Journal of Fluids Engineering

Discussion

Experimental Measurements in a Centrifugal Pump Impeller[1]

Y. N. Chen.[2] The authors presented very interesting and comprehensive experimental results on a centrifugal pump impeller with air as working medium. Their experimental results are compiled in Fig. 23 in order to obtain a better overview.

The authors explain the reduction of the axial relative velocity on the shroud surface at $y/y_o = 0.3$ of Station 2 (Fig. 9) to be caused by the secondary flows induced by the shroud curvature and the blade to blade Coriolis force. A secondary vortex in this zone as revealed by Fig. 8 is not considered. At Station 3, the low relative velocity travels along the shroud to the suction-side corner. The authors attribute this phenomenon to the thickening of the boundary layer in the pressure-side corner, and exclude the effect of the shroud curvature. No vortex behaviour of this low velocity flow is considered either.

The writer would like to point out the discovery of the vortex in the field of the relative velocities induced by the curvature of the blade channel due to bending from the axial to the radial direction. This vortex is indicated by an arrow L. It is a vortex low because of its rotation in the same sense as the impeller rotation.

The relative velocities over Station 2 show the pattern of a huge passage vortex, which has a property of vortex high H because of its rotational sense being against that of the impeller rotation. This passage vortex is induced by the rotating impeller due to suction of the fluid from the absolute frame of zero vorticity.

At Station 3 a vortex low L appears in the suction side shroud corner, developing from the Dean's type vortex pair of the curvature mentioned. The vortex high H of this pair cannot be distinguished from the prevailing passage vortex high H. This vortex low L also shrinks to a small size under the influence of the passage vortex high H. It extends to Stations 4, 5, and 6. The vortex low L is driven by the pressure field of the blade channel to this corner.

[1] By A. C. Bwalya and M. W. Johnson published in the December 1996 issue of the JOURNAL OF FLUIDS ENGINEERING, Vol. 118, No. 4, pp. 692–697.

[2] Sulzer Innotec Ltd., P.O. Box, CH-8401 Winterthur, Switzerland.

Station 2 already penetrates through the curvature of the blade channel. Therefore, the vortex low L of the Dean's type vortex pair can be formed there. However, this vortex low L is stabilized in the middle field of the cross section, because there is scarcely a pressure field generated by the inlet edge of the impeller.

The tangential relative flow at Station 1 is then the prerotation caused by the passage vortex of the impeller. No vortex low L is found there because this station lies in the straight part of the channel.

The core of the vortex low L is always formed in the field of both the lowest throughflow and the lowest pressure (Figs. 7, 10, 13, 16, and 20). Thus, the wake is a longitudinal vortex low L rotating in the same sense as the impeller (Chen et al., 1996). Very regular vorticities of the same sense are embedded in the vortex, so that a circulation can be assigned to it.

At Station 6 a second field of the lowest throughflow arises in the middle region of the hub side. This appears to be caused by the unsteadiness of the curvature of the blade at the outlet (Fig. 2).

Reference

Chen, Y. N., Seidel, U., Haupt, U. and Rautenberg, M., 1996, ''Jet Wake and Intrinsic Motion in Impellers of Centrifugal Compressors,'' ASME Paper 96-GT-261.

Authors' Closure

The authors thank Dr. Chen for his discussion. The vortex pair (low L and high H) described by Dr. Chen is the classic secondary flow pattern generated through either passage curvature or rotation superimposed on a passage vortex which enhances the vortex H. The passage vortex, as Dr. Chen states, is a result of the change from a stationary coordinate system to a rotating one. The strength of the secondary flows is directly dependent on the boundary layer development and it is interesting that there is little evidence in the current results (for a pump) of secondary flow up the SS and PS of the blades whereas secondary flow is apparent here in a compressor impeller (Johnson and Moore, 1983a, b). This is believed to be because the blade boundary layers are only formed beyond the leading edge of the blade. For the pump, the blade leading edge is close to Station 2 at which point the flow has already been turned through about 45 deg in the axial to radial direction. Thus the effects of the axial to radial bend on secondary flow are greatly diminished. This leads to the wake (and vortex L) moving onto the suction surface earlier in the pump than in the compressor.