RESEARCH GRANTS FOR PHD STUDENTS FROM THE CHINA SCHOLARSHIP COUNCIL
- CSC 2012 -

TITLE:

INVESTIGATION OF DYNAMIC FILTRATION TO INTENSIFY MEMBRANE BIOREACTOR

Laboratory:	**LISBP (CNRS UMR5504, INRA UMR792, INSA), Laboratory for Bio-systems and Chemical Engineering** http://www.lisbp.fr
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Chinese abstract:

生物反应器作为传统终端过滤和交叉过滤的替代技术已大量应用于生物技术和动态过滤中。本课题的主要目标是对动态过滤设备进行革新，以有利于强化生物过程，
突出生物反应器的优势，限制其不足。这一研究将致力于理解和控制动态反应的物理和生物机理。实验操作和整体及局部生物，非生物条件下的计算机模拟将用来研
究此动态过滤过程。具体工作如下:

1.
在细胞培养过程中，表征动态过滤的效果(生物活性，细胞裂解等)。在流动加料和选定的微生物（真核生物和原核生物）条件下进行氧化模式下无菌细胞的培养。

2.
分析整体和局部流体力学。粒子图像测速技术将用于非生物实验，并和流体动力学（CFD）计算得到的数值结果进行比较。这两项工作相互匹配和补充得到动态过滤条件下的复杂动力场，以便更好地解释污垢热阻减少和膜生物反应器随后的特性。

Context:

Among three phase reactors, membrane bioreactors (MB) appeared in the 70th *[Smith et al., 1969; Aimar and Daufin, 2004, Daufin et al., 2001]* and were largely applied in biotechnology field: pharmacy, food industry, white biotechnology. Increasing cell density in bioreactors is useful to improve the overall productivity of fed-batch and continuous processes particularly the bio-ethanol production which has to be competitive according to energetic, economical and environmental criteria. Another determinant factor to optimize the overall performance of biological process is the configuration of the MB. The performances are strongly influenced by the complex interactions between gas and liquid hydrodynamics as well as the microorganism activities. The specificity of microbial bio-reactions in relation with irreducible couplings between heat and mass transfers and fluid mechanics, led to complex and dynamic systems *[Smith et al., 1969]*.

Dynamic filtration and RVF module:

DF consists in creating relative motion between the membrane and its housing and stands as an alternative technology to classical dead-end and cross-flow filtration. DF modules could use either a vibrating *[Schneider et al., 2001]* or rotating membrane *[Serra et al. 1999]*, or the motion of a mechanical device with a rotating *[Jaffrin, 2008]* and/or vibration disc or impeller *[Fillaudeau et al., 2008]* close to the membrane surface. Several DF devices have been reported by manufacturer: Artisan (Artisan Industries), cross-rotational flow (ABB-Flootek), centrifugal membrane filtration (Spintek), cross-rotational membrane filtration (Komline-Sanderson), Hitachi (Hitachi), dynamic membrane filter and vibrating membrane filter (Pall society).

In this work, a new and promising DF device, called rotating and vibrating filtration (RVF technology) will be investigated. This module enables to improve overall biological and hydrodynamic performances by increasing permeability, by reducing the volume of filtration loop, by uncoupling feed flow rate and local shear rate at membrane surface and by filtering at low transmembrane pressure. Its specificity is that a mechanical device (impeller) has been introduced in order to promote turbulence at membrane surface independently of retentate flow-rate. This simple mechanical device runs continuously (up to 50Hz) and maintains a high shear rate as well as an unstationary hydrodynamics at the membrane surface.

Scientific questions:

The objective of this PhD project is to highlight the potentialities and constraints of an innovative DF device for bioprocess intensification. More precisely the study aims to understand and control dynamic interactions between physical and biological mechanisms in a context of bioprocess innovation.

To this end it is planned to perform experiments and numerical simulations to investigate DF at global and local scales under biotic and abiotic conditions:

1- To characterize the effect of DF on bioprocess performances (biological activity, cell lyses, etc) during cell cultures. Axenic cell cultures under oxidative mode will be carried out in fed-batch mode with selected microorganisms (eukaryote and prokaryote),

2- To analyse the global and local hydrodynamics. Particle image velocimetry (PIV) will be used in abiotic experiments and compared to numerical results obtained by computational fluid dynamics (CFD).

Both works will match to gain insight in the complex hydrodynamics fields which take place in the dynamic filtration module in order to better explain fouling resistance reduction and the subsequent performances of membrane bioreactor.

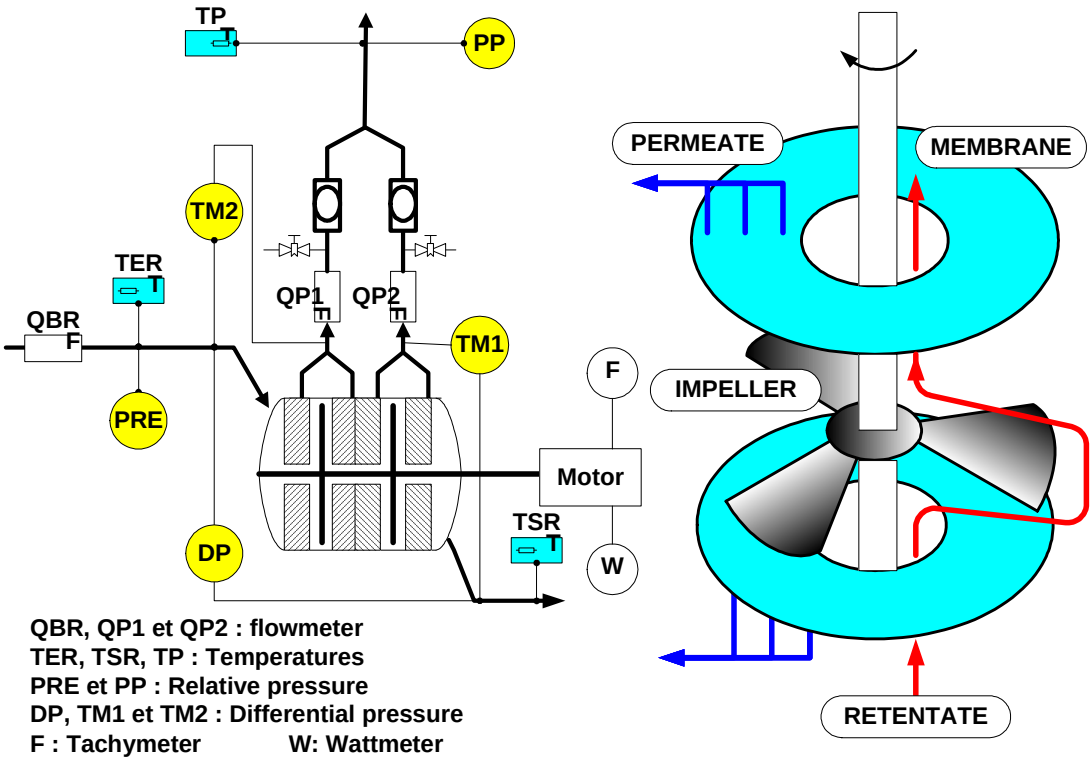

Figure 1 : Scheme of DF module.

Key-words: food and bioprocess engineering, membrane process, cell cultures, fluid mechanics, PIV, CFD.

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