

1

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TURBO-GENERATOR WITH DIRECT COOLING OF THE ROTOR WINDING

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4 Claims. (Cl. 310—61)

The subject of the present invention is the embodiment of the rotor winding of turbo-generators with direct hollow-conductor gas-cooling. The expression "direct cooling" which currently is in general use in this art, means that the cooling gas is in direct communication with the copper heated by Joule's losses.

Since these forms of construction were introduced, a whole series of different embodiments has become known. The most obvious method would seem to be for a coil wound from hollow conductors to have the coolant flowing through it from beginning to end. Such forms of construction have even been used for liquid-cooling of magnet coils in various appliances used in physics. These embodiments are impossible for gas-cooling in electrical machine building, because the gas pressure available in a turbo-generator, produced either by the rotating rotor member itself or by an additional fan, is generally insufficient to set up the required gas velocity in ducts which may be of great length. The gas is accordingly caused to flow through parallel portions of the hollow conductor which are electrically connected in series. As a result of the gas paths being kept short in this manner, the desired gas velocity can be attained with the available pressure. In a known solution, the gas enters at the middle of the coil ends of the winding from both sides of the machine, and emerges again into the air-gap at the middle of the machine. The distance which the cooling gas has to traverse is then equal to half the length of the coil end plus half the length of the slot part of the coil.

Another known solution is illustrated in FIGURE 1, where O—O signifies the axis of the machine, and M—M the plane of the middle of the machine. The active part of the rotor is disposed in the space between the planes E—E and E'—E'. In this case, the cooling gas enters the hollow conductors near the ends of the rotor at B and B', and splits up into two parallel streams, namely a cooling stream proceeding to the middle towards C and C', and a cooling stream through the coil ends of the winding, which emerges at A and A'. The paths through which gas flow has to take place are shorter in this case than in the aforementioned arrangement, with the result that this type of cooling is more advantageous. However, the changes in the direction of flow necessitate a complicated arrangement of pipe connections with corresponding pressure losses.

The present invention now relates to a turbo-generator with direct gas-cooling of the rotor winding, wherein the cooling gas enters the heads of the winding from both sides and emerges at the middle of the machine, but requires no incorporated elements for gas-distribution in the winding-end space. According to the invention, this is done by providing two gas inlets on each side in the direction of the gas flow, one being disposed in the middle of the end of the winding, and the second shortly before the point where the end portion enters the rotor.

2

A representative embodiment of the invention will now be more precisely explained with the aid of FIGURE 2 of the drawing. There it will be seen that there are two inlet apertures on each side in the hollow conductor, at A and B, and at A' and B'. The outlets lie in the middle of the machine and are designated by the apertures C and C'. The quantity of gas flowing in at A and B, and at A' and B' may be divided up as desired by imparting correct values to the hydraulic resistances of the two inlet apertures. If desired, suitable throttling can be provided at the inlet B whereby the gas velocity in the duct A—B can be set just high enough so that the maximum temperature at the end of this piece of conductor remains below a predetermined limit. After the addition of cold gas at B, the total quantity flows onwards into the duct B—C at the temperature resulting from mixing. The low velocity in the end portion of the winding causes a considerably smaller drop in pressure than if all the gas passes through in accordance with already known arrangements. With a given pressure, a high gas velocity is set up in the duct B—C in the embodiment shown in FIGURE 2, so that more gas flows through. The amount of exciter current may be increased, with a resultant increase in the power output of the machine.

A further form of embodiment of the invention is shown in FIGURE 3. The oblique inlet ducts at B and B' set up an injector action which aspirates gas from the duct sections A—B and A'—B'. In consequence of this, throttling at B and B' may be omitted, and the overall drop in pressure becomes still less than in the solution shown in FIGURE 2. Accordingly, with a given driving pressure, a still greater increase in exciter current and machine output power is possible.

A particularly favorable arrangement results if the conductors of the head of the winding are made wider than the conductors in the slot, as illustrated in FIGURE 3. This not only results in lower losses, but the thicker walls enable the oblique inlet ducts to be given a length which favors the injector effect.

I claim:

1. In a turbo-generator construction which includes a winding on the rotor member thereof constituted by hollow conductor turns having end portions at each end of the rotor and straight conductor portions in the slots of the rotor between said end portions, and wherein a gaseous coolant is passed through said hollow conductor turns, the improvement wherein two gas inlets are provided on each side of a conductor turn in the direction of the gas flow, and a gas outlet is provided at the middle of the straight portion of said conductor turn, the first of said gas inlets at each side being located in the middle of the end portion of the conductor turn and the second gas inlet at each side being located shortly before the point where the end portion enters the rotor.

2. A gas-cooled turbo-generator rotor construction as defined in claim 1, wherein each of said second gas inlets is throttled to an extent necessary to set up a gas flow in those portions of said conductor turn between the first and second gas inlets.

3. A gas-cooled turbo-generator rotor construction as defined in claim 1 wherein each of said second gas inlets is constituted as an obliquely set inlet orifice to establish an aspirating action on the gas flowing through said hollow conductor from the corresponding first gas inlet.

4. A gas-cooled turbo-generator rotor construction as

defined in claim 1 wherein each of said second gas inlets is constituted as an obliquely set inlet orifice to establish an aspirating action on the gas flowing through said hollow conductor from the corresponding first gas inlet, and wherein the wall thickness of the end portions of said hollow conductor turns is greater than the straight portions thereof at least in the region of said second gas inlets.

5

References Cited

UNITED STATES PATENTS

2,760,091	8/1956	Barlow	-----	310—61
2,786,951	3/1957	Morgan	-----	310—61

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