ON-LINE MEASUREMENT AND POWER CONSUMPTION ON GAS-LIQUID AGITATED SYSTEMS

Thiago Fermozelli Ganino, Campinas Stadual University – UNICAMP, Campinas – SP, Brazil, José Geraldo C. Pradella, Institute for Technological Research – IPT, Sao Paulo – SP, Brazil and José Roberto Nunhez, Campinas Stadual University – UNICAMP, Campinas – SP, Brazil

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ABSTRACTS

In some industrial processes there is the necessity of if exhausting a gaseous component in a liquid phase, particularly, in processes that involve aerobic fermentation for production of bioproducts as: agricultural inoculantes, recombinant proteins, antibiotic, vaccines, biopolymmers and others. Through the dispersion of this gaseous component,often the oxygen, one knows that a reduction in the apparent density of the liquid occurs, and it leads to a reduction in the power consumption that is transmitted in comparison to the ungassed liquid. From the on-line measurement of the power effectively transferred to the fluid, made possible for the use of strain-gauges, the present work has as objective to quantify this phenomenon of the power reduction, under different conditions of agitation and aeration. The quantification of the power effectively transferred to the fluid is very important as a parameter for the magnifying of scale of biotechnological processes, that allows transforming an optimized project into laboratory scale, in something with industrial applicability. From the instrumentation of the axis of benches tank of 10L owned by the Institute for Technological Research of State of São Paulo S.A. (IPT), it was built collection of data of power effectively transferred to the fluid. One expects that this study can provide a method of great utility in the forecast of power of agitated tanks and gassed, through the equations that will be offer.

Objective

This work investigated the power consumption effectively transferred to the fluid on gas-liquid agitated systems, since the *on-line* measurement using strain-gauges.

Introduction

Many industrial processes depends of the dispersion of a gas in a half liquid, with the intention of if transferring one or more gaseous components to the middle of liquid. Usually the gas enters in contact with the liquid for bubbling. The bubbles, of varied diameters, when ascending through the liquid, transfer and receive composites. Diverse processes of engineering depends, in minor or greater degree, of the dissolution of gases in liquids, according to GODBOLE and SHAH (1986).

An agitation system puts into motion the mixture gas-liquid, make it homogeneous and promoting the dispersion of the gas. The shear, when generating bubbles of small diameters, aims at to increase the area of mass exchange. The dispersion of the bubbles for the middle of liquid aims at to guarantee its presence in all the parts of the reacting system.

According to URENHA (2002), the typical equipment of all these processes is a tank that contains a liquid or a suspension of solids and receives the gas through sparger.

The factors that govern the system are:

a) Type and geometry of the tank;

b) Type and geometry of the sparger;

c) Pressure of the gas and the system;

d) Specific interfacial area of exchange that is tied with the distribution of size bubbles in the system;

e) Temperature of the system;

f) Difusivitty and solubility of the gas (kinetic of the solubilization);

g) Kinetics of the reaction between the gaseous composition and the liquid (when it has reaction);

h) Superficial tensile in the interface gas-liquid;

i) Reological characteristics of the liquid or the suspension;

j) Degree of turbulence and standard of draining generated for the injection and ascension of the gas or tax mechanicaly to the system;

k) Capacity of retention of gases for the system.

The bubbles and the swarms of bubbles go to follow liquid chains (laminar or turbulent). The mainly difference is that the presence of the gaseous phase reduces the mean density of the system. Therefore, because of the volume of the bubbles, these are in greater or lesser degree affected by the push force. The great bubbles tend to escape more quickly of the system, while the minors can be arested to the system for a long time.

The Industrial Fermentation Laboratory of IPT considered the study of the behavior of the power effectively transferred to the fluid in tests with biological material.

Because of the kind of the involved microrganismos, during the fermentation, it is observed formation of extracellular material (for example, polysaccharide) that changes the reological characteristics of the fluid in agitation, that in this case it will increased (viscosity), or same, in case that the culture is in high cellular density, also one observes alterations of the density and viscosity of the fluid.

Consequently the demand of power for its agitation will be bigger, comparing with the case of unchanged density and viscosity. Besides it will generate difficulty for the oxygen transference.

In the case of microrganismos with high demand of dissolved oxygen, what it requires one high tax of aeration, the phenomenon of "drowning" of the impellers, mainly next to the aspersor of air is observed. As the air outflow is high, the bubbles involve the impellers, occupying the space destined to the impeling of the liquid. From this alteration of the apparent density of the fluid, the power required consequently goes to be minor.

This kind of study, where it is possible to determine the demands of required powers, besides supplying subsidies a more efficient project of engines, with process economy, it still allows to form all the base for an excellent condition of scale-up, from the found curves.

In function of this it was analyzed possibility to instrument the axis of one of the fermentors and to make the characterization of the equipment how much to the power effectively required during a culture.

Very complex systems are multi-phases (one or more liquid phases, one or more solid phases and a gaseous phase) and can need agitations and intense shears, multiple impellers, special impellers, gas injections in multiple points, absolute mechanical hermethism of the tanks and controls of temperature, pH, pressure, viscosity, potential of oxide-reduction and rigorous superficial tension.

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Modelling this kind of systems is pretty complex, in view of the amount and variability of all the involved parameters. In the practical one searchs systems well simpler shape, imposing diverse conditions of contour. So we can divide two great groups of models that are used in systems of agitation and aeration:

a) empirical ones, based in non-dimensional relationship or relationship between a few cited variables, the most important to the specfic case on study;

b) models based on CFD - Computational Fluid Dynamics, which uses programs, commercials or not, that applies methods as “Finites volumes” to solve the foundamentals equations of mass, heat and mommentum transportation, in net previously definite and adjusted to the geometry of the equipment, in which occurs the process in study.

Materials and Methods

In the experimental apparatus, we used the fermentor *Biostat ED* manufacturated by *B. Braun Biotechnology (Germany)* that belongs to Industrial Fermentation Laboratory of IPT (LFI) of Biotechnology Group (AB), of Chemical Division. This equipament is composed of three enchained parts: the eletronic control, utilities and the fermentor tank. This tank is agitated and gassed, with maximum capabiity of 10 liters. The control variables is: temperature, aeration and rotation. The air flow is evaluated by mass fluoxometer enchained to the equipament. The maximum compressed air flow allowed in the sparger is 20 L/min, according to IPT (2002).

A potência efetivamente transferida pelo sistema de agitação ao líquido foi avaliada em diversas condições de agitação e aeração em água, a temperatura constante de 30^{o}C, utilizando o eixo instrumentado com strain-gauges pela DITT/IPT e três impelidores do tipo Rushton.

A instalação dos sensores logo abaixo de cada turbina do tipo Rushton permite o estudo da contribuição de cada uma delas e a influência do sêlo mecânico da tampa. Os sinais provenientes dos quatro pontos de medida (três próximos às turbinas e um próximo ao sêlo) são captados independentemente e enviados para as placas eletrônicas instaladas na extremidade do eixo que sai do fermentador, atravessando o sêlo mecânico superior.Para aquisição dos valores, durante os ensaios, será utilizada unidade de Sistema de Aquisição de Sinais ADS/2000 da Lynx e da licença de uso de uma cópia do Programa de Aquisição de Sinais modelo AqDados, versão para sistema operacional MS-DOS. O tratamento dos valores foi feito em planilha eletrônica. Todos estes componentes citados foram adquiridos anteriormente e disponíveis no IPT, para uso.

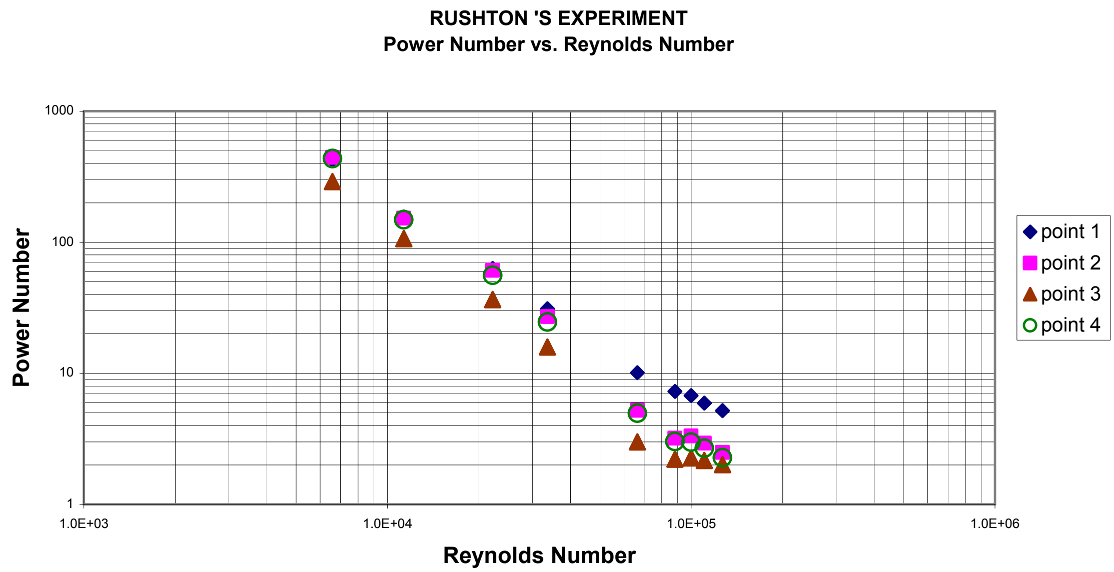
Após o desenvolvimento do eixo, foi necessária sua prévia calibração dinâmica do equipamento. Para tanto, com o auxílio de um motor elétrico e um torquímetro Kiowa de 10 N.m montou-se um aparato de fixação do conjunto tampa-eixo do fermentador, e procedeu-se ao teste de calibração. Elaborando-se um protocolo de ensaio. O motor era monitorado por um tacômetro e o registro de valores era manual. O torquímetro possuía uma saída para o sistema condicionador de sinais ADS/2000 da Lynx, sendo necessário apenas sua calibração através das constantes fornecidas pelo fabricante.

Com isso tinha-se condições de prever o comportamento dos strain-gauges durante a rotação do eixo no interior do fermentador.

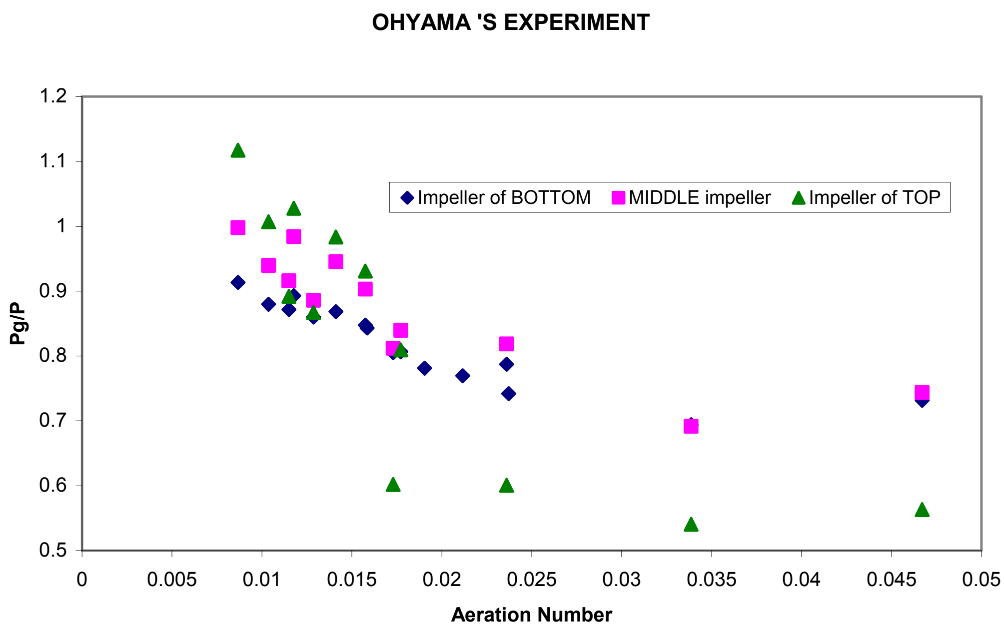
Results and discussion

Some classical expirementals were repeated with the IPT's tank, in the same conditions of the authors: Rushton, Ohyama and Michel-Miller.

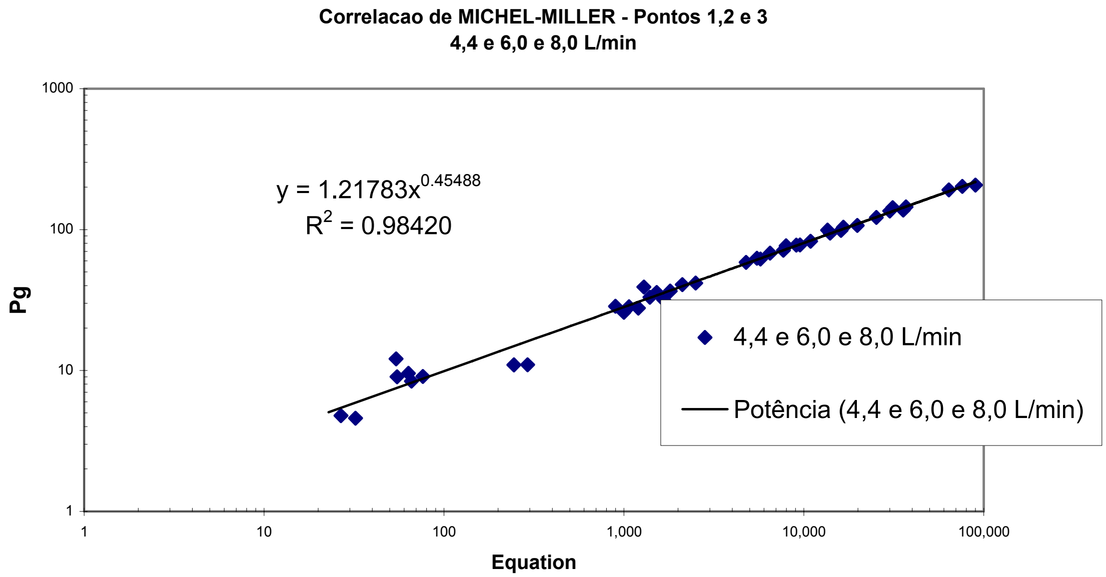
All of the expirementals follow the behavior studied by this authors.



Classical experimental of J. H. Rushton for agitated tanks.



For Ohyama's experimetal can analyse de influence of each impeller. This apparatus had three Rushton impellers at different positions.



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