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New Impeller for Gas Dispersion

Bob Higbee[1], Binxin Wu[1] and Wojtek Wyczalkowski[1]

[1]Philadelphia Mixing Solutions, Ltd., 1221 E. Main Street, Palmyra, PA 17078, USA

ABSTRACT

This project was initialized as a response to industry demand for an improved impeller for gas dispersion. Several impeller prototypes were built and tested in 0.61 m diameter test rig, CFD and PIV. Analysis was focused on different combinations of blade shape, blade size, and blade location in relation to axis of rotation. All impeller prototypes were made by Laser Stereo Lithography method to ensure accuracy of shape. The project resulted in an optimized design that provides excellent process results, can be built for high power applications, and can be assembled on site.

INTRODUCTION

Production of PTA, hydrogenation and fermentation processes require efficient gas dispersing impellers that can produce high mass transfer and have high gas handling capability therefore improving process economy. The scope of this work was to improve and optimize existing impeller design using a combination of experiments, CFD and PIV.

For decades the impeller of choice was Rushton turbine. The first break-through was by Prof. Smith who introduced a concave blade. Later, SCABA and John Middleton pioneered the sharp edge design on the trailing side of the concave blade. Both innovations helped to reduce drag coefficient of a standard Rushton blade.

When blades are rotating through a liquid the pressure in front of blade is lower than behind the blade. Gas phase introduced into the mix goes into large cavities in a streamline formed from the blades. The result is a drastic reduction of resistance and power required to turn the turbine. Power reduction deficit must then be adjusted by RPM increase, which is inconvenient for operation and requires specialized hardware. When concave blades are used, the effect of gas cavities is diminished and power decrease in gassed conditions is much less~~er~~. Also, with smaller gas cavities the impeller is less prone to flooding.

It is generally desirable that a gas dispersing impeller has low Power Number that is constant or close to constant in gassed condition and can handle large amounts of gas without flooding. The point of flooding and gas handling characteristics strongly depend upon the blade shape, length and location in relation to axis of rotation. There is no literature data on systematic approach to gas dispersing impeller design.

Several prototypes of impellers were built and tested in order to determine how geometry influences mixing characteristics.

MODEL/EXPERIMENTAL

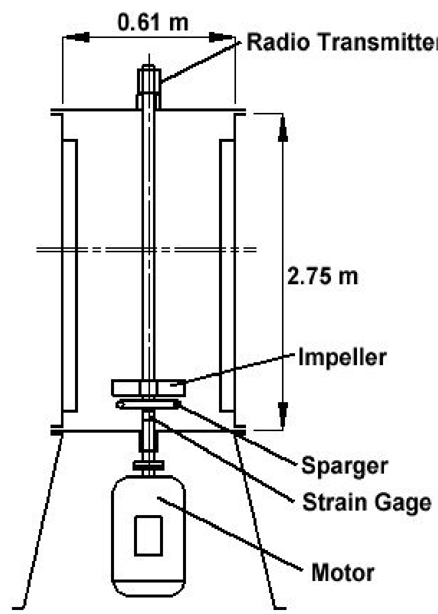

Fig 1. Experimental setup, 0.61 m diameter vessel x 1.83 m tall, Electric motor with Variable Speed Drive, Torque measurement with Strain Gages and Telemetry Transmitter. Air delivered through Toroidal Sparger

Tested Impellers:

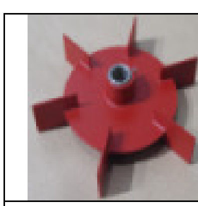		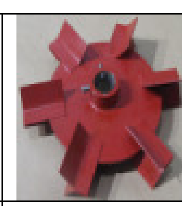
Rushton	Smith	C-1

Fig 2. Tested impellers (1)

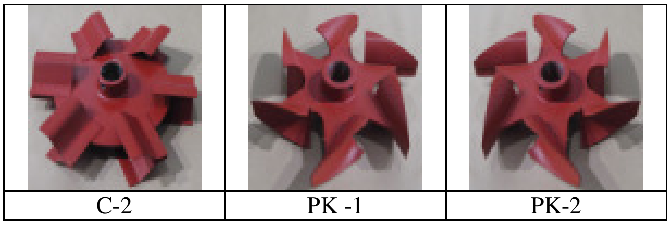

Fig 3. Tested Impellers (2)

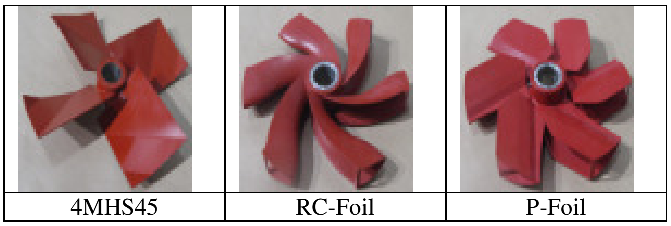

Fig 4. Tested Impellers (3)

Impellers were tested for gas dispersion characteristics, solids suspension capability in gassed and un-gassed conditions. Impeller flow and dissipation were measured in 0.61 m diameter test vessel using PIV technique.

RESULTS

Selected test results are presented below

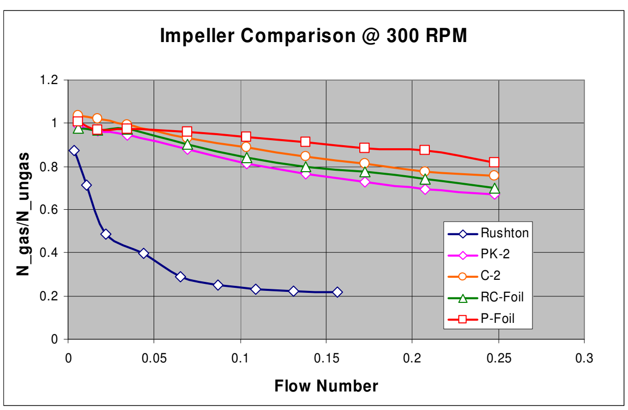

Fig 5. Comparison of selected impeller performance in gassed condition @ 300 RPM in 0.61 m diameter vessel.

Solids suspension capability was tested in 0.62 m diameter vessel with ASME dish bottom. All comparative tests were performed on sieved alumina particles with fraction size 125-149 microns. For each impeller Just Suspended speed was recorded. Experiments were done for gassed and un-gassed condition. Toroidal sparger was mounted under impellers.

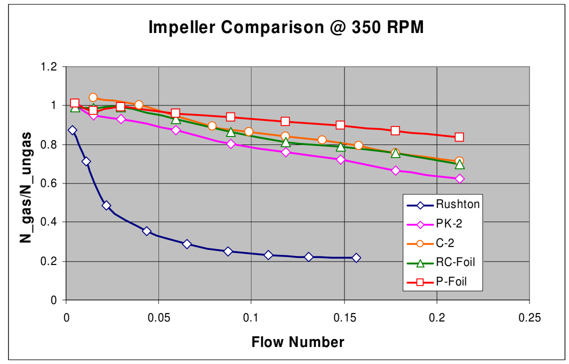

Fig 6. Comparison of selected impeller performance in gassed condition @ 350 RPM in 0.61 m diameter vessel

CONCLUSION

The final impeller design achieved desirable performance for gas dispersion as it has been presented in Fig 5 and 6. The gased power characteristics is flat. This design also performs very well in solids suspension applications.

Impeller blades are relatively easy to manufacture with a series of single bends.

Blade length significantly influences impeller performance. Blade length increase can be achieved by reduction of disk diameter. Elimination of disk does not have negative effect on impeller gassed characteristics.

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Smith, J., van’t Riet and Middleton, J (1977), “ Scale up of agitated gas-liquid reactors for mass transfer”, Second European Conference on Mixing, Cambridge UK, paper F4-51 t0 66

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