**Power and Flow Characteristics of the in-line Rotor-Stator Ytron ZC1**

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**Highlights**

* The suction performance of an in-line rotor-stator used for powder incorporation into a liquid, the Ytron ZC1, showed an optimum range of operation avoiding liquid flow into the powder inlet for both 1.5 and 3.0 mm gap heads
* Power characteristics of the Ytron ZC1 were determined and two expressions were obtained for 1.5 and 3.0 mm gap rotor-stator heads
* Results obtained will form the basis for further studies on incorporation and deagglomeration

**1. Introduction** Nanoparticles incorporated in novel formulations have been shown to improve product properties or achieve properties and performance that cannot be achieved otherwise. Abrasion-resistant coatings, pharmaceuticals, catalysts, paints and coatings with increased colour brilliance and increased protection from sun creams are examples of such products. Final or intermediate products in the form of nanoparticulate dispersions in a liquid require initially the incorporation of the dry nanoparticle powder into the liquid, which is often performed using a stirred tank[1]. The pre-dispersion formed is then deagglomerated using a power-intensive device, such as a rotor-stator. In this study, the performance of an in-line rotor-stator, Ytron ZC, used for powder incorporation, is assessed in terms of its power and suction characteristics.

**2. Experimental**

Experiments were conducted using a variable speed Ytron ZC1 operated up to 6,500 rpm in the recirculation loop of a 0.58 m diameter stirred tank equipped with a hydrofoil (Figure 1). The liquid volume was 100 l. The Ytron ZC1 rotor-stator head shown in Figure 2 is available with gap sizes of either 1.5 or 3.0 mm; the stator teeth had a length of 9.19 mm. Power input was determined using a calorimetry technique. The suction performance of the device was determined by making air velocity measurements with an anemometer at the powder inlet.

Powder Funnel

Rotor-Stator

**Figure 1**. Experimental set up

 **Figure 2** Ytron ZC mixer head stator, on the left, of diameter 0.089 m and rotor, on the right, of diameter 0.095 m

**3. Results and discussions**

Figure 3 shows that the liquid flow rate through the rotor-stator is not affected by the rotor speed or teeth gap, which suggests that the Ytron YC1 has negligible pumping action and therefore

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| requires an external pump. The liquid flow through the rotor-stator head induces suction from the powder inlet to achieve incorporation when dry powder is added. It can be seen from the air velocity results (Figure 4) that at a given rotor speed, the air velocity increases slightly as the liquid flow rate is increased, then tends to a plateau which corresponds to the optimum operating range.  | **Figure 3** Liquid flow rates for a range of rotor speeds using the Ytron-ZC1 |
| **Figure 4** Air velocities over a range of conditions for Ytron-ZC1 and ZC0 | Further increases in the liquid flow rate decreases the suction performance (Figure 4). This reduction in suction at high liquid velocities is caused by the flooding of the powder inlet by the liquid, which is highly undesirable as the wetted powder can form clumps and cause blockage. Increasing the |

rotor speed increased the air velocity, resulting in improved suction performance. The 3.0 mm gap head has a higher suction air velocity and is therefore better suited for powder incorporation.

From the data obtained, the following relationships were obtained in which the values for *Po1* and *Po2* ($P=Po\_{1}ρN^{3}D^{5}+Po\_{2}ρN^{2}D^{2}$) were of the same order of magnitude as those reported for other in-line rotor-stators[2]:

$P=0.28ρN^{3}D^{5}+13.95 ρN^{2}D^{2}Q$ for 3.0 mm head and

$P=0.20ρN^{3}D^{5}+15.07ρN^{2}D^{2}Q$ for 1.5 mm head.

**4. Conclusions**

The suction performance of an in-line rotor-stator used for powder incorporation, the Ytron ZC1 was determined over a range of rotor speeds and liquid flow rates, which demonstrated that there is an optimum range over which powder incorporation can be achieved. The effect of gap width could be identified. In addition, the study on the power characteristics of the device allowed two relationships to be obtained for the different gap sizes. These will form the basis of further work on incorporation and deagglomeration.

**References**

1. Özcan-Taskin, N.G. (2013) *Chemical Engineering Research and Design,* pp. 1-7 (DOI: 10.1016/j.cherd.2013.03.019)

[2] Özcan-Taşkin, N. G. Padron, G., Kubicki, D. (2011) *Canad. Jrnl of Chem Eng.*Vol. 89, Issue: 5, p:1005-1017 (DOI 10.1002/cjce20553)