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Calculation of Some Crude Oil Flow Parameters in A Cylindrical Tube and Their Modelization in Small and Great Variable Radius

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ABSTRACT: In this work, we establish the kinematic of flowing of crude oil inside a cylindrical tube which is rare in the literature. From velocity expression, we find kinematic. Pressure, temperature and heat distribution of crude oil flowing are also find from equations in the literature. Silmilation of these expressions shows that Kinematic of crude oil is similar to a flow of a fluide with a small viscosity what is true in the reality. Velocity of crude oil is not similar in any points during the flowing but increasing and decreasing according to the position point and seams like to be more fast in the border than in the center with a small radius and more fast in the center than in the border with a great radius. Temperature of the crude oil is not similar in any points during the flowing. It is more elevated in the the border than in the center. Pressure in small radius is more important in the center than in the border contrarily in great radius. results are more conformable in the reality in small than in great radius. Results of the heat is more conformable in the reality in small than in great radius.

KEYWORDS: Crude oil, heat distribution, kinematic of flowing, pressure, temperature, velocity.

1 INTRODUCTION

Study of kinematics of flowing of fluids is very important in mechanic of continuous mediums because those kinematic are starter point of the calculation of all the tensors [1,2].

Oil is a mixture of hydrocarbons (molecules made up of carbon and hydrogen atoms) and molecules also containing other atoms, mainly sulfur, nitrogen and oxygen. Some of its constituents are, at ambient temperature and pressure, gaseous (methane, propane, etc.), liquid (hexane, heptane, octane, benzene, etc.) and sometimes solid (paraffins, asphalts, etc.)[3]. Turbulent eddy dissipation be large only at the entering (bottom) and gradually reduced along the tubing till it minimum value at the exit (top). The turbulent kinetic energy be larger be larger at the entering (bottom) and minimized throughout the tubing till it be in a lower value at the exit (top). Crude oil temperature was decreased along the tubing centerline and the minimum value at the tubing exit (top). The heat transfer coefficient value be minimum at the entering and increased suddenly through the (0.1) of the total tubing length [4].

Computational fluid dynamics formulations are preferred despite the computational effort involved in the calculations. Also in the majority of those models, simple pseudocomponent kinetic rate expressions have been applied, without enough experimental information referring to kinetic parameters. Finally a generalized reactor model, which considers all mass and heat transfer phenomena, is proposed based on the literature, and details are provided to estimate all of the model parameters [5].

The main objective of this work is the numerical simulation of axisymmetric unsteady viscoelastic fluid modelled by the differential and realistic laws of behaviour: like the model of Phan-Thien and Tanner (MPTT) with relaxation time. Fluid is assumed incompressible. We studied a type of crude oil from North Africa (Algeria). The results converge on the experimental results.So the validated model MPTT, allows simulation to better understand the phenomena of corrosion inside the pipelines [6].

However, almost all the studies about crude oil are not focus in mechanical behaviour of the crude oil like the elaboration of kinematic of deformation or kinematic of flowing of crude oil. We remember that a mechanical study of a transformation of a solide or fluid often starts from a kinematic, because from this last, we can calculate the gradient tensor, the stress tensor and the CauchyGreen tensors. These tensor can allow us to have the elementaries invariant, to know the incompressible condition of the flow and elaborate the equilibrium equations.

In this Document, we use velocity expression of the crude oil find in the in the literature in the target to elaborate a kinematic of flowing of the crude oil. Some equations will be resolved to fine expressions of pressure, the temperature and the heat distribution.

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All these different parameters will be similated i matlab in the target to have new informations in the spatial behaviour. The analyse and interpretation of behaviour will contribute in the better understanding of the crude oil flowing.

2 MATHEMATICAL EXPRESSIONS

2.1 Pressure

In the case of a study flow in a pipeline, the balance of forces allows us to write a relationship between the stress at the wall and the pressure gradient [4]:

$$\tau_\omega = \frac{\partial P}{\partial z}\frac{r}{2} \tag{1}$$

where *P* is the pressure, *r* is a variable radius and *z* the altitude position.
The previous formulas allows us to have the expression of the pressure given by:

$$P(r,z) = \frac{2z}{r}\tau_\omega \tag{2}$$

2.2 velocity and kinematic

To determine the speed profile. The Navier Stockes equations associated with the Krieger apparent viscosity model allow us to obtain, after a few developments, the expression of the following speed profile given in [4] by:

$$\begin{aligned} V(r) = \frac{a^{\frac{1}{3}}}{4\eta_\infty}\left(R^2 - r^2\right) + \left(\frac{a^{\frac{1}{3}}A}{2\eta_\infty} - \frac{|\tau_c|}{\eta_\infty}\right)(r - R) \\ + \left(\frac{|\tau_c|A}{\eta_\infty} - \frac{a^{\frac{1}{3}}A^2}{2\eta_\infty}\right) ln\left(\frac{r+A}{R+A}\right) \end{aligned} \tag{3}$$

with $A = \frac{2\eta_0|\tau_c|}{a\eta_\infty}$, the pressure fall.

from that last and with the consideration that the redius is dependends only on cartesian cordonates as $r^2 = x^2 + y^2$, we obtain the following kinematic of flowing

$$\begin{aligned} \chi(r,t) = \frac{a^{\frac{1}{3}}}{4\eta_\infty}\left(R^2 - r^2\right)t + \left(\frac{a^{\frac{1}{3}}A}{2\eta_\infty} - \frac{|\tau_c|}{\eta_\infty}\right)(r - R)t \\ + \left(\frac{|\tau_c|A}{\eta_\infty} - \frac{a^{\frac{1}{3}}A^2}{2\eta_\infty}\right) ln\left(\frac{r+A}{R+A}\right)t \end{aligned} \tag{4}$$

2.3 Temperature and heat distribution

2.3.1 temperature distribution

The transient one-dimensional heat flow around the well is given by the following partial differential equation.

$$\frac{1}{r}\frac{\partial}{\partial r}\left(k_i r\frac{\partial T_i}{\partial r}\right) = \rho_i C_{pi}\frac{\partial T_i}{\partial t} + \tag{5}$$

when we focus in this previous equation, we obtain the following relation

$$r\frac{\partial^2 T_i}{\partial r^2} + \frac{\partial T_i}{\partial r} - \frac{\rho_i C_{pi} r}{t k_i}T_i = 0 \tag{6}$$

from this last differential equation, we have:

$$1 + 4\frac{\rho_i C_{pi} r^2}{t k_i} > 0 \tag{7}$$

wathever the variable r and the others paramaters. what gives the following solution

$$T_i(r,t) = Ae^{\frac{-1-\sqrt{1+4\frac{\rho_i C_{pi} r^2}{t k_i}}}{2r}} + Be^{\frac{-1+\sqrt{1+4\frac{\rho_i C_{pi} r^2}{t k_i}}}{2r}} \quad (8)$$

where A and B are real numbers. Here we can see that the where r 7−→ ∞ and t constant, we obtain

$$T_i(r \simeq \infty) = (A+B)\, e^{\sqrt{\frac{\rho_i C_{pi}}{t k_i}}} \quad (9)$$

And when $t \longmapsto \infty$ and r constant, we obtain

$$T_i(t \simeq \infty) = Ae^{-2} \quad (10)$$

2.3.2 Heat distribution

The heat transfer between the surrounding formation and wellbore - soil interface as can be calculated according to the following ordinary differential equation.

$$\frac{\partial Q}{\partial z} = -\frac{2\pi K_e}{W K_D}(T_{wb} - T_e) \quad (11)$$

According to that previous relation, we have:

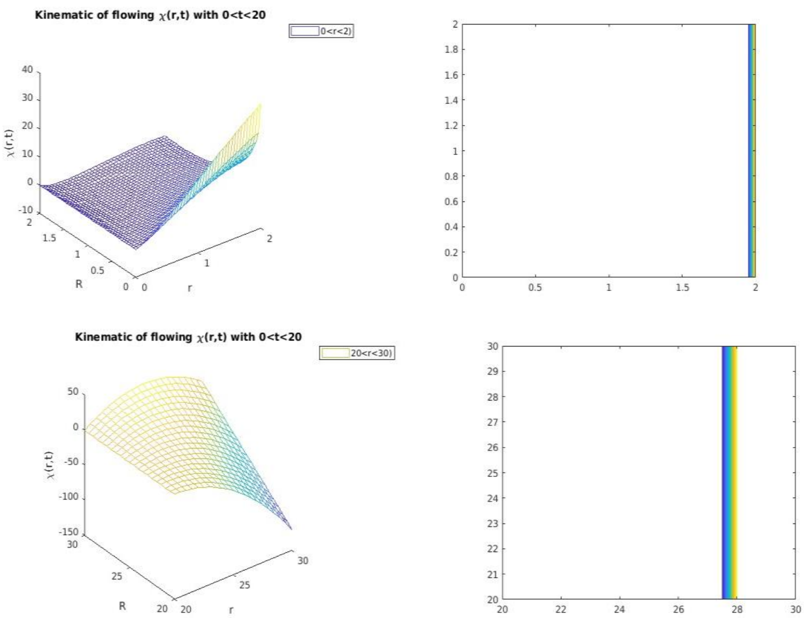
$$Q = -\frac{2\pi K_e}{W K_D}(T_{wb} - T_e)\, z \quad (12)$$

3 SIMULATION AND INTERPRETATION

In all this part of similation, we will consider two tipe of radius. The first which is small will vary between $r = 0m$ and $r = 2m$, and the second radius between $r = 20m$ and $r = 30m$. To better visualize the behaviour in the space, we will mesh all the expression obtained in the first part.

3.1 kinematic

Here we simulate the kinematic of flowing $\chi(r,t)$ find in the mathematical calculation by integrating the velocity $V(r)$ according to time.



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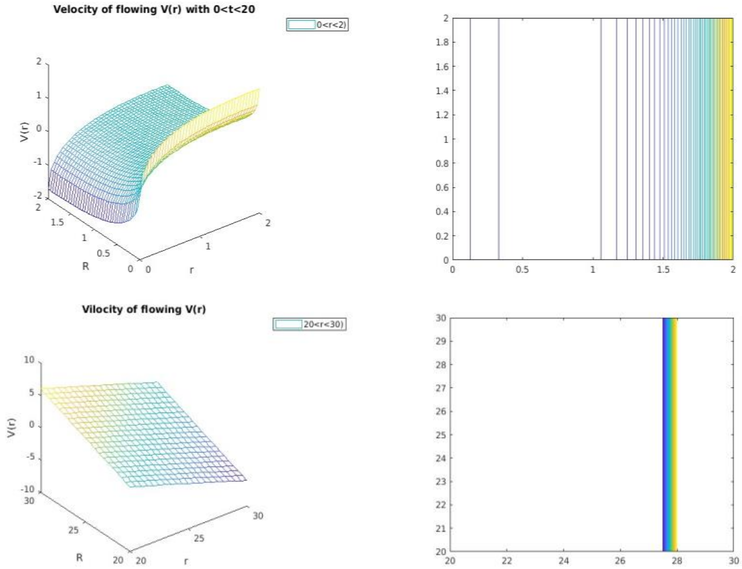
The spatial view given by the similation of the kinematic shows a set of many points with different altitude, find that many points with the same altitude are aligned. As an interpretation, we can say that the crude oil kinematic flowing follows a waving trajectory according to the variation of the radius and the time. As a result that's mean that the crude oil behaviour is similar to a flow of a fluide with a small viscosity what corroborates with the reality.

3.2 Velocity

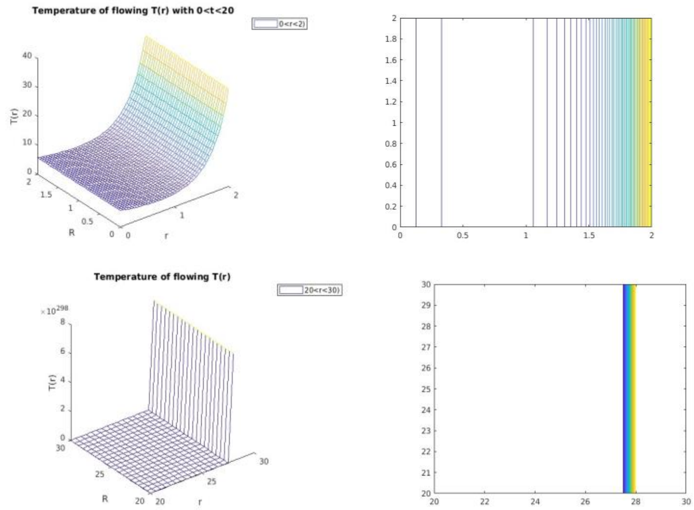
The simulation of the velocity of flowing find in the literature $V(r)$ with a non dependence of time gives the following figures.



For the velocity, the spatial view given by the similation shows a set of many points with a progressive increasing altitude, we also find many points with the same altitude aligned. As an interpretation, we can say that the crude oil velocity follows also a waving behaviour like the trajectory according to the variation of the radius. Result means that the crude oil velocity behaviour is not similar in any points during the flowing but increasing and decreasing according to the position point and seams like to be more fast in the border than in the center with a small radius and more fast in the center than in the border with a great radius.

3.3 Temperature

The simulation of the temperature of flowing which depends only on r by using $T(r)$ find in the mathematical calculation by the resolution of the second order differential equation without second member shows the following paths.



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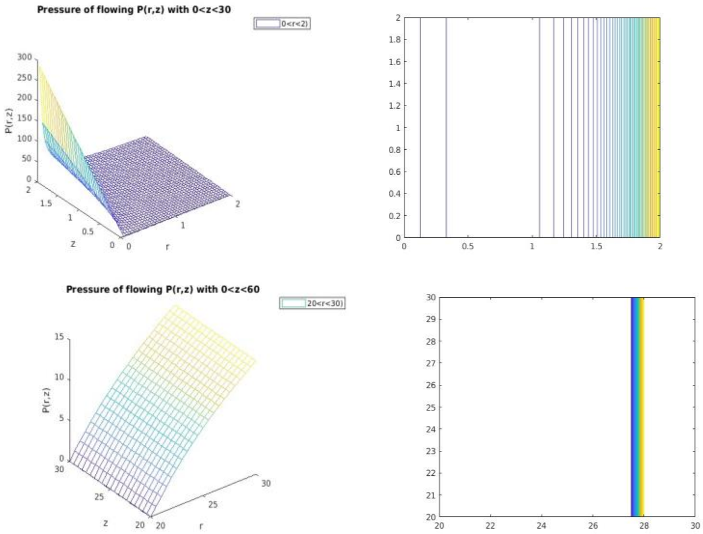
For the temperature, the spatial view given by the similation shows an increasing temperature according to the radius, we also find that the exponential behaviour have a big influence in the expression which increases quickly from certain value of the radius but we have to clarify that the temperature will have a limit value given by the equation (9). As an interpretation , we can say that the crude oil temperature follows an increasing behaviour like the trajectory according to the variation of the radius. Result means that the crude oil temperature behaviour is not similar in any points during the flowing. It is more elevated in the the border than in the center.

3.4 Pressure

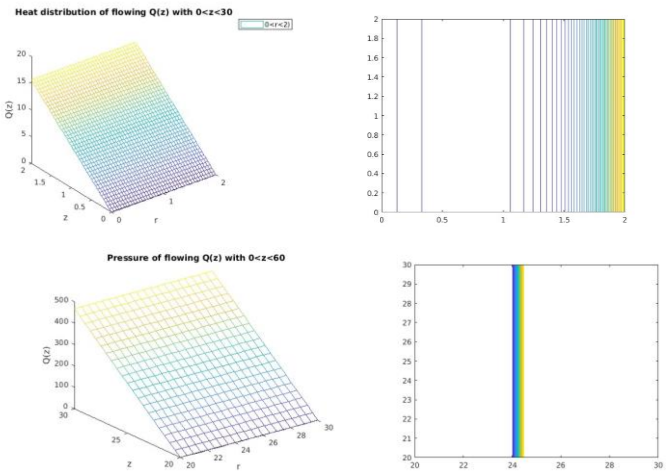
The simulation of the temperature of flowing $P(r,z)$ find in the mathematical calculation by the integration according to time the equation of the pressurefall gives shows the following paths.



For the pressure, the spatial view given by the similation shows an increasing presure according to the altitude z in the small radius and according to the radius r in great radius, so we find that there is no dependence on z in great radius flowing. In small radius flowing, the pressure is more important in the center than in the border contrarily in great radius flowing. the results are more conformable in the reality in small than in great radius.

3.5 Heat

The simulation of the heat of flowing $Q(z)$ find in the mathematical calculation by the integration according to z ordinary differential equation gives the following paths.



About the heat distribution, the spatial view given by the similation shows an increasing presure according to the altitude *z* which is the only variable. This behaviour is similar in small and great radius. As a result, we find that for the increases with *z*.

4 CONCLUSION

In this work, we set ourselves the objective of establishing the kinematic of flowing of crude oil inside a cylindrical tube because it is rare in the literature. A velocity expression find in the literature is used for the job. Pressure, temperature and heat distribution of crude oil flowing are also calculated from equations find in the literature. After that, all the calculated expressions are silmilated in the cases of small and great varieted radius.

-Kinematic result mean that the crude oil behaviour is similar to a flow of a fluide with a small viscosity what corroborates with the reality and validate the study.

-Velocity resut of the crude oil shows that its behaviour is not similar in any points during the flowing but increasing and decreasing according to the position point and seams like to be more fast in the border than in the center with a small radius and more fast in the center than in the border with a great radius. -Temperature result of the crude oil shows that its behaviour is not similar in any points during the flowing. It is more elevated in the the border than in the center.

-About pressure in small radius flowing, it is more important in the center than in the border contrarily in in great radius flowing. the results are more conformable in the reality in small than in great radius.

-And about the results of the heat, it is more conformable in the reality in small than in great radius.

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