

Printed from

Journal of Scientific Research

<http://www.univ-bechar.dz/jrs/>

A hydrodynamic and mass study of a stirred tank by a chamfered bladed

Benyamina Leila^{1*}, Bouanini Mohamed¹, Rebhi Mébrouk¹, Draoui Belkacem¹,
Belloufa Larbi¹, Nebbou Abdelkader¹

¹ *Research Laboratory ENERGARID
University of Bechar
BP 417 Béchar ALGERIA
Corresponding E- mail: lben05@yahoo.fr*

Published on 20 December 2013

The Editor, on behalf of the Editorial Board and Reviewers, has great pleasure in presenting this number of the Journal of Scientific Research. This journal (ISSN 2170-1237) is a periodic and multidisciplinary journal, published by the University of Bechar. This journal is located at the interface of research journals, and the vulgarization journals in the field of scientific research. It publishes quality articles in the domain of basic and applied sciences, technologies and humanities sciences, where the main objective is to coordinate and disseminate scientific and technical information relating to various disciplines.

The research articles and the development must be original and contribute innovative, helping in the development of new and advanced technologies, like the studies that have concrete ideas which are of primary interest in mastering a contemporary scientific concepts. Actually, the JRS is indexed in **Google Scholar**, **Universal Impact Factor**, **Research Bible**, **DRJI**, **Scientific Indexing Services**, **Global Impact Factor (with GIF=0,632 in 2012)** and **Index-Copernicus (with 2012 ICV : 4.87 points)**. The journal is obtainable in electronic form, which is available worldwide on the Internet and can be accessed at the journal URL:

<http://www.univ-bechar.dz/jrs/>.

Director of Journal

Pr. BELGHACHI Abderrahmane

Editor in Chief

Dr. HASNI Abdelhafid

Co-Editor in Chief

Pr. BASSOU Abdesselam

Editorial Member

TERFAYA Nazihe
BOUIDA Ahmed
LATFAOUI Mohieddine
MOSTADI Siham

Reviewers board of the Journal.

Pr. KADRY SEIFEDINE (The American University in KUWAIT)
Pr. RAZZAQ GHUMMAN Abdul (Al Qassim University KSA)
Pr. PK. MD. MOTIUR RAHMAN (University of Dhaka Bangladesh)
Pr. MAHMOOD GHAZAW Yousry (Al Qassim University KSA)
Pr. RAOUS Michel (Laboratory of Mechanic and Acoustic France)
Pr. RATAN Y. Borse (M S G College Malegaon Camp India)
Pr. LEBON Frédéric (University of Aix-Marseille 1 France)
Pr. MONGI Ben Ouédou (National Engineering School of Tunis)
Pr. BOUKELIF Aoued (University of Sidi Bel Abbes Algeria)
Pr. DJORDJEVICH Alexandar (University of Hong Kong)
Pr. BENABBASSI Abdelhakem (University of Bechar Algeria)
Pr. BOULARD Thierry (National Institute of Agronomic Research France)
Pr. LUCA Varani (University of Montpellier France)
Pr. NEBBOU Mohamed (University of Bechar Algeria)
Pr. LABBACI Boudjemaa (University of Bechar Algeria)
Pr. DJERMANE Mohammed (University of Bechar Algeria)
Pr. BASSOU Abdesselam (University of Bechar Algeria)
Pr. ABOU-BEKR Nabil (Universit of Tlemcen Algeria)
Pr. TAMALI Mohamed (University of Bechar Algeria)
Pr. ABDELAZIZ Yazid (University of Bechar Algeria)
Pr. BERGA Abdelmadjid (University of Bechar Algeria)
Pr. Rachid KHALFAOUI (University of Bechar Algeria)
Pr. FELLAH Zine El Abiddine Laboratory of Mechanic and Acoustic France)
Dr. ZHEN Gao (University of Ontario Institute of Technology Canada)
Dr. OUERDACHI Lahbassi (University of Annaba Algeria)
Dr. HADJ ABDELKADER Hicham (IBISC – University of Evry France)
Dr. KARRAY M'HAMED ALI (National Engineering School of Tunis)
Dr. ALLAL Mohammed Amine (University of Tlemcen Algeria)
Dr. FOUCAL Fazia (GEMH - University of Limoges France)
Dr. TORRES Jeremi (University of Montpellier 2 France)
Dr. CHANDRAKANT Govindrao Dighavka (L. V. H. College of Panchavati India)
Dr. ABID Chérifa (Polytech' University of Aix-Marseille France)
Dr. HAMMADI Fodil (University of Bechar Algeria)
Dr. BENSABI Abd-El-Hamid (University of Tlemcen)
Dr. BENBACHIR Maamar (University of Bechar Algeria)
Dr. BOUNOUA Abdennacer (University of Sidi bel abbes Algeria)
Dr. FAZALUL RAHIMAN Mohd Hafiz (University of Malaysia)
Dr. TIWARI Shashank Amity University Lucknow (India)

Pr. BALBINOT Alexandre (Federal University of Rio Grande do Sul Brazil)
Pr. TEHIRICHI Mohamed (University of Bechar Algeria)
Pr. JAIN GOTAN (Materials Research Lab., A.C.S. College, Nandgaon India)
Pr. SAIDANE Abdelkader (ENSET Oran Algeria)
Pr. DI GIAMBERARDINO Paolo (University of Rome « La Sapienza » Italy)
Pr. SENGOUGA Nouredine (University of Biskra Algeria)
Pr. CHERITI Abdelkarim (University of Bechar Algeria)
Pr. MEDALE Marc (University of Aix-Marseille France)
Pr. HELMAOUI Abderrachid (University of Bechar Algeria)
Pr. HAMOUINE Abdelmadjid (University of Bechar Algeria)
Pr. DRAOUI Belkacem (University of Bechar Algeria)
Pr. BELGHACHI Abderrahmane (University of Bechar Algeria)
Pr. SHAILENDHRA Karthikeyan (AMRITA School of Engineering India)
Pr. BURAK Barutcu (University of Istanbul Turkey)
Pr. LAOUFI Abdallah (University of Bechar Algeria)
Pr. Ahmed Farouk ELSAFTY (American University of the Middle East Kuwait)
Pr. Sohrab MIRSAEIDI (Centre of Electrical Energy Systems Malaysia)
Pr. SELLAM Mebrouk (University of Bechar Algeria)
Pr. BELBOUKHARI Nasser (University of Bechar Algeria)
Pr. BENACHAIBA Chellali (University of Bechar Algeria)
Dr. ABDUL RAHIM Ruzairi (University Technology of Malaysia)
Dr. CHIKR EL MEZOUAR Zouaoui (University of Bechar Algeria)
Dr. KAMECHE Mohamed (Centre des Techniques Spatiales, Oran Algeria)
Dr. MERAD Lotfi (Ecole Préparatoire en Sciences et Techniques Tlemcen Algeria)
Dr. SANJAY KHER Sanjay (Raja Ramanna Centre for Advanced Technology INDIA)
Dr. BOUCHAHM Nora (Centre de Recherche Scientifique et Technique sur les Régions Arides Biskra)
Dr. Fateh Mebarek-ODINA (University of Skikda Algeria)

Journal of Scientific Research

University of Bechar

P.O.Box 417 route de Kenadsa

08000 Bechar - ALGERIA

Tel: +213 (0) 49 81 90 24

Fax: +213 (0) 49 81 52 44

Editorial mail: jrs.bechar@gmail.com

Submission mail: submission.bechar@gmail.com

Web: <http://www.univ-bechar.dz/jrs/>



A hydrodynamic and mass study of a stirred tank by a chamfered bladed

Benyamina Leila^{1*}, Bouanini Mohamed¹, Rebhi Mébrouk¹,
Draoui Belkacem¹, Belloufa Larbi¹, Nebbou Abdelkader¹

¹ Research Laboratory ENERGARID
University of Bechar
BP 417 Béchar ALGERIA
E-mail: lben05@yahoo.fr

Abstract- A mechanical agitation system is primarily intended to provide mechanical energy to the fluid and therefore promote intimate contact between the substances or phases for obtaining the best conditions in the mass and heat transfer. When addressing a problem of a stirring-mixing, the first question we should ask is the type of mobile used to achieve the objectives of the mixing process. This work proposes mixing equipment that studies the mass transfer and the main characteristics of mechanically agitated systems (the tangential velocity). The steps encountered in industrial production lines, food, cosmetics, pharmaceuticals, petrochemicals, cleaning products, etc ... are based on the precepts of agitation, mechanical agitation of the fluids promotes mixing to obtain a certain degree of homogeneity of the final product and increases the mass transfer phenomena. A hydrodynamic and mass study is needed to optimize the design of tanks and the mobile agitation. A local (tangential velocity) and global study (the number of power) in a conventional stirring system agitated by a straight blade ($d/D = 0.5$) allowed us to compare our results with the experimental literature, a very good agreement was observed. This validation will allow us to perform simulations on two-bladed chamfered. The velocity profile and the mass transfer are analyzed. It has been shown that the hydrodynamics and mass transfer are modified by the effect of the chamfering of the mobile that plays a role. A comparative analysis between the straight and the chamfered mobile is adopted.

Keywords: Bladed chamfered, mass transfer, miscible fluids, hydrodynamics, numerical simulation, Computational fluid dynamics (CFD)

I. Introduction

Following the market demand for quality of pharmaceutical, cosmetic, chemical food, ect ..., researchers continue to study, innovate and explore the genius techniques of the mechanically agitated system processes to achieve their goals to get a quality finished product. Crude product, the raw material to finished product packaging, the entire engineering process of production involve a coordinated series of separate and independent fundamental operations of the process itself called unitary operation, for each, the engineer must consider the thermodynamic aspect, i.e., the feasibility of reactions and the energy required to achieve them. Some reactions are exothermic; they are accompanied by a release of energy, but most are endothermic and therefore require an energy input by mechanical agitation, which is a unit operation that is a big step in a manufacturing process of engineering where the fluid flows are present.

The objective of this study is to model and simulate the flow generated by our mobile numerically, to prove its performance in the homogenization mixing with a reduced time.

The first works in the agitation consist of experimental investigations. [1] which were interested in the flow driven by Rushton turbine and agitators inclined blades; it was made of the speed measurements with several changes of the turbine. These results are limited to the local area. Then comes the work of [2,3], which conducts the experimental analysis of the generated flow by a moving blade. The

majority of these works show that these low speed agitators mainly generate a tangential flow, in the same context in the work of [4], [5], [6], [7].

Numerically, the first models simulating the flow around a bladed stirrer, that were studies of [8,9], were based on a discretization by finite difference centered method which is valid only for low Reynolds numbers. However, the simulations [10], [11] are based on a discretization of differential equations of continuity and primitive motion variables (u , v , w). [12] studied a three-dimensional numerical simulation of the flow of an incompressible fluid around a paddle stirrer and a flat blade turbine, which operate in a laminar flow in a stirred vessel; the aim is to get the three: tangential, radial and axial velocity components.

The experimental study of the turbulent flow induced by a six-blade stirrer inclined 60° in a baffle-tank was made by [13]. The amount of power, the three velocity components and the corresponding quantities of turbulence were measured in rough water. The results showed a significant decrease in power from 2.5 to 2.2 with a Reynolds number of 1200, and are associated with a change of a axial to a radial flow, after which the number of power remains approximately constant at high Reynolds numbers with values between 2.2 and 2.3 velocity measurements, averaged over 360° of stirrer rotation, indicating an axial jet.

The stirring speed under the paddle is proportional to the radius. Comparison with a Rushton turbine of the same size shows that the pumping efficiency is about 2.5 times higher, therefore it absorbs less power in the inclined stirrer, the thing makes it a better choice for

applications where high throughput is required. In the same context, there is an experimental study of a two-bladed where the velocity and

energy consumption are achieved by [14] for a viscoelastic fluid, Newtonian and inelastic fluids.

The results are interpreted considering of a numerical simulation using a finite element method. Numerically and experimentally significant influence of the elasticity is effective for a Reynolds number greater than a threshold value from 5 to 7. Above this value, the number of power is increased, and the velocity field has changed considerably.

This behavior is mainly due to the elasticity of the fluid. [15] Studying the hydrodynamic flow over the heat transfer presented a detailed simulation in a tank of 1.20 m diameter stirred by an anchor of 1.07 m diameter and 0.707 m in height. The set of equations written in cylindrical coordinates model was solved by the finite volume method using the CFX-4.2 software.

For low number of Re [16] who have studied experimentally and numerically the flow of a Newtonian fluid around an anchor stirrer inclined in a flat-bottomed cylindrical vessel without a baffled one. The flow is induced to three number of Re, 1, 10 and 28, it was found that, the pumping capacity is much reduced due to the low number of Re. The study also looked at the influence of the inclination degree of the blades on the hydrodynamic structure. [17], The purpose of this paper is to study numerically the detailed morphology of the flow and mixing a thermoplastic liquid 2D mixer which consists of a rotating drum and a static wheel. It is shown that the application of a low elasticity eliminates vortices.

Increasing the rotational speed, is generally not sufficient to reduce the size of the rigid zones. Finally, it seems that the configuration with two perpendicular blades was the best result for agitating viscoplastic fluids. In addition, it was noted that the reduction in size of the rigid zone is not the only criteria involved in improving the quality of the mixture.

For inclined agitators new design [18], they have made experimental studies on the impact of this technology on energy consumption and mixing time, by comparing the two types of agitator movement: rotational or alternative movements. It is shown that the energy consumption is much lower in the case of alternative agitator. [19] in this study, experiments of solid-liquid mixture were carried out and the cloud height was measured as a function of operating conditions and configuration of the tank. The study of turbulent dispersion strength on the cloud height determined that the inclusion of turbulent dispersion force was critical to accurate prediction of cloud height for the studied conditions. The drag model was observed to have a much lower influence.

II. Geometric representation of the system, mathematical formulation

This work is a contribution to the study of the difficulties encountered in the field of agitation and a contribution to the study of agitation in a laminar flow of an incompressible Newtonian fluid in a cylindrical container without baffled flat bottom agitated by a chamfered bladed whose problems arise in various industries of great economic importance.

The goal of this work is to model and simulate numerically the flow generated by our mobile, and to prove its performance in homogenization mixing in less time.

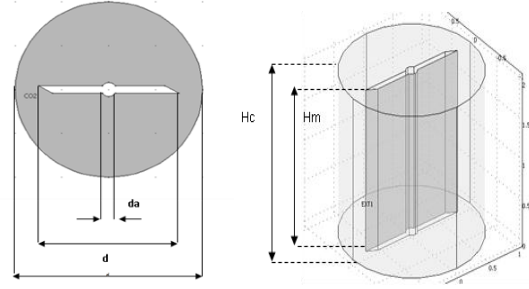


Fig.1. Physical model.

The governing equations: the fluid flow is written in dimensionless form, taking into account the following simplifying assumptions:

- Newtonian fluid
- Incompressible fluid
- The laminar and two-dimensional flow
- The permanent regime.
- Adiabatic solid walls

We have the dimensionless parameters

$$X = \frac{2x}{D}, Y = \frac{2y}{D}, C^* = \frac{C}{C_0}, U = \frac{u}{V_0}, V = \frac{v}{V_0} \text{ and } V_0 = \pi \cdot N \cdot D \quad (1)$$

$$t^* = 2 \cdot \pi \cdot N \cdot t \quad (2)$$

The dimensionless equations are as follows:

- The hydrodynamic study

$$\frac{\partial U}{\partial X} + \frac{\partial V}{\partial Y} = 0 \quad (3)$$

$$\frac{\partial U}{\partial \tau} + U \frac{\partial U}{\partial X} + V \frac{\partial U}{\partial Y} = -\frac{\partial P}{\partial X} + \frac{1}{\text{Re}} \cdot \frac{2}{\pi} \left(\frac{d}{D} \right)^2 \left(\frac{\partial^2 U}{\partial X^2} + \frac{\partial^2 U}{\partial Y^2} \right) \quad (4)$$

$$\frac{\partial V}{\partial \tau} + U \frac{\partial V}{\partial X} + V \frac{\partial V}{\partial Y} = -\frac{\partial P}{\partial Y} + \frac{1}{\text{Re}} \cdot \frac{2}{\pi} \left(\frac{d}{D} \right)^2 \left(\frac{\partial^2 V}{\partial X^2} + \frac{\partial^2 V}{\partial Y^2} \right) \quad (5)$$

- The concentration equation :

$$\frac{\partial C^*}{\partial t^*} + U \frac{\partial C^*}{\partial X} + V \frac{\partial C^*}{\partial Y} = \lambda_2 \cdot \left(\frac{\partial^2 C^*}{\partial X^2} + \frac{\partial^2 C^*}{\partial Y^2} \right) \quad (6)$$

With:

$$\lambda_2 = \frac{2}{\pi} \left(\frac{d}{D} \right)^2 \frac{1}{\text{Re} \cdot \text{Sc}} \quad (7)$$

III. Numerical solution of equations

For the numerical solution of the equations governing the hydrodynamic flow, CFD code is used where the finite volume method is integrated, so that the resolution is passed through three stages.

The first step is the Gambit CFD code pre-processor that builds the geometry and generates the mileage.

The second step is the code of the solver where we proceeded to define the data, prescribing initial and boundary conditions, testing and optimization of the convergence of computing and simulation.

The third and final step is the post processing, here we used the Tec plot where we operate and where our results are viewed.

IV. Results

IV. 1. Velocity components, Tangential velocity

IV. 1.1 .Effects of inertia

We chose a size $d/D = 0.9$ with a 45° chamfer (scraper agitator) by varying the Re (0.1, 4.12, 10, 30, and 50), then we analyzed the influence of the inertia into the variation of the (tangential velocity), the results are as follows:

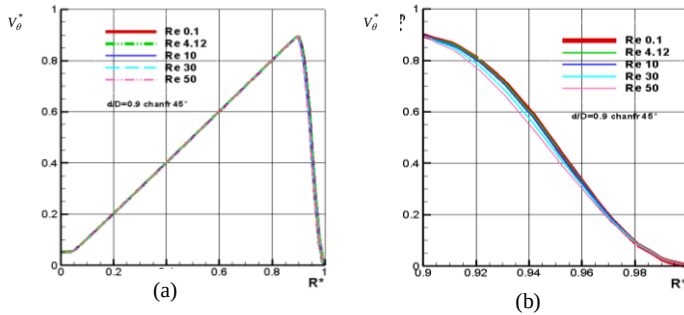


Fig.2. Tangential velocity relative to the blade and its extension

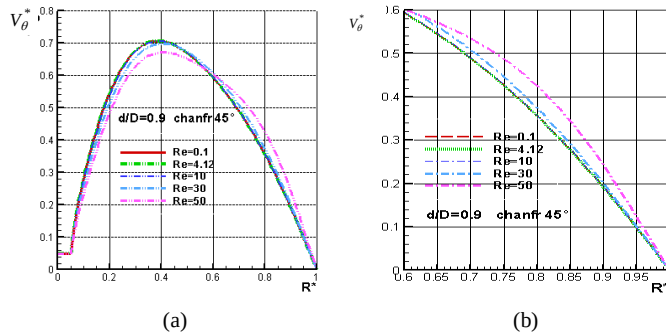


Fig.3. Tangential velocity with respect to the mediator

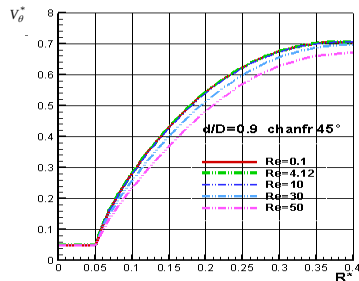


Fig. 4. Tangential velocity with respect to the mediator

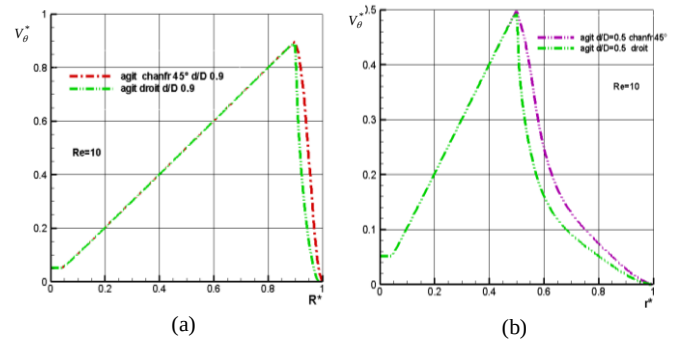


Fig. 5. Tangential velocity relative to the blade and its extension

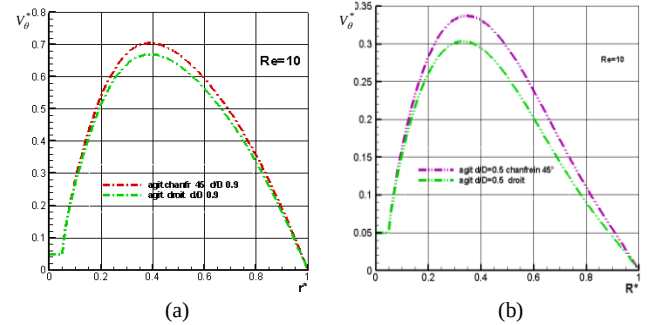


Fig. 6. Tangential velocity with respect to the mediator

IV. 1.2. Influence of size d/D (45° chamfer)

We set a $Re=10$ then we varied the size of the mobile d/D (0.5, 0.6, 0.7, 0.8, 0.9) with a 45° chamfer, and then we analyzed the influence of the size of the blade on the evolution of local parameter (tangential velocity), we concluded that:

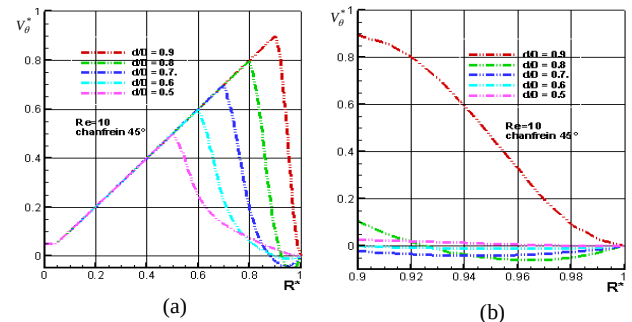


Fig.7. Tangential velocity relative to the blade and its extension

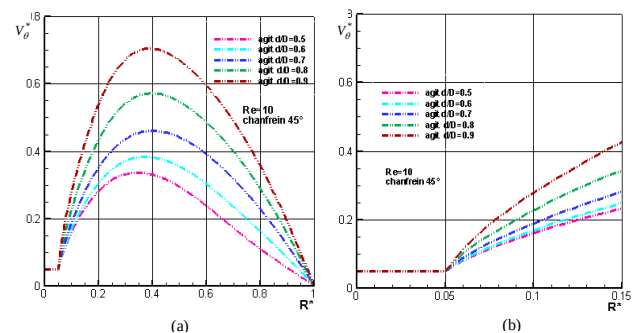


Fig.8. Tangential velocity with respect to the mediator

IV. 1.3. Influence of the degree of the chamfering

We chose a $Re = 10$ with size of bladed $d/D = 0.7$, then varied degrees of chamfer (22.5° , 45° , 67.5°), compared with 90° (straight agitator) then monitored and analyzed the influence of the degree of chamfering on the evolution of local parameter (tangential velocity), the results are:

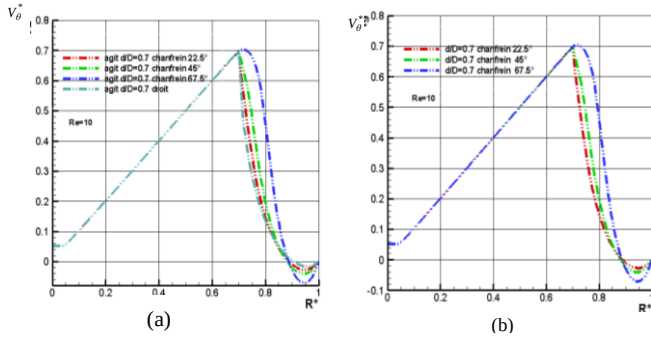


Fig.9. Tangential velocity relative to the blade and its extension

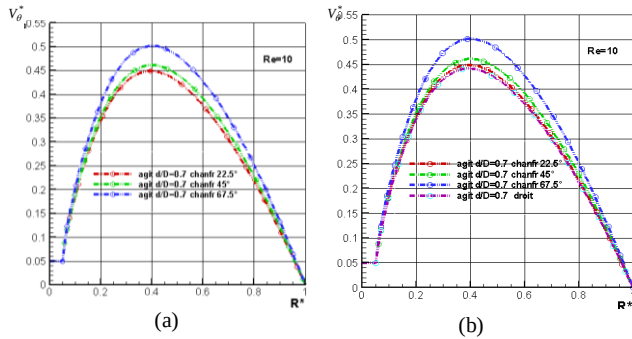


Fig.10. Tangential velocity with respect to the mediator

IV. 2. Comparison between the tangential and radial velocity

Our mobile is a two-bladed agitator generating a tangential flow; its radial velocity is very low compared to the tangential, as stated in the figures below:

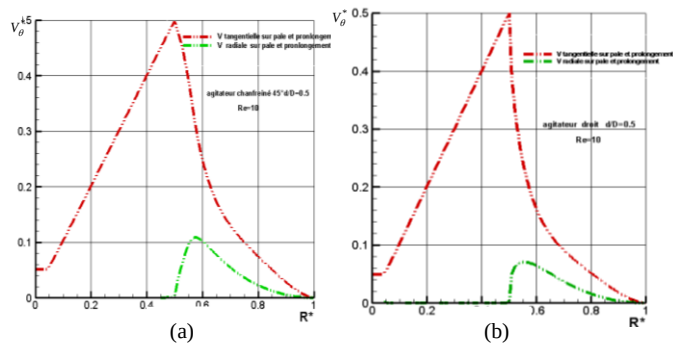


Fig.11. Tangential and radial velocity with respect to the blade and its extension

IV.3. Evolution of the stream function depending on the degree of chamfering

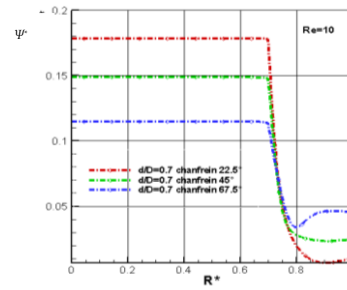


Fig.12. Stream function on the blade and its extension

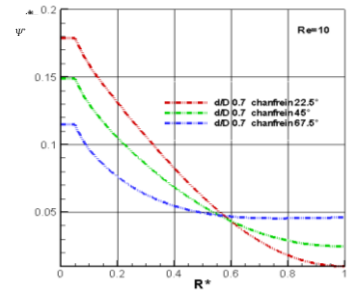


Fig.13. Stream function on the mediator

IV. 4. A comparative study of mass transfer between the chamfered and the straight

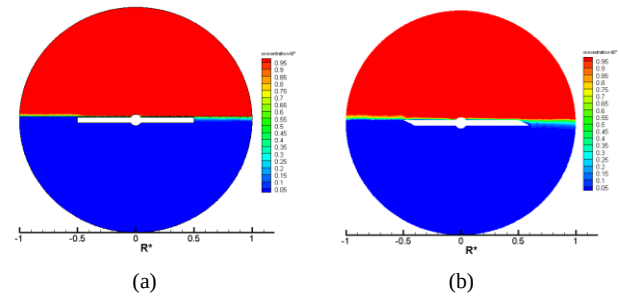


Fig.14. At $t^*=0$

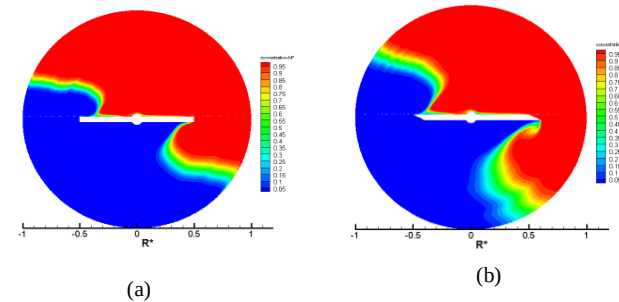


Fig.15. At $t^*=4$

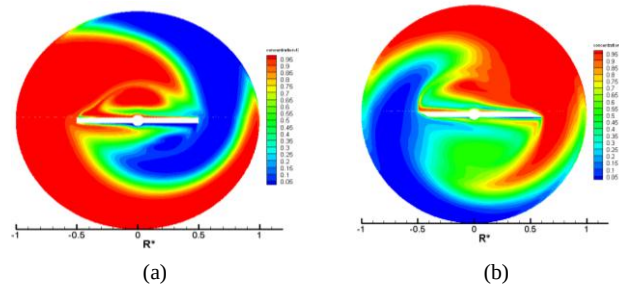


Fig.16. At $t^*=34$

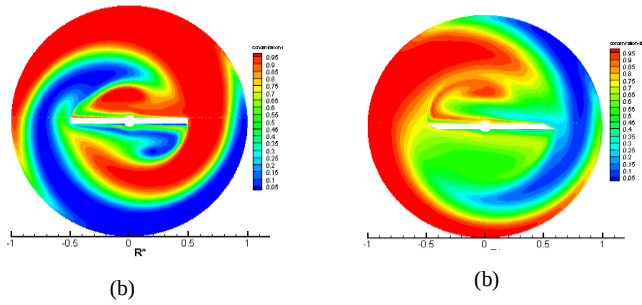


Fig. 17. At $t^*=54$

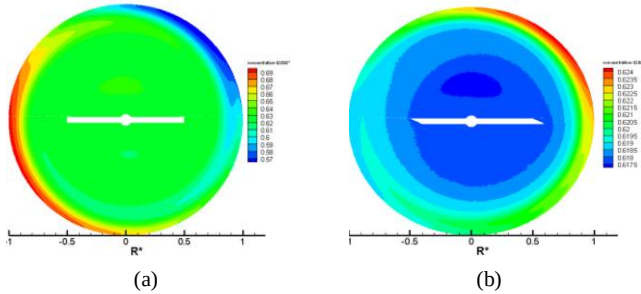


Fig. 18. At $t^*=2000$

Mixing time (t^*)	Standard deviation		
	The straight bladed	The bladed 45° chamfered	The bladed 67.5° chamfered
0	0,403	0,402	0,400
4	0,421	0,420	0,431
34	0,415	0,414	0,341
54	0,363	0,357	0,314
100	0,304	0,302	0,240
200	0,171	0,169	0,140
350	0,093	0,101	0,064
750	0,057	0,065	0,018
1000	0,050	0,051	0,011
2000	0,019	0,019	0,001

Table 1. Standard deviation based on mixing time

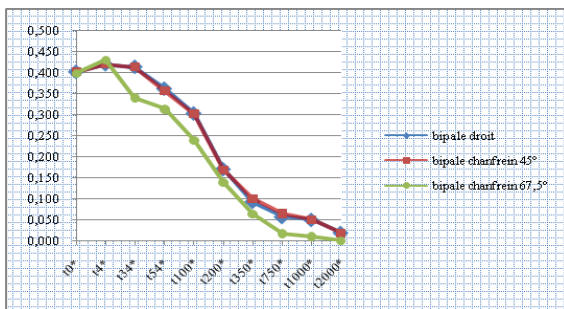


Fig. 19. Standard deviation based on mixing time

V. Interpretation of results

V.1.Tangential velocity

V.1.1. Effects of inertia

V.1.1.1. Variation of the tangential velocity relative to the blade and its extension

The curves are divided into two parts;

1- The first part there is a linearity and growth until the end of the blade reaching a peak.

2- The second part is a decrease to the wall.

Figure 2 (a, b): increasing the number of Re (0.1, 4.12; 10, 30, 50) we see that it does not affect the appearance of the first part of the linearity of the curve and growth until the end of the blade to reach the maximum value $V_{\theta}^* = 0.9$ for the position of $R = 0.9^*$, followed by a decrease to the value 0 at the wall, with a trend almost linear with large values of Re = 50 and with a variation inversely proportional to the Reynolds number, thus the largest values of the blade are at the Re = 0.1.

From the blade tip, the velocity decreases with the increase of Re.

Comparing the two agitators (the straight and the chamfered), Figures 5 (a, b) show the shape of the first part of the curves (linear axis to the end of the blade) is the same, but the second portion (the end of the blade to the wall), the tangential velocity decreases rapidly in the case of the straight blade with respect to the chamfered stirrer, so that the tangential velocity of the chamfered blade is higher than the straight blade.

V.1.1.2. Variation of the tangential velocity with respect to the mediator

Figure 3(a, b) figure indicates that the velocity profile has a parabolic shape with a local maximum of the order of 0.7, with values inversely proportional to the number of Re up to the position of $R^* = 0.6^*$ of the blade, from this point until the end of the blade, the speed values become proportional to the number of Re and decrease rapidly with the lowest rate.

Comparing the two chamfered agitators and the right mobile in Figure 6 (a, b) clearly confirms that the tangential velocity relative to the mediator is low in the case of the straight agitator.

V.1.2. Influence of size d/D

V.1.2.1. Tangential velocity relative to the blade and its extension

Figure 7(a, b) reveals that the curves are divided into two parts:

The first part is linear up to the end of the blade where the curves reach local maximum namely $\max V_{\theta}^* = 0.5$ for the diameter $d/D = 0.5$

to 0.9 for the diameter $d/D = 0.9$, therefore the maximum value of the velocity is proportional to the size of the blade.

The second part is a decrease in speed which is even faster than the diameter increases, up to the value zero at the wall, this decrease is slower for smaller sizes d/D (0.5, 0.6 and 0.7) and has a quasi-linearity for diameters (0.8 to 0.9) (agitators scrapers).

In Figure 7(b), we see negative values of the velocity for sizes (0.6, 0.7 and 0.8) near the wall from point $R^* = 0.9$, it is reflected in the existence of a vortex (suction and flow to the bottom of the tank), the flow will be delayed in this area.

V.1.2.2 Tangential velocity with respect to the mediator

The velocity profile to a parabolic shape, with the values of the which are 0.35 for a size $d/D=0.5$, 0.4 for a size of $d/D = 0.6$, 0.45 for a diameter of $d/D = 0.7$, 0.55 for a diameter of $d/D = 0.8$, and a maximum of $V_{\theta}^* = 0.7$ near the agitator $d/D = 0.9$, so this is a proportionality relative to the size of the blade.

Figure 8 (b) shows that for all sizes, the speed is constant up to the point $R^* = 0.05$

V.1.3. Influence of degree chamfer

V.1.3.1 Tangential velocity relative to the blade and its extension

Figure 9 (a, b) clearly shows that the change in velocity as a function of the degree of the chamfer is linear and is growing up to the tip of the blade with the same maximum

This means that in the first part, the chamfer does not affect, from the blade tip, the speed is proportional to the degree of chamfer, with an exponential form for the chamfered 67.5° and fairly linear for (22.5° and 45°), all curves intersect (at $R^* = 0.9$) with negative speeds, up to the wall ($R^* = 1$) (zero speed)

Figure 9 (a) shows a comparison between the two geometries, bladed chamfered and the right curves have the same speed up to the end of the blade. And a decrease in speed to zero at the wall, this decrease is much faster in the straight bladed and negative velocities in the vicinity of the wall are lower in the chamfered, announcing that there is no recirculation zone and no aspiration in this field; the curves meet at two points ($R^* = (0.9 \text{ to } 1)$ with zero velocity.)

V.1.3.2 Tangential velocity with respect to the mediator

Figures 10 (a, b), show that the speed profile has a parabolic shape with a peak (maximum), which varies proportionally to the degree of the chamfer, of the order of 0.45 for the chamfer 22.5° , of 0.46 to 45° and a value of 0.5 to 67.5° , with a linearity for lower speeds.

The curves have the same starting point and the same end point. Then compared between the two chamfered and law geometries, we say that their curves have the same shape with large values of speed for the stirrer chamfered.

So we see that the speed varies proportionally to degree of chamfering.

V.2. Evolution of the stream function depending on the degree of chamfering

Figure 12 shows that the value of the stream function is constant along the blade to the three degrees of chamfers, it also confirms what has been shown above that the maximum value of the stream function is inversely proportional to the degree of chamfering, gradually as one increases the degree of chamfer of the blade, the function value of current decreases.

Figure 13 confirms that the value of the stream function in the remote area of the blade (near the walls) increases with the rising degree of chamfer of the two blades, of the order of 0.01 at 22.5° degree, to a value of 0.03 for the measurement of 45° at the end reaches a value of 0.05° at a 67.5° bevel.

Figure 13 shows the curves of different degrees chamfer have an exponential form and intersect at $R^* = 0.6$. Upstream of the point $R^* = 0.6$ current function is inversely proportional to the degree chamfer, downstream we see a proportionality.

V.3. A comparative study of mass transfer between the chamfered and the straight blades

From the initial time $t = 0$ to the end $t^* = 2000$, homogenization of the mixture and efficiency of the chamfered blades 67.5° are clearly confirmed in the figure (14 to 18), Table 1 and Figure 19.

Note that the value of the standard deviation (variance) of the distribution of concentration in each of the areas of the three mobile (law, the chamfer 45° and 67.5°), corresponding to successively different mixing time, is still significantly lower in the case of the agitator beveled 67.5° with respect to the other two movable, whose standard deviation is not very distinct

These data demonstrate that the homogenization of the mixture with 67.5° beveled blade is quickly reached, where the particles have the same concentration.

See the chart where the green curve on our proposed model (beveled bladed 67.5°) confirms the performance of our homogenization choice with a short mixing

$$time = \frac{\text{mixing time of } 67.5 \text{ chamfered}}{(\text{mixing time of bladed straight})} = \frac{1}{19} \text{ whether } 5\%$$

VI. Validation

To test the reliability of our simulations and the conformity of our results, a comparison with previous work on a two-bladed paddle straight ($d/D = 0.5$, $da/D = 0.05$) [7] and [5].

The validation of this work, in terms of two parameters (local and globale) were performed.

The local parameter is the tangential velocity (V_{θ}^*) on the blade and its extension as well as the mediator, which has been validated by the experimental study [7], as shown in Figure 20, a good agreement is demonstrated.

The global parameter is the number of power N_p , we validated with the experimental study of [5], as shown in figure 21, good agreement is clearly confirmed.

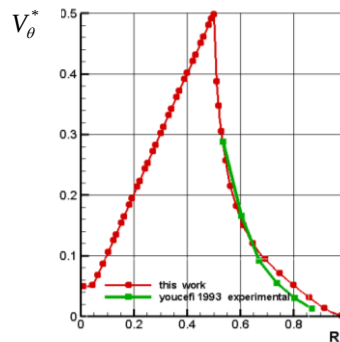


Fig.20. Validation of Tangential velocity relative to the blade and its extension its extension with the experimental study

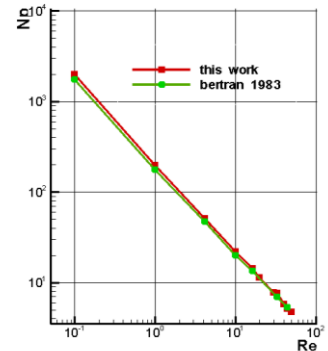


Fig.21. Validation of the number of power with the experimental study

VII. Conclusion

This work is a contribution to the study of problems that encountered the phenomena of agitation in tanks with Newtonian fluid rheology. Note that such problems arise in different industrial sectors of great economic, industrial plastics, inks and paints, cosmetics and beauty products, food industries, bio industries, etc..

A 2D simulation was undertaken studying the hydrodynamics and mass transfer of incompressible flow around a two-bladed chamfered. Then, the hydrodynamic results of a chamfered bladed were presented with changes in the degree chamfer 22.5° , 45° and 67.5° , the size of the agitator and the Reynolds number.

It has been shown that the hydrodynamic effect is modified by chamfering of the mobile that plays a key role.

This study confirms the performance of our (bladed chamfered) in the homogenization with a short mixing time.

Acknowledgements

The authors wish to thank the support of the ENERGARID laboratory, University of Bechar.

Nomenclature

a	mass diffusivity
d	Diameter of the agitator
D	Diameter of the tank
da	Shaft diameter
e	The space between the blade tip and the wall
Hc	Height of the vessel
Hm	Mobile height
Np	Number of power
P	Power agitation
tm	Mixing time
U, V	Speed Cartesian velocity
V _θ	Tangential speed
Ur	Radial velocity
X, Y	Cartesian coordinates dimensionless
t*	Dimensionless time (mixing time)
R*	Dimensionless radius of the vessel
x, y	Cartesian coordinates dimensional
t	Temps
C*	Dimensionless concentration
a	Mass diffusivity

Greek symbols

θ	Tangential position
ψ*	Dimensionless Stream function
ν	Kinematic viscosity of the fluid
ρ	Density of the fluid
μ	Dynamic viscosity of the fluid
τ	Dimensionless time

Dimensionless numbers

$$N_p = \frac{P}{\rho N^3 d^5} \quad \text{Number of power}$$

$$Re = \frac{d^2 N \rho}{\mu} \quad \text{Reynolds number}$$

$$Sc = \frac{\nu}{a} \quad \text{Schmidt number}$$

References

- [1] A. Metzner, R. Otto. Agitation of non-newtonian fluids, American Institute of Chemical Engineering vol.3, N°1, (1957), pp 3-10.
- [2] Y. Murakami, K. Fujimoto, I. Shimada, A. Yamada and K. Asano, Evaluation of performance of mixing apparatus for high viscosity fluids, Chem. Eng. Japan Vol. 05, N°03, (1972), pp 297-303.
- [3] S. Nagata, Mixing principles and applications, Kodansha LTD. Tokyo, 1975.
- [4] M. Kuriyama, H. Inomata, K. Arai and S. Saito, Numerical solution for the flow of highly viscous fluid in agitated vessel with anchor impeller, A. I.Ch. E. Journal. Vol. 28, N° 03, (1982), pp 385-391.
- [5] J. Bertrand, Agitation of viscous fluids case of mobile paddle, anchor and gates, Ph.D. Thesis, National Polytechnic Institute of Toulouse, 1983.
- [6] J. Bertrand and J.P.COUDERC, Numerical study of flow generated by an anchor in the case of viscous Newtonian or pseudo-plastic fluids, Entropy No. 125/126, 1985.
- [7] A. Youcefi, Experimental study of the flow of a viscoelastic fluid around a bladed stirrer stirred tank, PhD Thesis, Toulouse National Polytechnic Institute, 1993.
- [8] S. Hiraoka, I. Yamada, and K. Mizoguchi, Numerical analysis of flow behaviour of highly viscous fluid in agitated vessel, Chemical Engineering of Japan, 11, 6, (1978), pp 487-493.
- [9] S. Hiraoka, I. Yamada, and K. Mizoguchi, Two dimensional model analysis of flow behaviour highly viscous non-newtonian fluid in agitated vessel with paddle impeller, Chemical Engineering of Japan, 12, 1, (1979), pp56-62.
- [10] D. AnneArchard, Numerical simulation of flow generated in a tank with A bladed stirrer with a finite element method , Internal Report No. 88-7. Toulouse National Polytechnic Institute, 1988.
- [11] D. AnneArchard, H.C.Boisson, H.HA-Minh, Finite element simulation of rotating flow of a viscoelastic fluid, XI The International Congress on Rheology. Brussels, Belgium, 1992.
- [12] C. Kuncewicz, Three-dimensional model of laminar liquid flow for paddle impellers and flat-blade turbines, Chemical Engineering Science, Vol. 47, No. H/16, (1992), pp. 3959-3967.
- [13] R. M. Hockey and J.M. Nouri, Turbulent flow in a baffled vessel stirred by a 60° pitched blade impeller, Chemical Engineering Science, Vol. 51, No. 19, (1996), pp. 4405-4421.
- [14] A. Youcefi, D. Anne-Archard, H. Boisson and M. Sengelin, On the influence of liquid elasticity on mixing in a vessel agitated by a two-bladed impeller. J Fluids Eng, vol. 119 N°3, (1997), pp. 616-622.
- [15] S M C P. Pedrosa, J. R. Nunhez, The behaviour of stirred vessels with anchor type impellers, Computers and Chemical Engineering 24, (2000), pp 1745-1751.
- [16] G. PapaDakis, M. Rice, J. Hall and M. Yianneskis, Investigation of laminar flow in a stirred vessel at low Reynolds numbers, Chemical Engineering Science, 61, 2006, pp 2762 – 2770.
- [17] F. Savreux, P. Jay, A. Magnin, Viscoplastic fluid mixing in a rotating tank, Chemical Engineering Science.62 ,(2007) ,2290 – 2301.
- [18] S.Masiuk, R. Rakoczy and M. Kordas, Comparison density of maximal energy for mixing process using the same agitator in rotational and reciprocating movements, Chemical Engineering and Processing 47, (2008) 1252–1260.
- [19] S. Gohel, S. Joshi, M. Azhar, M. Horner and G. Padron, CFD Modeling of Solid Suspension in a Stirred Tank: Effect of Drag Models and Turbulent Dispersion on Cloud Height, Hindawi Publishing Corporation International Journal of Chemical Engineering, Volume (2012), Article I D 956975, 9 pages. doi:10.1155/2012/956975.

**Journal of Scientific Research
University of Bechar**

P.O.Box 417 route de Kenadsa

08000 Bechar - ALGERIA

Tel: +213 (0) 49 81 90 24

Fax: +213 (0) 49 81 52 44

Editorial mail: jrs.bechar@gmail.com

Submission mail: submission.bechar@gmail.com

Web: <http://www.univ-bechar.dz/jrs/>
