Flow Field Analysis of Different Types of Blade and Baffle in a Fermentor

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Abstract—The reasons why mechanical stirring tanks are extensively applied to fermentation, gas absorption, waste water treatment and so on are because of its advantages of easily modified operating conditions, effective liquid separation and many more. Its primary function is to effectively separate liquid so as to boost the liquid flowing efficiency. The paper is mainly focused on analyzing the two-dimensional flow field of mixing blades of different sizes at dissimilar rotational speed. The result shows that the baffles of longer length will easily lead to instability of the flow field. However, we also find out that the longer the tank baffle is, the easier the eddy currents will occur, and the pressure generated by the tank baffle is greater as well. It is easier to mix liquids evenly if the length of a mixing blade is longer.

Keywords—fermentation; blade; baffle

I. INTRODUCTION

The earliest record of massive sterile cultures the way of producing acetone by tanks, which was conducted by Chaim[1]. The most common problem that arose at the initial stage of the culture was the contamination of the antibacterial bodies. Without the help of appropriate tanks, the ones with lids were used at the outset; they could not be used, however, to proceed with steam-pasteurization under normal pressure, so the kind of cylinder-shaped iron tanks with lids on the tops and semispherical bottoms were employed instead, and the pressurized steam-pasteurization was implemented. The process of pasteurization also brought out the importance of sterilization of the cultured genes and seeds; the pipes, interfaces, etc. must be sterilized, only by which can the requirement of sterilization be met.

The key to whether the fermentation can be successful during the process lies in the selection of appropriate fermentation tanks; the design and application of the tanks, therefore, has become highly significant. As far as the culture of microbes is concerned, the conditions of growth environment and the process should be treated differently according to different kinds of microbes; hence, the difference among the microbial systems should be taken into consideration when designing and manufacturing the fermentation tanks, so as to attain the optimal results under the suitable environment and conditions. Not only can the yield of microbes be greatly increased by the use of large-sized fermentation tanks, but the quality can be controlled to be stable with the steady provision of microbes, and the time span of culture can be substantially shortened, which can help save both time and energy. [2]

Mixing is the most extensively applied unit operation, the relations of which with the principles of hydrodynamics, thermal conductivity, chemical reactions and so forth make it a complex existence. Mixing can be applied to various and sundry production processes. In industries, for instance, it is utilized during the manufacturing process of numerous products to evenly separate and mingle the different chemical compounds to produce the assorted products that serve in different functions, such as adhesive (whose manufacturing process involves separating the resin by the act of mixing), asphalt (manufactured by adding various chemical substances during the process to further stabilize the elasticity coefficient, the state of freeze, etc.), food products (mixing is required in order to add flavors or nutrients to the foods) and so on. The quality of products is influenced by the act of mixing throughout the manufacturing process; if the mixing fails during the manufacturing process, the products will end up being unsatisfactory, discordant in quality or unbalanced in constituents, which will not match up with our expectation and result in a converse outcome. [3-4]

There are some common requirements of every mixing process which are determined by characteristics of products. What is indispensable to a mixing tank throughout every type of mixing process is convectional circulation, and the requirement of the degree of convectional diffusion varies. Different characteristics, e.g. the design of a mixing blade, the distance between adjacent mixing blades, rotational speed and the capacity rate of fluid flow, will have different influences on different mixing processes as well. [5-6]

II. GEOMETRIC DESIGN OF THE FERMENTATION TANK

The mixing tank employed in the experiment, as shown in Fig. 1, is a sealed cylindrical tank (without the passages that connect the inside and outside of the tank itself) whose diameter is 114mm long, and the surface of the exterior wall is set to be non-slip. The letters ‘a’, ‘b’, ‘c’ and ‘d’ are used to represent the length of the tank baffle, the width of the tank baffle, the length of the mixing blade and the width of the mixing blade, respectively. The tank baffle and the mixing blade are placed symmetrically; the mixing blade is set to rotate counterclockwise at the speed of 100 rpm under the simulation. Please refer to Table 1 for the details of the dimensional parameters.

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