FloEFD Validation Example:
Flow in an Impeller

WHITEPAPER

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Let us now validate the FloEFD ability to perform calculations in a rotating coordinate system related to a rotating solid. Following Reference 1, we will consider the flow of water in a 9-bladed centrifugal impeller having blades tilted at a constant 60° angle with respect to the intersecting radii and extending out from the 320 mm inner diameter to the 800 mm outer diameter (see Figure 1). The water in this impeller flows from its center to its periphery. To compare the calculation with the experimental data presented in Reference 1, the impeller's angular velocity of 32 rpm and volume flow rate of 0.00926 m^3/s are specified.

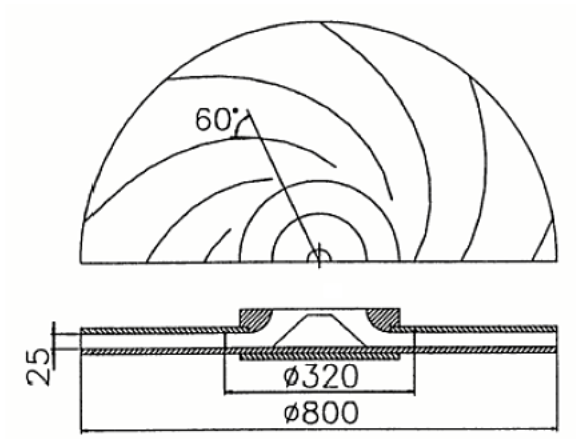

Figure 1. The impeller's blades geometry.

Since the impeller's inlet geometry and disk extension serving as the impeller's vaneless diffuser have no exact descriptions in Reference 1, to perform the validating calculation we arbitrarily specified the annular inlet as 80 mm in diameter with an uniform inlet velocity profile perpendicular to the surface in the stationary coordinate system. The impeller's disks external end was specified as 1.2 m diameter, as shown in Figure 2.

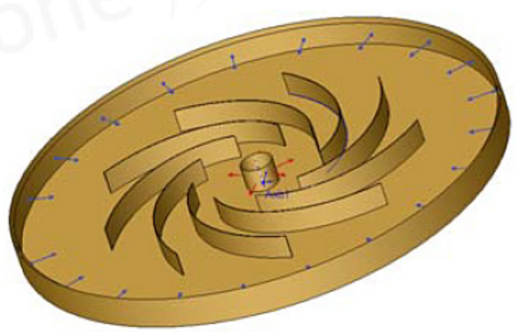

Figure 2. The model used for calculating the 3D flow in the impeller.

The above-mentioned volume flow rate at the annular inlet and the potential pressure of 1 atm at the annular outlet are specified as the problem's flow boundary conditions.

The FloEFD 3D flow calculation is performed on the computational mesh using the result resolution level of 5 and the minimum wall thickness of 2 mm (since the blades have constant thickness). To further capture the curvature of the blades a local initial mesh was also used in the area from the annular inlet to the blades' periphery. As a result, the computational mesh has a total number of about 1,000,000 cells.

Following Reference 1, let us compare the passage-wise flow velocities (w_s, see their definition in Figure 3, $\beta = 60°$) along several radial lines passing through the channels between the blades (lines g, j, m, p in Figure 4) at the mid-height between the impeller's disks.

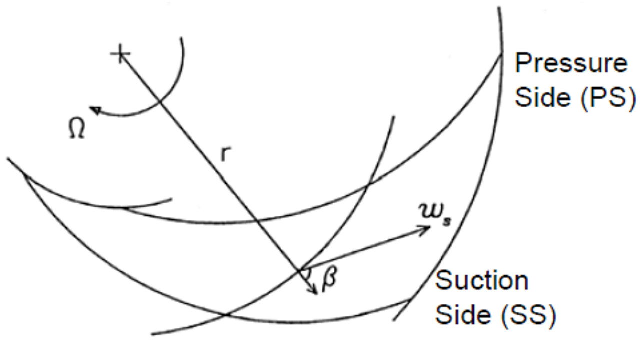

Figure 3. Definition of the passage-wise flow velocity.

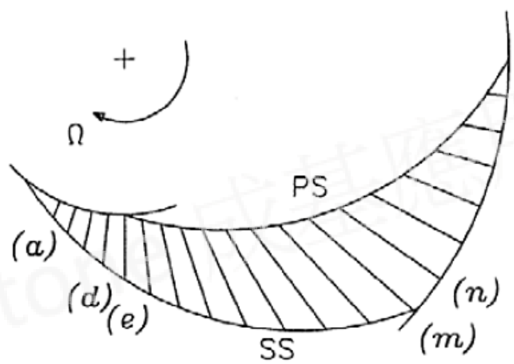

Figure 4. Definition of the reference radial lines along which the passage-wise flow velocity was measured in Reference 1 (from a to s in the alphabetical order).

The passage-wise flow velocities divided by $\Omega x r_2$, where Ω is the impeller's angular velocity and $r_2 = 400$ mm is the impeller's outer radius, which were measured in Reference 1 and obtained in the performed FloEFD calculations, are shown in Figures 5-8. In these figures, the distance along the radial lines is divided by the line's length. The FloEFD results are presented in each of these figures by the curve obtained by averaging the corresponding nine curves in all the nine flow passages between the impeller blades. The calculated passage-wise flow velocity's cut plot covering the whole computational domain at the mid-height between the impeller's disks is shown in Figure 9. Here, the g, j, m, p radial lines in each of the impeller's flow passages are shown. A good agreement of these calculation results with the experimental data is seen.

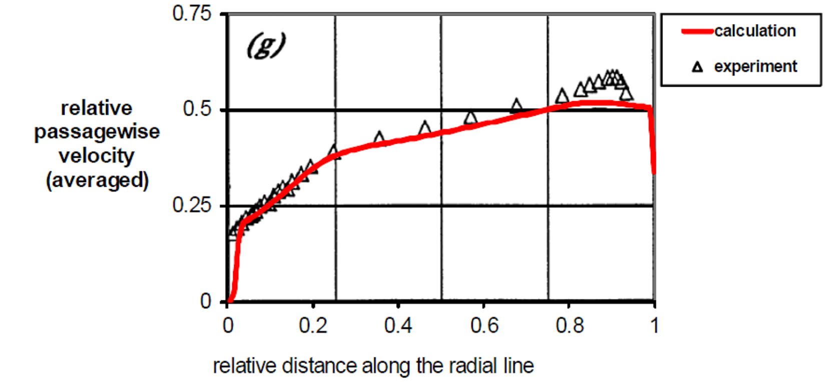

Figure 5. The impeller's passage-wise flow velocity along the g (see Figure 4) radial line, calculated by FloEFD and compared to the experimental data.

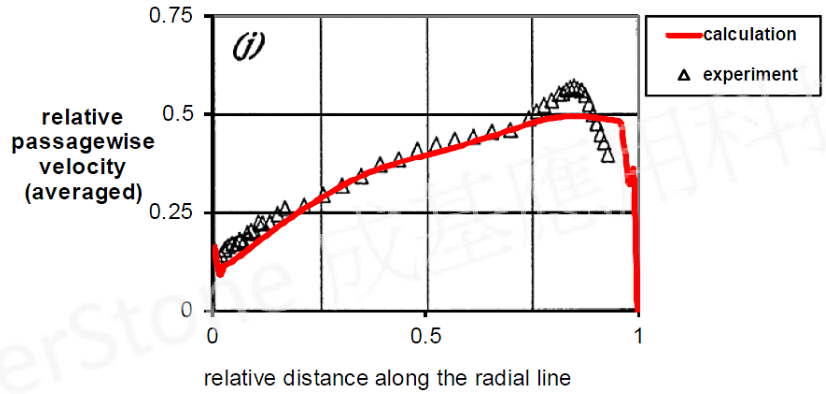

Figure 6. The impeller's passage-wise flow velocity along the j (see Figure 4) radial line, calculated by FloEFD and compared to the experimental data.

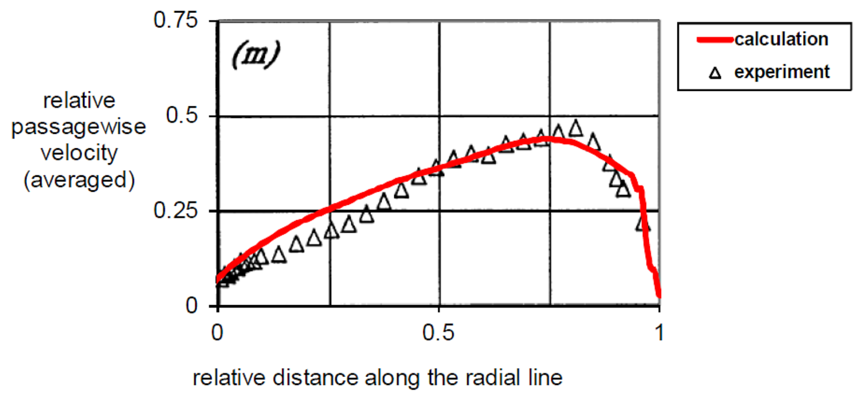

Figure 7. The impeller's passage-wise flow velocity along the m (see Figure 4) radial line, calculated by FloEFD and compared to the experimental data.

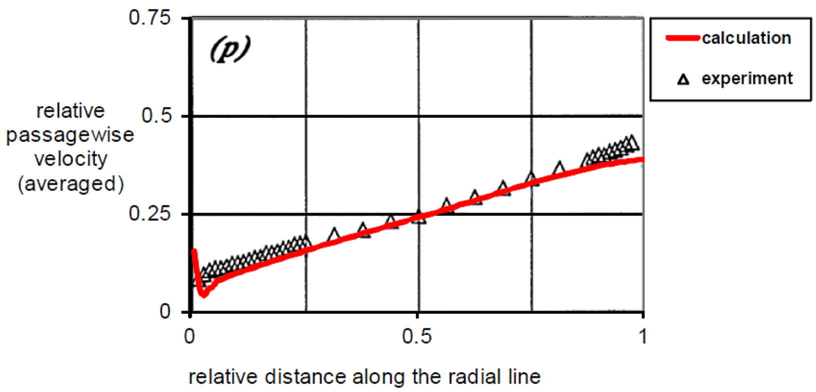

Figure 8. The impeller's passage-wise flow velocity along the p (see Figure 4) radial line, calculated by FloEFD and compared to the experimental data.

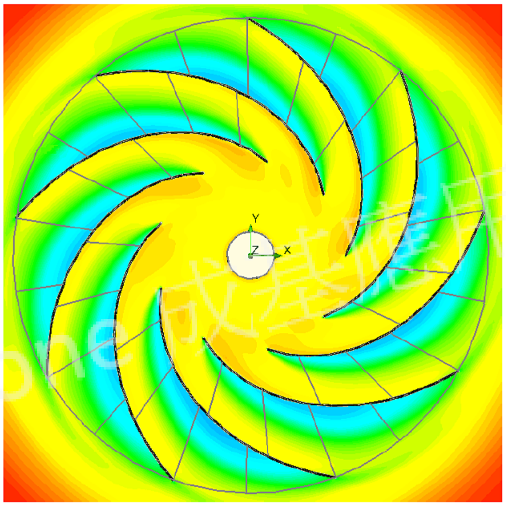

Figure 9. A cut plot of the impeller's passage-wise flow velocity calculated by FloEFD.

REFERENCE

1. Visser, F.C., Brouwers, J.J.H., Jonker, J.B.: Fluid flow in a rotating low-specific-speed centrifugal impeller passage. J. Fluid Dynamics Research, 24, pp. 275-292 (1999).

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