Performance Analysis of Pitched Blade Turbine Impeller Using CFD

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Abstract- *Mean flow and turbulence intensities have been measured using laser Doppler anemometer for pitched blade down flow turbines (PTD). Fully baffled, flat bottomed cylindrical vessels of 300 and 500 mm internal diameter were employed. The effect of impeller clearance on flow characteristics has been investigated. The influence of geometry of PTD, that is blade angle(30-60°), blade width (0.2D-0.4D) and impeller diameter (0.25T-0.5T)on the flow have been studied in detail. The energy balances have been established a round all the impellers and the hydraulic efficiency values have been reported. This part provides a right set of boundary conditions to the model as well as provides necessary and sufficient set of data to evaluate the model performance.*

Keywords- Metal Matrix Composites, Silicon Carbide, Boron Carbide, Tensile and Hardness strength

I. INTRODUCTION

In industrial mixing applications, the power consumption per unit volume of fluid is used extensively for scale-up, scale-down and design. In spite of its widespread use, the dependence of power consumption on impeller and tank geometry is defined only in the most general terms. This is partly due to the difficulty of obtaining accurate torque measurements on the small scale, and partly due to the predictive limitations of drag theory, particularly for recirculation three dimensional flows.The first studies of power consumption date back to 19341, but the early study by Ruston et al2 is widely cited as the first definitive work in the area. Using dimensional analysis, Ruston et al. developed a number of dimensionless groups, including the power number, Np:

The power number is one of the most widely used design specifications in the mixing operation and has proven to be a reliable predictor of a number of process results. Given the success of the power number the reader will rightly expect that this dimensionless group can be derived from physical fundamentals; namely a drag force analysis, or alternately an angular momentum balance. The drag force analysis which originated with White1,3 is discussed in detail by Tatterson4 and can be summarized as follows:

$$T_q = \int_0^{D/2} F_D dr = \int_0^{D/2} C_D \rho \frac{V^2}{2} hrdr$$

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II. EFFECT OF IMPELLER AND TANK GEOMETRY ON POWER NUMBER

This approach has the advantage of using velocity profiles around the impeller, so that the connection between circulation patterns and power number can be examined and the effect of geo powmber can be better un derstood.

The dependence of power number on Reynolds number is analogous to well establish results for the friction factor in pipe flow, and for the drag coefficient on a sphere. In the laminar range (Re < 10 to 100, depending on the impeller of interest), the power number is inversely proportional to the Reynolds number6 (Npoc 11 Re). In the fully turbulent range (Re>2x 104), the power number is constant and independent of the Reynolds number. The fully turbulent power number, N^ or simply Np, is often quoted as 'the' power number for a fixed impeller geometry.

EXPERIMENTAL SETUP

The dynamic response of the torque measurement to a change in N. The torque measurement can take up to 30 minutes to stabilize due to heating or cooling of the lubricant in the pillow bearing, and the resulting change in the bearing friction. In order to reduce both the bearing friction and the dynamics, temperature control was installed around the bearing. An aluminum block

(0.102m£0.076m£0.050m) was added to enclose the bearing. A thermocouple and two 125 watt electric rod heaters were used to hold the temperature of the block at 50°C. This is two degrees above the maximum temperature attained by the bearing at 1600rpm without temperature control. A higher set point temperature would further reduce the bearing friction, but could also lead to degradation of the bearing lubricant and heating of the liquid in the tank. With temperature control, the dynamic period of the torque measurement was reduced by a factor of five and the friction in the bearing was substantially lower

III. RESULTS

The above figure shows the output response of MARC. It meets the desired set point quickly without overshoot. The output responses clearly show Model Reference Adaptive controller is the best controller it reach the set point quickly without overshoot then all other controllers.

The results are presented in two groups: the first group examines the effect of blade thickness on power number; the second the effect of *D/T*. In both cases, the fully turbulent power number (N_{pft}) is used to provide an overall perspective, followed by more detailed results showing the variation of power number with Reynolds number.

$$T_q = 2\pi\rho\left[\int_0^R (V_{z2}V_{\theta 2})r^2 dr - \int_0^R (V_{z1}V_{\theta 1})r^2 dr + R^2 \int_0^{z=(D/5)\cos(45^\circ)} V_{r3}V_{\theta 3}\,dz\right]$$

IV. CONCLUSION

This work compares the importance of impeller andtank geometry for two widely used impellers. For the Ruston turbine, power consumption is dominated by form drag, so details of the blade geometry and flow separation have a significant impact (30%) on the power number. For the PBT, form drag is not as important, but the flow at the impeller interacts strongly with the proximity of the tank walls, so changes in the position of the impeller in the tank can have a significant impact on the power number (15%) due to changes in the flow patterns. For both impellers,

REFERENCES

[1] Uhl, V W. and Gray, J. B., 1966, Mixing, Theory and Practice, vol. 1 (Academic Press, New York, USA), pp 120.

[2] Rushton, J. H., Costich, E. W. and Everett, H. J., 1950, Power characteristics of mixing impellers, Chem Eng Prog, 46(8): 395-476. Nagata Shinjie, 1975, Mixing Principles and Applications (John Wiley and Sons, New York, USA), pp 13.

[3] Wu, J. and Pullum, L., 2000, Performance analysis of axial-flow impellers, AIChE J, 46(3): 489-498.

[4] Bujalski, W., Nienow, A. W., Chatwin, S. and Cooke, M., 1987, The dependency on scale of power numbers of Rushton disc turbines, Chem Eng Sci, 42(2): 317-326.

[5] Rutherford, K., Mahmoudi, S. M. S., Lee, K. C. and Yianneskis, M., 1996, The influence of Rushton impeller blade and disk thickness on the mixing characteristics of stirred vessels, Trans IChemE, Part A, Chem Eng Res Des, 74(A3): 369-378.

[6] Bates, R. L., Fondy P. L. and Corpstein, R. R., 1963, An examination of some geometric parameters of impeller power, I and EC Proc Des Dev, 2(4): 310-314.

[7] Nienow, A. W. and Miles, D., 1971, Impeller power numbers in closed vessels, I and EC Proc Des Dev, 10(1): 41-43.

[8] Gray, D. J., Treybal, R. E. and Barnett, S. M., 1982, Mixing of single and two phase systems: Power consumption of impellers, AIChE J, 28(2): 195-199. 9.

[9] Medek, J., 1980, Power characteristics of agitators with flat inclined blades, Inter Chem Eng, 20: 664-672.

[10] Armenante, P. M., Mazzarotta, B. and Chang, G., 1999, Power consumption in stirred tanks provided with multiple pitched-blade turbines