end 10.

According to various embodiments, the inlet and outlet openings may be placed in series along the upstream end 8 and the downstream end 10 of the blade 6 in a direction which may be perpendicular to the direction of the main flow E, as shown by the outlet openings 24 of Fig. 2.

According to a particularly advantageous embodiment, the outlet openings are arranged so as to open into the downstream end 10 of the blade 6 in the direction of the main flow E. The openings open, for example, into the base of the blade 6. The injection of the flow tapped into the downstream end makes it possible to eliminate the eddy zone that is formed in the zone of turbulence of the blades 6.

The blades 6 of the rotor 4 are placed between a ceiling 28 and a belt 30.

According to one embodiment, the phenomena of cavitation on the blades may also be prevented by openings 31 made in the ceiling 28 opposite the blades 6, as shown in Fig. 3. These openings 31 communicate with the outlet openings 24, 26 and/or with the outlet openings 20 opening into the downstream end 10 by means of channels not shown. In this embodiment, a flow E_2 is tapped off from the main flow E and passes through the spaces between the fixed part of the turbine and the moving blades 6. The tapped flow E_2 is tapped off in the annular space 34 situated above the ceiling 28. This flow E_2 enters the openings 31 and is then guided to the outlet openings 24, 26 and/or 20.

In addition to the cavitation phenomena on the blades, there may also be phenomena of forming a vortex in the space 33 between the blades 6. These phenomena may be alleviated by means of ducts, the inlet and outlet orifices of which are placed between the upstream and downstream ends of the blades and open into the space 33 between the blades. According to one embodiment, the problem of forming a vortex between the blades 6 is solved by means of orifices 32 made in the ceiling 28, as shown in Fig. 2.

In this embodiment, the flow E_2 tapped off upstream of the blades 6 in the annular space 34 travels into the openings 32 and supplies the spaces 33 between the blades 6, as shown in Fig. 3. The openings 32 are distributed in the ceiling 28 facing the spaces 33 separating the blades 6. Therefore, the tapped flow E_2 is injected between the blades 6 and modifies the properties of the flow E in order to prevent the phenomena of forming a vortex between the blades 6.

As a variant, instead of or in addition to travelling via the ceiling 28, the tapped flow E_2 can travel through the belt 30 by means of openings (not shown) made in the latter.

According to an embodiment that can be applied to all the injection means described above, the injection means comprise a valve 72 placed in the path of the tapped flow, as shown in Figs 2 and 5. The valve 72 can be moved between an open position in which it allows the tapped flow to pass and a closed position in which it prevents the passage of the tapped flow. The valve 72 is for example placed in the vicinity of each inlet opening of the injection means and makes it possible manually or automatically to control the injection of the tapped flow. In the case of the Francis turbine, the valve 72 is provided in the vicinity of each

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opening 32 arranged in the ceiling 28.

The movement of the valve 72 is controlled by control means (not shown) which are mechanical or electric in a manner known per se. Therefore, during operating conditions of the hydraulic machine causing the formation of eddy or reduced-pressure or cavitation zones, an automatic system or an operator of the machine switches the valve(s) to the open position which makes it possible to inject the tapped flow in the said zones and to prevent the formation of these zones, as described above.

It should be noted that the tapped flow is not modified relative to the main flow E, that is to say that the water does not sustain any operation to modify its composition during the tapped flow.

The above references to the background art do not constitute an admission that the art forms part of the common general knowledge of a person of ordinary skill in the art. The above references are also not intended to limit the application of the hydraulic machine as disclosed herein.

In the claims which follow, and in the preceding description, except where the context requires otherwise due to express language or necessary implication, the word "comprise" and variations such as "comprises" or "comprising" are used in an inclusive sense, i.e. to specify the presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the hydraulic machine as disclosed herein.

CLAIMS

1. A hydraulic machine traversed by a main flow of water, comprising at least one blade profile of a turbine, having an upstream end and a downstream end, in the vicinity of which is formed at least one eddy zone or a reduced-pressure zone or a cavitation zone, the machine comprising means of injecting a flow tapped from said main flow, not modified relative to the main flow, in said eddy or reduced-pressure or cavitation zone so as to locally modify the main flow or increase the pressure in this zone, wherein the means of injection of the flow comprise a duct opening into the downstream end substantially in the direction of the main flow.

2. A hydraulic machine according to Claim 1, wherein the duct of the blade profile includes an inlet drawing the tapped flow from the main flow upstream of the blade profile and an outlet opening into the eddy or reduced-pressure or cavitation zone.

3. A hydraulic machine according to Claim 2, wherein the injection means comprise a valve placed in the path of the tapped flow, the said valve being able to be moved between an open position in which it allows the tapped flow to pass from the main flow and a closed position in which it prevents the passage of the tapped flow.

4. A hydraulic machine according to Claim 3, wherein the movement of the valve is controlled by suitable control means.

5. A hydraulic machine according to any one of Claims 1 to 4, wherein the blade profile is at least one blade of a plurality of blades of a Francis turbine wheel, said blades being arranged between a ceiling and a

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belt, the flow being tapped from the ceiling or from the belt by means of openings formed in said ceiling or in said belt, said flow opening into the downstream end of the at least one blade.

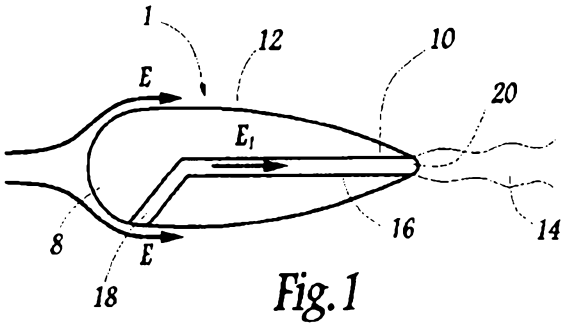

Fig.1

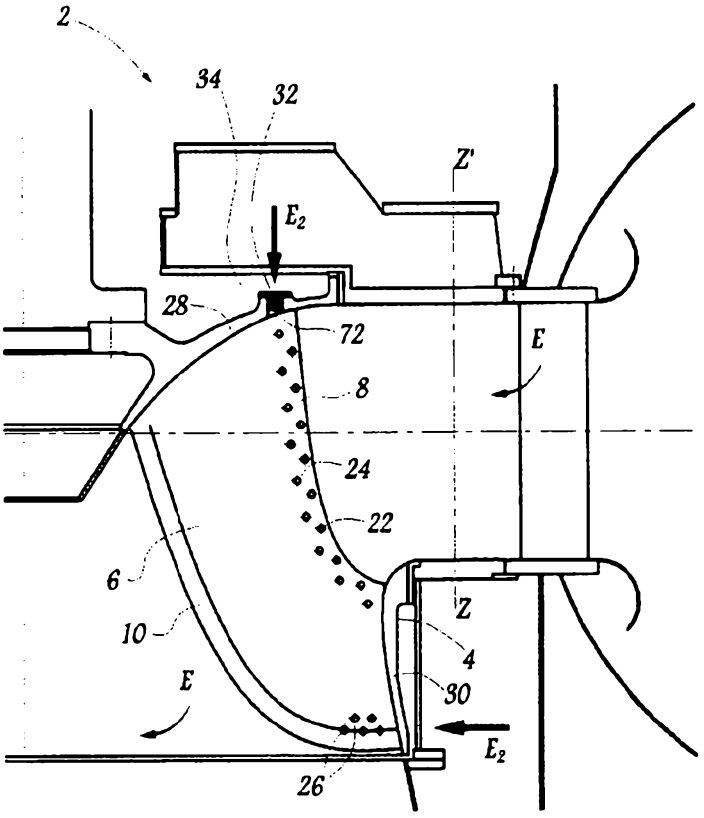

Fig.2

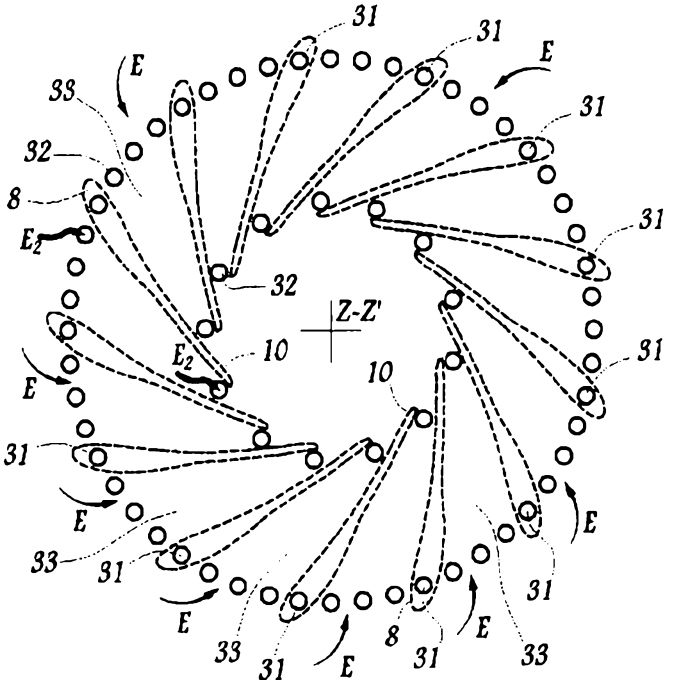

Fig.3