POWER REQUIREMENT IN AN AERATED AGITATED VESSEL UNDER FOAMING

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Two typical methods, namely chemical and mechanical means, are available for foam control in aerated agitated vessels (AAVs). Chemical antifoam agents have been employed successfully in foam control. However, the addition of antifoam agents to the AAV causes not only a marked reduction of the mass transfer rate (MTR)[3,10] but also an increase in agitation power due the decreased gas holdup.[1,2,8,9] By contrast, if the foaming is controlled mechanically by an appropriate foam-breaker, a steady reduction of agitation power can be expected due to the increased gas holdup, without fear of lowering the MTR. Previously, we developed a mechanical foam-breaker with a rotating disk (MFRD), which facilitated foam-breaking action by the impact between the dispersed liquid particles from the disk and the ascending foam. The MFRD proved to be useful in controlling foaming in an AAV[4] and a bubble column.[5] The main objective of the present note is to reveal the differences in aerated power consumption and gas holdup between two AAVs when the foaming was controlled by this MFRD and an antifoam agent.

1. Experimental

A schematic diagram of the experimental set-up is shown in **Fig. 1**. The vessel (made of transparent acrylic resin), 2.3×10^{-1} m in diameter D_T and 5.2×10^{-1} m in height, was equipped with four baffles, an impeller and a ring sparger with twelve holes of 1.0×10^{-3} m diameter. A six-blade turbine impeller was used. The impeller depth was held at $D_T/3$ and the working volume was set as 9.45×10^{-3} m^3. The air sparge rates ranged from 3.78×10^{-3} to 7.58×10^{-3} m/s, corresponding to 1.0 and 2.0 *vvm*. The MFRD was set at a height of 2.0 D_T from the bottom. The rotating disk diameter D_d was 1.8×10^{-1} m. The liquid subjected to foam-breaking was pumped from the bottom onto the rotating disk at a constant rate of 1.50×10^{-5} m^3/s through an annular feeder (2.0×10^{-2} m diameter) with twenty holes of 1.0×10^{-3} m diameter. Additional details of the MFRD have been reported.[4,5] Agitation power at impeller speeds ranging from 6.67 to 16.67 rps was determined with a torque meter of spring type. The mean gas holdup was determined by the manometric technique. The manometer reading was corrected for dynamic pressure differences.[6,7] The foaming liquid used at 293 K was a diluted solution of a commercial anionic soft detergent (Lipon F, manufactured by Lion Corp.).[4,5] The density of this liquid was 999 kg/m^3, the viscosity was 1.00 mPa·s and the surface tension was 38.6 mN/m. As the non-foaming liquid, a detergent solution to which an antifoam, silicon oil (KM 70, Shin-Etsu Chemical Co. Ltd.), was added at a concentration of about 5.7×10^{-2} percent of the working volume was used.

2. Results and Discussion

The power requirement P_{gf} in a mechanical foam-

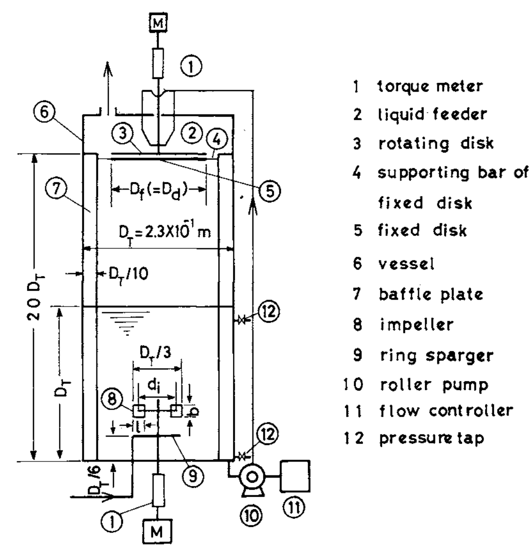

Fig. 1. Experimental apparatus. Impeller dimensions are: $D_i=D_T/3$; $b=D_i/5.00$; $l=D_i/2.86$; and $d_i=D_i/1.30$.

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control system (MFS) and the power requirement P_g in a non-foaming system (NS) including an antifoam agent were respectively measured by varying the gas velocity V_s and the impeller speed N_i. Typical results are shown in **Fig. 2a**. The foam-breaking data corresponding to each operating condition of the MFS in Fig. 2a, namely, the values of the required critical disk speed N_c of the MFRD, are shown in **Fig. 2b** for reference (the oblique-lined portions below respective solid lines show the regions of non-foam-breaking). As for the difference in agitation power between the two AAVs, as might be expected, P_{gf} in the MFS was small compared with P_g in the NS under the same aeration-agitation rate conditions, and the values of the ratio of P_{gf} to P_g, P_{gf}/P_g were below 1.0 in all the experimental systems. It was also found that the difference in power requirements in the MFS and the NS tended to be large with the increase of N_i.

Typical results of gas holdups, ε_{gf} and ε_g, measured respectively in the MFS and the NS are shown in **Fig. 3**. Comparing ε_{gf} and ε_g, it is clear from the results shown in Fig. 3 that ε_{gf} values in the MFS were considerably large compared to ε_g values in the NS. That is, the values of the gas holdup ratio $\varepsilon_{gf}/\varepsilon_g$ between the two AAVs were found to be larger than 1.0.

As mentioned already, the mechanical foam-control method is free of problems such as the lowering of the MTR seen when foaming is controlled by antifoam agents. In addition, its application to the AAV treating a foaming system also allows substantial reduction of agitation power compared to the NS, as demonstrated above. These results shown in the present study are expected to be beneficial to the development of a new aeration-agitation operational technique, useful for treating effectively a foaming system without using antifoam agents, i.e., development of an AAV having a mechanical foam-breaking mechanism, which has hitherto received little attention.

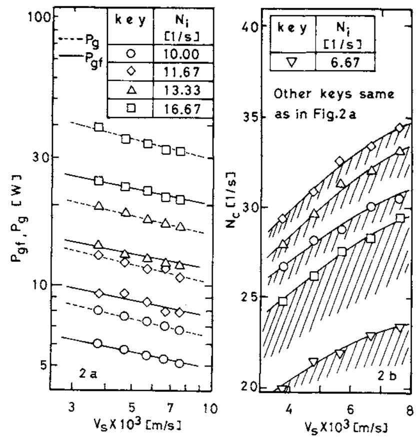

Fig. 2. (a) Comparison of agitation power between the MFS and the NS. (b) Relationship between N_c and V_s.

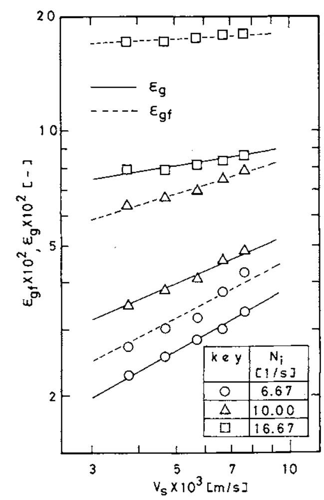

Fig. 3. Comparison of gas holdup between the MFS and the NS.

Nomenclature

b	=	impeller blade width	[m]
D_d	=	rotating disk diameter	[m]
D_f	=	diameter of disk fixed underneath the rotating disk ($=D_d$)	[m]
D_i	=	impeller diameter	[m]
D_T	=	vessel diameter	[m]
d_i	=	impeller disk diameter	[m]
l	=	impeller blade length	[m]
N_c	=	rotating disk speed required at the critical foam-breaking state	[1/s]
N_i	=	impeller rotational speed	[1/s]
P_g	=	agitation power in gassed liquid	[W]
V_s	=	gas superficial velocity	[m/s]
vvm	=	volumetric gas flow rate per minute per working volume	[1/min]
ε_g	=	gas holdup based on dispersion volume	[—]

⟨Subscript⟩

f	=	mechanical foam-controlling system

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