

[54] DIAPHRAGM FOR STEAM TURBINE
STAGE

[76] Inventors: **Jury Fedorovich Kosyak**, prospekt
Moskovsky 202, kv. 85; **Sergei
Petrovich Sobolev**, pereulok
Molchanovsky 7, kv. 5; **Ary
Fedorovich Rudkovsky**, ploschad
Tevelva, 2/2, kv. 9; **Viktor
Vasilievich Ugolnikov**, ploschad
Teveleva 2/2, kv. 28; **Yakov Lvovich
Iglinsky**, ulitsa Mezhlauka, 9/2, kv.
39; **Nikolai Artemovich
Babadzhanian**, ulitsa Ganny, 44, kv.
3; **Semen Iosifovich German**, ulitsa
Mayakovskogo, 11, kv. 21; **Ivan
Fedorovich Ochkovsky**, ulitsa
Kleimenovskaya 15; **Teodor
Markovich Zilber**, ulitsa
Danilevskogo, 22, kv. 100, all of
Kharkov, U.S.S.R.

[22] Filed: Apr. 10, 1973

[21] Appl. No.: 349,813

[52] U.S. Cl. 415/168; 415/121 A

[51] Int. Cl. F01d 25/32

[58] Field of Search 415/121 A, 168; 416/168

[56]

References Cited

UNITED STATES PATENTS

2,362,831	11/1944	Kraft.....	415/168
2,399,009	4/1946	Doran.....	415/121 A

FOREIGN PATENTS OR APPLICATIONS

343,407	2/1931	United Kingdom.....	415/168
948,293	1/1964	United Kingdom	

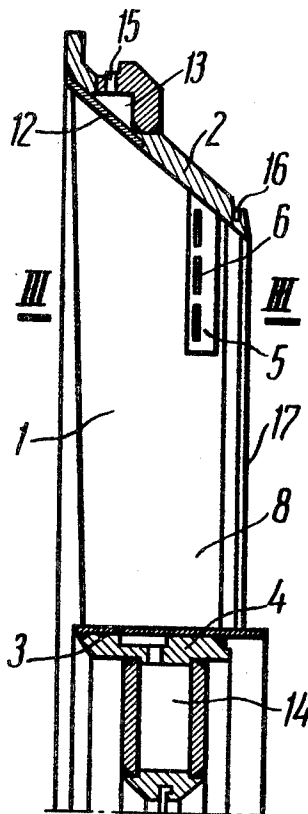
Primary Examiner—Henry F. Raduazo

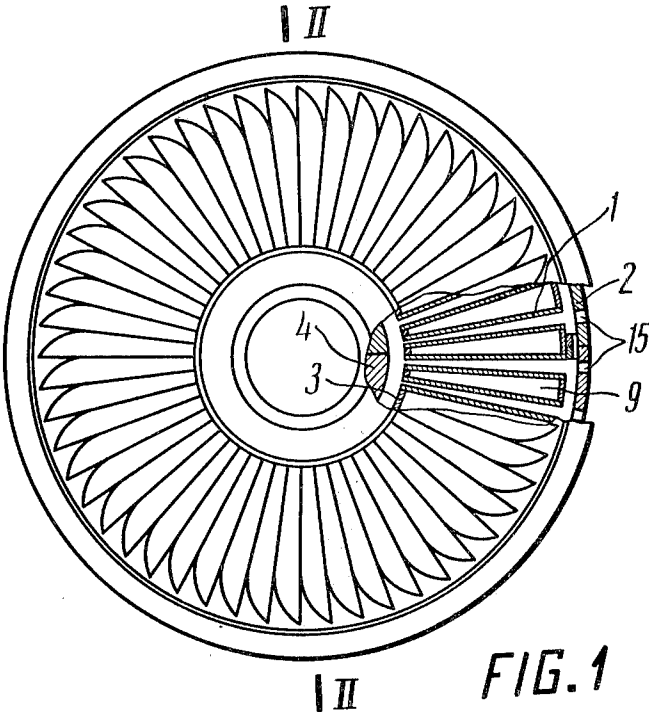
[57]

ABSTRACT

A diaphragm for a steam turbine stage comprises hollow guide blades with one end of each blade being fixed to a diaphragm rim and with the other — to a diaphragm body. Each blade is provided with at least one slot for removal of liquid phase from wet steam, said slot being communicated with the interior of a blade and located in a moisture collecting groove made on the flat surface of the blade profile from the intake side of the wet steam main flow.

2 Claims, 4 Drawing Figures





DIAPHRAGM FOR STEAM TURBINE STAGE

The present invention relates to the field of steam turbines and, more particularly, to diaphragms for a steam turbine stage.

The present invention may be successfully used for removal of a coarse dispersoid phase from diaphragms of steam turbine stages working within wet steam ranges.

A diaphragm for a steam turbine comprising hollow guide blades is known. Each of the blades has one end fixed to the diaphragm rim and the other— to the diaphragm body. The arrangement of the diaphragm with respect to the runner of the turbine is so that the wet steam main flow, which leaves the guide blade channels formed by adjacent blade profiles, acts upon the runner thereby rotating it. The diaphragm and the runner form a turbine stage. The effective part of a turbine consists of a number of serially arranged turbine stages.

Wet steam consists of gaseous and liquid phases.

Upon passage of the wet steam flow through the guide blade channels, the liquid phase settles down to the surfaces of the guide blades and flows towards the outlet ends thereof. Having separated from the outlet ends of the guide blades the liquid phase reaches the runner blades. The direction of the velocity vector of liquid phase is opposite to the vector of the runner rotational speed, thereby hampering the rotation of the runner decelerating it and resulting in a loss of efficiency of a turbine stage, and hence, of a turbine as a whole.

Furthermore, the contact between the liquid phase and the runner of a turbine brings about the erosion of the latter which also leads to a loss of efficiency and shortening of the service life of the blade and a turbine as a whole.

Attempts to prevent contact of the liquid phase with the runner blades of a turbine were made following two paths:

peripheral and intrachannel removal of liquid phase from guide blades of the diaphragm.

In the case of the peripheral removal of the liquid phase the latter is rejected into the peripheral zone and led out of the effective part of the turbine under the action of the wet steam main flow and the centrifugal forces upon the runner blades.

The common practice revealed that the peripheral moisture removal is not effective.

An example of the intrachannel liquid phase removal from the surface of the guide blades is a diaphragm of a condensing turbine comprising the hollow guide blades. Each blade has one end fixed to the diaphragm rim and the other — to the diaphragm body. Furthermore, each blade is provided with a slot for removal of the liquid phase from wet steam. This slot is communicated with the interior of the blade and is located at the outlet end of the blade along the profile surface thereof. The interior of the blade is connected to a condenser. The liquid phase, upon flowing around the guide blade profile, is sucked into the interior of the blade through the slot due to a pressure difference in the channel formed by the profiles of the two adjacent blades. From the interior of the blade the liquid phase is led out into the condenser through the body and the rim of the diaphragm. However, only a small quantity of the liquid phase can be led out of the effective part of the turbine due to the fact that the slots are located

in the zone of high pressure gradients, and in this zone the liquid phase is atomized, blown off and entrained by the main wet steam flow to the runner of the turbine stage. This also gives rise to the erosion of the runner blades thus resulting in a loss of the efficiency of the turbine stage.

Also known in the art is a diaphragm of a steam turbine low pressure stage.

The diaphragm of a low pressure stage comprises hollow guide blades. These blades partially or wholly are made of porous metal. One end of each blade is fixed to the diaphragm rim, and the other — to the diaphragm body. The interior of the blade is communicated with a condenser.

Upon contacting the surface of the guide blade the liquid phase due to the pressure difference between the interior of the guide blades and the guide blade channels is sucked into the interior of the guide blade and then is fed into the condenser.

However, the liquid phase removal from the guide blade surface of this diaphragm is not very effective, because a portion of the liquid phase upon encountering the porous surface is rebound to the wet steam flow thus leading to the erosion of the runner blades and to gradual destruction of the blade edges resulting in a loss of the efficiency of a turbine stage.

Furthermore, known in the art is a diaphragm of a steam turbine stage with the intrachannel moisture separation. This diaphragm comprises hollow guide blades. One end of each blade is fixed to the diaphragm body and the other — to the diaphragm rim. The hollow blade is provided with an opening for moisture removal. These openings located at the outlet end of the blade are communicated with the interior of the blade. The interior of the guide blade is connected to a turbine condenser.

Liquid phase flowing around a blade profile is sucked under the action of the pressure difference between the interior of the guide blade and the guide blade channel into the interior of the blade through the openings and upon passing further through the body and rim of the diaphragm it reaches the condenser.

Such an arrangement, however, allows only a small quantity of the liquid phase to be removed from the effective part of the turbine since the openings provided in the guide blades are located in the zone of high pressure gradients thus leading to atomization of the liquid phase and entrainment thereof with the wet steam main flow to the runner blades.

Upon contacting the edges of the runner blades the liquid phase gives rise to erosion thereof, i.e. gradual destruction of the inlet edges of these blades, thus leading to a loss of the efficiency of the turbine blades.

Also known in the art is a diaphragm of a steam turbine stage with intrachannel separation of moisture.

The diaphragm comprises hollow guide blades. One end of each blade is fixed to the diaphragm rim and the other — to the diaphragm body. The hollow blade is provided with grooves made on the concave and convex sides thereof. The grooves are communicated with the interior of the blade which in turn is connected to a condenser.

Liquid phase flowing around the guide blade is sucked under the action of the pressure difference between the interior of the guide blade and the guide blade channel into the interior of the blade and then flows further into the condenser. However, such em-

bodiment of the diaphragm permits only a small quantity of the liquid phase to be led out of the effective part of the turbine since the slots are located in the zone of high pressure gradients, where the liquid phase is subjected to atomization, blowing off the blades and entrainment by the wet steam flow giving rise to the runner blades erosion and a loss of the efficiency of a turbine stage.

It is also known another construction of a turbine diaphragm with the intrachannel moisture separation system comprising the guide blades. One end of each blade is fixed to the diaphragm body and the other — to the diaphragm rim. In this construction a slot is provided on the concave surface of the blade for moisture removal. Furthermore, openings are made in the concave surface of the blades, said openings being arranged downstream relative to the slots and on the isobar line as to the height of the blade. Each group consisting of the slot and the openings is provided with individual lip and a bleeding chamber. The interior of the blade is divided into chambers sealed off each other, said chambers in turn being communicated with a condenser.

Liquid phase flowing around the guide blade enters the internal chambers of the blade due to the pressure difference in the interior of the guide blade and in the channels of the guide blade, and then flows further to the condenser. However, such an arrangement of the guiding system cannot provide for maintenance of the moisture film in the vicinity of moisture-removing slots located in the zone of high pressure gradients. This film is atomized and entrained by the main flow bypassing the moisture-removing slots. Coming to the runner rotor blades the liquid phase destructs the inlet edge thereof and leads a loss of the efficiency of the turbine stage.

It is an object of the present invention to increase efficiency of a steam turbine stage by substantially removing the coarse dispersoid liquid phase from the main wet steam flow.

Another object of the present invention is to prolong the service life of the runner blades of the turbine stage and to increase reliability thereof by reducing their erosion.

In accordance with these and other objects, the invention consists in that in a diaphragm for a steam turbine stage comprising hollow guide blades having one end fixed to the diaphragm rim and the other — to the diaphragm body and being provided with at least one slot for removal of the liquid phase from wet steam, said slot being communicated with the interior of the blade, according to the invention, each hollow guide blade is provided with a moisture collecting groove formed on the flat surface of the blade profile on the wet steam inlet side thereof, and a slot for removing the liquid phase is located in the groove.

A steam turbine diaphragm made in accordance with the invention prevents a loss of the efficiency of a steam turbine stage.

These objects are achieved by removing the coarse dispersoid liquid phase from the wet steam flow. The film flowing in the groove eliminates the possibility of the rejection of the drops of moisture back into the wet steam flow at the moment of their contact with the blade. At the same time, the liquid phase is accumulated in the groove of each blade, wherefrom it is sucked out into the interior of the guide blade.

Considerable reduction of quantity of the coarse dispersoid liquid phase ensures, due to less intensive erosion, an increase in the service life and reliability of the runner blades of a turbine stage.

It is advantageous to arrange the groove on the flat surface of the convex portion of the blade which is characterized by rather low pressure gradients.

Such an arrangement of the groove prevents the liquid phase accumulated in this groove from being entrained and separated by the main wet steam flow, while on the other hand, this arrangement contributes to an increase in quantity of the liquid phase removed from the effective part of the turbine.

It is also advantageous to arrange the slots for moisture removal at 150° to the plane extending through the inlet edges of the hollow guide blades which also contributes to an increase in quantity of the sucked-out moisture.

It is advisable that the size of the slot be such as the velocity of the wet steam flow in this slot would be approximately equal to that of the main wet steam flow.

This condition ensures the most effective suction of the liquid phase from steam. The reduction of wet steam suction speed in the slot results in an additional entrainment of the liquid phase from the slot to the guide blade channels by the main flow thereby reducing the efficiency of operation of the diaphragm.

An increase in the wet steam velocity in the slot leads to the removal of an additional quantity of working medium from the effective part of the turbine which also leads to a loss of the turbine stage efficiency.

A diaphragm made in accordance with the present invention makes it possible to remove from the effective part of a turbine up to 8 percent of the liquid phase and about 60 percent of the coarse dispersoid liquid phase which is most detrimental from the viewpoint of the erosion and the liquid phase effectivity. The removal of the liquid phase from the low-pressure cylinder of a stationary turbine used at a power plant substantially reduced the runner blade erosion and increased the turbine efficiency.

Further features and advantages of the present invention will appear from the following detailed description with reference to the accompanying drawings, in which:

FIG. 1 is a view of a diaphragm for the ultimate stage of a steam turbine;

FIG. 2 is an enlarged sectional view taken along the line II—II in FIG. 1;

FIG. 3 is a sectional view taken along the line III—III in FIG. 2;

FIG. 4 is a view of another embodiment of a steam turbine stage diaphragm made in accordance with the present invention.

A diaphragm for the ultimate stage of a steam turbine comprises welded hollow blades 1 (FIG. 1). One end of each blade 1 is welded to a diaphragm rim 2 and the other — to a diaphragm body 4 by means of a bandage 3. The rim 2 and the body 4 may have either cast or welded structure.

At the wet steam inlet side each hollow guide blade 1 is provided with a groove 5 (FIG. 2) adapted to collect liquid phase. The groove is communicated with a slot 6 for the liquid phase removal. The size of the slot 6 is such as to ensure that velocity of steam-and-water mixture in this slot be approximately equal to that of the wet steam main flow.

5

The profiles of the adjacent guide blades 1 define a guide channel 7 (FIG. 3) adapted to receive the wet steam main flow.

The liquid phase collecting groove 5 is arranged on the flat surface 8 of the profile of the blade 1. The surface 8 on the convex portion of the blade 1 is subjected to the action of low pressure gradients. The slot 6 is communicated with the interior 9 of the guide blade 1.

In order to ensure a required distance between the outlet edges 10 of the guide blades 1 and those of a throat 11 of the guide channels 7, an external bandage 12 (FIG. 2) is made only at the outlet portion of the blade 1, this bandage being welded along with the blade 1 to the rim 2 on the wet steam outlet side. On the wet steam inlet side the guide blades 1 are welded directly to the rim 2.

The interior 9 of the guide blade 1 (FIG. 3) is communicated only with an annular channel 13 (FIG. 2) of the rim 2 and with an annular channel 14 of the body 4. The rim 2 is provided with openings 15 facing each guide blade 1, which are adapted to establish communication between the channel 13 and a condenser (not shown in the drawings), and with an annular channel 16 formed on the wet steam outlet side to remove moisture from the preceding stage.

In case where a diaphragm is used in the ultimate stage of a steam turbine, the slots 6 (FIG. 4) provided for the liquid phase removal are disposed at 150° to the plane extending through the inlet edges 17 of the hollow guide blades 1, thereby contributing to an increase in quantity of the liquid phase being sucked out.

In operation of the ultimate turbine stage the wet steam leaving the preceding stage contains a substantial quantity of the coarse dispersoid moisture. Under the action of a high circumferential velocity, component drops of moisture are deflected towards the periphery and guided to the convex portion of the guide blades 1 (FIG. 1) of the next turbine stage. A fraction of moisture is removed via the channel 16 (FIG. 2) formed in the rim 2 of the diaphragm at the wet steam inlet side, while the rest of the moisture flows to the convex portion of the hollow guide blades 1. Due to a pressure difference between the chamber 9 of the guide blade (FIG. 3) and the guide channel 7, moisture passes into the interior 9 of the guide blade 1 through the slots 6.

Some quantity of moisture flows from the interior 9

6

of the guide blades in the upper half of the diaphragm into the annular channel 14 (FIG. 2) formed in the diaphragm body 4, and then flows to the lower half of the diaphragm and through the interior 9 of several blades 1 to the channel 13 made in the rim 2, wherefrom moisture reaches the condenser through the openings 15. A portion of moisture is entrained by wet steam and led out of the stage through the openings 15. From the blades of the lower half of the diaphragm moisture flows directly to the annular channel 13 of the rim 2 and to the condenser through the openings 15.

In order to ensure the most effective moisture removal from the surface of the guide blades 1, the ratio between the cross-sectional areas of the throttle openings 15 and of the slots 6 of the guide blades 1 is selected so that the wet steam velocity in these slots be equal to the velocity of the wet steam main flow. This velocity is an optimal one from the viewpoint of the moisture removal.

It will be apparent to those skilled in the art that various modifications may be made in the structure of the steam turbine stage without departing from the scope of the appended claims.

What is claimed is:

1. A diaphragm for a steam turbine stage comprising hollow guided blades having concave and convex surfaces for directing the main wet steam flow onto turbine rotor blades; a diaphragm rim having one end of each guide blade being fixed thereto; and a diaphragm body having the other end of each said guide blade fixed thereto, each said guide blade having a flat surface portion on the convex surface proximate the wet steam inlet side thereof, a plurality of radially spaced slots in said flat surface portion extending along the upstream side of each said blade and communicating with the interior of said blade, and a radially extending recessed portion forming a groove common to all of said slots on respectively each of said blades for collecting the liquid phase formed on said flat surface portion of each blade.

2. A diaphragm as claimed in claim 1, each of said slots for the liquid phase removal being inclined at an angle of 150° relative to the inlet plane of said hollow guide blades.

* * * * *

50

55

60

65