BIOTECH

Application Note

USD 3405

The Pall Magnetic Mixer Power Number (N_p) Characterization

The Pall Magnetic Mixer is a well-established compact single-use mixing system. The heart of this system is a mixing biocontainer incorporating a bottom-mounted magnetically-driven Rushton-type impeller capable of providing efficient high-torque mixing for powder-liquid and liquid-liquid mixing applications. The impeller rides on a low-friction, inert bearing assembly which allows mixing of high powder loads in large liquid volumes.

Introduction

The power-input-to-volume ratio (P/V, expressed in units of W/m³) is an important consideration when designing a mixing process for process scale-up. The ratio can be calculated using the following equation:

$$\frac{P_{input}}{V} = \frac{N_P \, \varrho \, N^3 d^5}{V}$$

Where,
P_{input} = power transferred to the fluid by the impeller, Watts
N_p = impeller power number
N = impeller speed, rev/s
d = impeller diameter, m
V = volume of liquid to be

The power number (N_p) is a key characteristic of a mixing system. Although primarily determined by the impeller shape, it is also affected by the shape and size of the mixing vessel. In this experimental study, the power number of a Magnetic Mixer impeller was estimated across a range of typical mixing chamber sizes and shapes. The impact of the filling level and the mixing speed on the power input were also studied.

Experimental

A Magnetic Mixer drive, modified to incorporate a torque monitoring sensor, was used to mix water at different speeds in both cubical and round mixing tanks ranging from 50 L to 2000 L as summarized in Table 1. For each of the performed experiments, the power number was calculated.

Table 1

Experimental conditions

System Description	Shape	Tested Filling Volumes	Tested Mixer Speed (rpm)
50 L	Cubical	17 L (34%), 25 L (50%), 50 L (100%)	50, 100, 150, 200, 250, 300**
650 L		76 L (12%), 162.5 L (25%), 325 L (50%), 650 L (100%)	
2000 L*		117 L (6%), 500 L (25%), 1000 L (50%), 2000 L (100%)	
50 L**		15 L (30%), 25 L (50%), 50 L (100%)	
500 L*	Round	36 L (7%), 50 L (10%), 100 L (20%), 200 L (40%), 350 L (70%), 500 L (100%)	

* the 500 L & 2000 L tank have off-center impeller configuration
** not all permutations were tested

Results

A typical chart showing the relationship between N_p, mixing speed and fill volume is presented in Figure 1, with a red box indicating the torque measurement is most accurate – typically at higher mixing speeds (where the measurement error due to internal friction of the drive is proportionally lower) and higher liquid levels (to minimize the effect of air entering the impeller). This data was then averaged at each scale to estimate similarly the most relevant values for N_p (Table 2).

Figure 1

Typical N_p-speed-volume chart

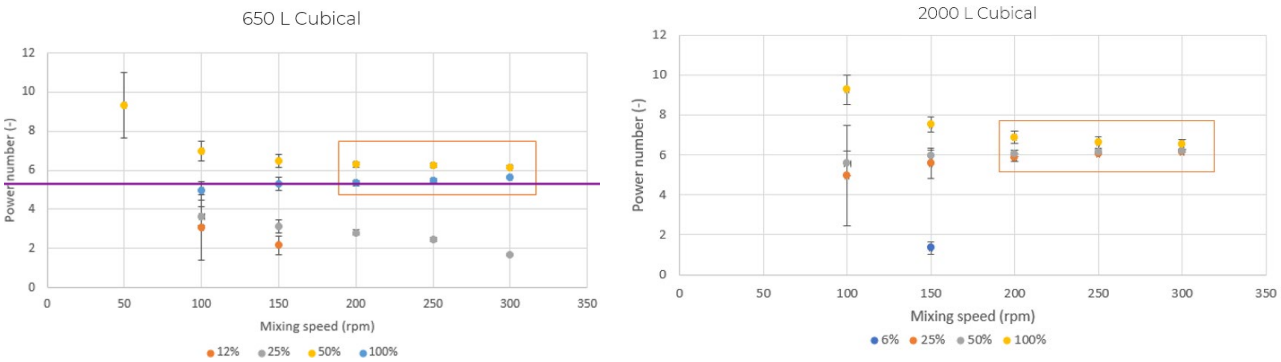

Table 2

Summary of mean Power Number (N_p) values

Tank	N_p (Measured)
50 L cubical	2.9
650 L cubical	5.5
2000 L cubical	6.3
50 L round	1.4
500 L round	6.2

Conclusions

Rushton-type impellers are known to offer relatively high N_p, and the mean N_p values determined in this study confirm that the Magnetic Mixer system lives up to that expectation, especially at larger scales, in cubical tanks or with off-center impeller configurations. The measured N_p values at lower mixing speeds and at volumes below 50% of nominal maximum volume were found to deviate significantly from the mean values; this observation should be considered when attempting to predict mixing performance in any application.

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