Abstract

In order to have a clear knowledge and understanding of the physical phenomena of the real case of the rapid expansion of steam condensation process that lead to form a two phase mixture of saturated vapor and fine liquid droplet (condensation shock), experimental test were carried out in the low pressure steam turbine cascade in order to determine the effect of back pressure on second phase generations.

The experimental tests, instrumentations were installed to obtain the blade surface static pressure distribution, the passage mid distance between two adjusting blades static pressure distribution, isentropic Mach number distribution and color shadowgraph photos at the blade trailing edge region. The experimental results obtained gave an imagination for understanding and help to analysis and treatment to the theoretical procedure employed.

The experimental results show that when the outlet is supersonic, the heat release causes a pressure rise in the zone of rapid condensation. However, the use of the term ((condensation shock)) for this feature is misleading. Also, when the outlet is subsonic there is generally a zone of over expansion on the suction surface and the flow accelerates up to the throat section and then diffuses. Then zone of rapid condensation occurs downstream of the throat but the effect of the heat release is masked by the diffusion and does not show any sign of condensation on shadowgraph photos. In all the results obtained the rapid condensation region has occurred downstream of the throat. This process was accompanied by pressure rise when the flow was supersonic, otherwise it is still occurs downstream of the throat but does not has any effect on the development of the pressure on shadowgraph photos. The experimental part tests also show that the most important influence of rapid condensation on the pressure distribution is experienced on the suction surface.

The numerical investigations were carried out by using the well known package code FLUENT 12.1. The calculations were carried out by assuming that the flow is two dimensional, compressible, turbulent and viscous. A classical homogenous nucleation model applied for the mass transfer in the transonic conditions. Numerical results show that most of the condensation occurred on the suction surface of the blade and continuing grows by continuing decreasing the back pressure. Also, any increment in the pressure ratio, causes more nucleation and water mass fraction to increase.

An Eulerian–Eulerian multi phase approach used in order to modeling the numerical simulation. This approach gave acceptable results when comparing the numerical output results with the experimental mainly the pressure distributions.

The internal heat transfer associated with phase change is thermodynamically an irreversible process. It is particularly dramatic during the nucleation process that incurs an entropy increase associated with an increase in the stagnation temperature and hence a loss in work potential.