18th International Conference
ENGINEERING MECHANICS 2012
Svratka, Czech Republic, May 14 – 17, 2012

pp. 330–331
Paper #31

FLOW CONDITIONS IN THE LAST STAGE DURING IDLING OPERATION AND LOW OUTPUT OF 1000MW TURBINE

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Abstract: *Measurement of temperatures at the tip of the last stage during startup and idle operation of the turbine with nominal output of 1000 MW is described. Monitoring of liquid phase coarse dispersion occurrence, the direction of drops movement and investigating whether the origin of the drops comes from the natural expansion of steam in the stage or from an additional cooling system is presented. The flow of the steam phase behind the last stage is determined.*

Keywords: ***Experimental measurement, steam turbine, low output***

1. Introduction

At low output levels of the turbine and during idling, the last stages are run in a ventilation mode. Due to the effect of centrifugal power, steam is transported to the tip of the rotor blade. Separation of the flow from the hub end wall occurs together with the suction of steam to the blading root section from the area of the output diffuser after the last stage. Backflow area is formed here. A part of the turbine stages performs the work, while another part partially or completely consumes it. An enclosed eddy area may be formed at the tip of the last stage during idling operation and very low turbine outputs. There is a certain risk of local overheating. The ventilation mode is accompanied by heat production. To prevent the overheating of last sections of low-pressure parts during operation of the turbine at a low output due to ventilation losses, additional cooling is installed on the internal side of the exhaust hood. Cooling water is injected into the area after the last stage. If the non-evaporated drops are caught by return flow, they may be sucked into the last stage and erode the blades near the root section radius. This phenomenon was first noticed on the trailing edges of the last stage of the 200 MW turbine Tajč & Bednář (2001). Therefore, there is an effort to place and direct the cooling system nozzles in such a way as to minimise the risk of damaging the blades. The objective of the performed experiments was to verify whether or not the last stage overheats at the tip of the blading, and whether the water droplets from the nozzles reach the rotor blades.

2. Arrangement of the experiment

Various types of probes may be placed in the area after the last stage during operation. The arrangement of measuring places is shown in fig. 1.
A pair of thermocouples is used for measuring temperature. One thermocouple is placed in the well in the slot between the L-1 rotor blades and the last stage stator blades. The second well with the thermocouple is placed at the tip between the stator and the rotor of the last stage. The movement of the steam phase may be verified using a multi-hole pneumatic probe behind the last stage.

3. Measuring of temperature in the last stage

If the turbine is on the turning gear, the temperature behind the stator blade is higher than behind the inlet to the stator blade. This is a ventilation loss effect. The temperature in both wells gradually

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grows. If turbine operation passes from a warming-up speed (ca 1600/min) to full speed as confirmed by fig. 2, a step change of temperatures occurs.
The temperature behind the stator cascade is now smaller than the temperature at the inlet to the last stage. During long-term ventilation mode, temperatures in the last stage increase. The growth of temperature is also probably caused by the ventilation loss from the L-1 stage.

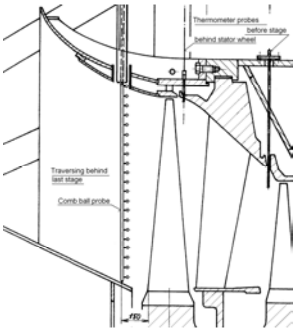

Fig. 1: Arrangement of measuring places in the last stage of the steam turbine

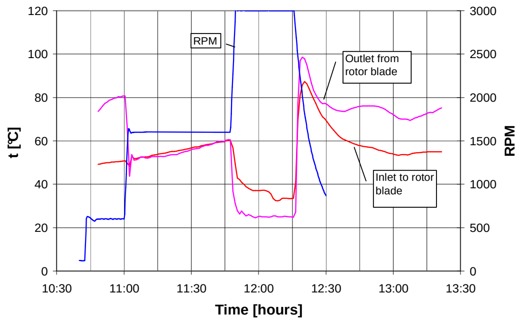

Fig. 2: Temperatures in last stage

4. Identification of liquid phase

The occurrence and movement direction of coarse dispersion liquid phase using an erosion probe is monitored behind the last stage on the right and left side of the turbine. The erosion effect of drops differs according to the distance from the blading root section. The highest effect tends to occur at the tip of the rotor blade. As the experiment was to verify the origin of droplets at the root of the blading, the exposition time was governed by the need to capture the effect of droplets near the hub radius. It is always necessary to take various differences in 3D flow along the perimeter of a stage into account. This is the main reason for measuring and recording of data on the right and left side of the turbine.

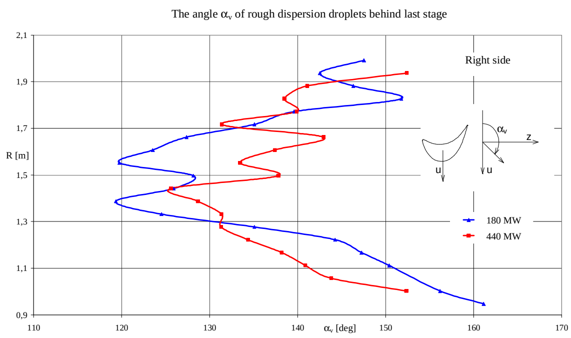

Fig. 3: Movement of droplets behind last stage

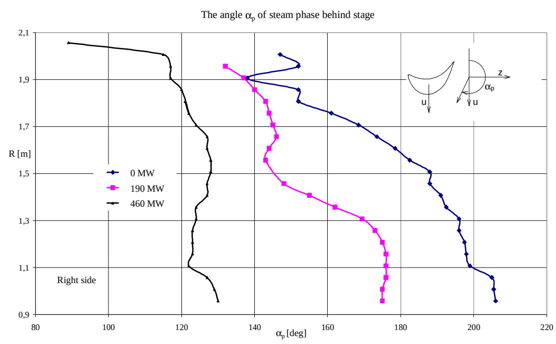

Fig. 4: Direction of movement of steam

Droplets movement in the circumferential direction is shown in fig. 3. Angle α_v is a projection angle of the vector of droplets speed in the plane defined by circumferential and axial direction. If $\alpha_v >$ 180°, then the droplets move towards the rotor blade. It shows that this instance does not occur even during idling operation. The movement of the steam phase in the area behind the stage is shown in fig. 4. The backflow of steam was established during idling operation and low output. The direction of droplets movement did not correspond to the direction of flow of the steam phase. Water droplets of coarse dispersion are not carried by steam at the root section. Therefore, these are not droplets from the additional cooling system but droplets from the flow-through part of the turbine.

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