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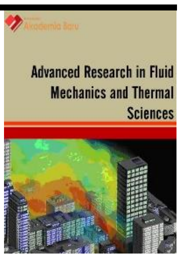

Computational Fluid Dynamic Study on Oil-Water Two Phase Flow in A Vertical Pipe for Australian Crude Oil

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ABSTRACT

A 3D steady state numerical model for the oil-water dispersed flow has been discovered to study the impacts of shear stress on the dispersed phase behaviour in a pipe with vertical situation. CFD tool by ANSYS software is used to investigate the wall shear stress and water droplet pressure. The flow range for the continuous process was explained through the resolution of the Navier-Stokes conservation equations with k–β turbulence model are summed in Reynolds. A recent experimental method analysis was simulated. The geometry is 3.2 m long and 38 mm in diameter tube. Oil droplet width has been presumed to be dependent on flow Reynolds number and it has demonstrated numerically for this case of study. When the mixture velocity Um of1.5 m/s, the droplet diameter Dd was found 4 mm. Shear stress was developed by current work for a different number of velocities (1.5,2,2.5 m/s) at oil fraction (cut off) is 0.2 ,the simulation results show that, the greatest shear stress value was at the uppermost point of pipe and it was 69 Pa.

1. Introduction

Two-phase dispersion of oil-water in the pipe flow, like that of petroleum droplets, is commonly used in the oil industry [1]. Dispersions are often considered unfavorable during oil production because they increase the effectiveness of the system's fluid viscosity, resulting in increased pressure decreases. However, emulsions contribute to problems in oil-water separation. In certain situations, however, as with extremely viscous oils, pressures could be decreased by spreading the oil in water [2]. It contributes to a viscosity of the substance closer to the water than crude. Oil continuous dispersions can be chosen during processing as good corrosion steps by steel pipe oil.

Many experiments on a rheological characteristic of the various types of raw oils were undertaken [3]. In overall, specific gravity (API), density (Ś) and sulfur content (S) were the key variables for determining petroleum.

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Petroleum does have a complex organic system that explains the physicochemical output of crude oils. Carboxylic and phenolic acids, organic bases and metal complexes are considered equatorial additives. In expectation of the action of any natural product, the chemical structure must be known. Oxidation, hardness, adhesive consistency, adsorption pressure and solubility are all essential physiochemical characteristics that influence the functioning and management of crude oil. The physicochemical behavior of crude oils has indeed been shown to be among the many significant factors of arctic materials. Per fluorinated and polymer coating acids, chemical bases and metal clusters are considered polar substances. Naphthenic acid is popular for all organic acids [4].

Emulsion viscosity is substantially influenced by sheer physical level. The impact of the shear level on the conductivity is ascribed to the distributed stage intensity. The above conduct is due to swarming of particles or structural viscosity. Its portion of a volume of water in the distributed stage indeed has a major impact on emulsion viscosity. Emulsion viscosity increases by an expanding percentage of water volume. The water volume portion is primarily affected by amount of hydrogen connections and the hydrostatic pressures. The study of fluid effects of petroleum emulsions in rheology is deemed essential to figure out ways of producing and transporting oil [5].

In the 18 m long Plexiglass tube, with such a thickness of 10 cm. Wu *et al.,* [6] researched the effect of orientation, oil viscosity, and mixing speeds on the stream pattern and water holdup in the oil-water flow, as well as the workable volume of the normal ASTM seawater. There have been three separate flow behaviors – quasi-segregated, semi-mixed.

Crude oil is often contained in a depressive state with a very limited water content. Due with its dynamic nature, it is subordinate to multiple challenges in different procedures such as growth, extraction, distribution and processing. In addition, the large hydrogen and acid emissions in the supplies of powerful fuel products have such adverse effect on their transportation by pipes. That two-phase supply of oil & water in the petroleum industry is really normal that is shown on the wells to a final phase of segregation [7]. Aboriginal water is usually encountered in the pipeline and could be combined in the tank with gas to improve oil production. Water can be hard to distinguish from oil, particularly as the oil and water densities reach each other. Disbanded during the water bath, corrosive species like carbon dioxide (CO_2) and sulfur dioxide (H_2S) can cause severe trouble with interior deterioration inside carbohydrate pipelines. Both these issues lead to a lack in productivity of output due to the rise in capital and operational costs. The behavior and features of the oil-water double-phase flow in planning and running wells, storage facilities and distribution pipes are also very important to be understood. In recent decades, a variety of projects have concentrated on the detection and analysis of specific flow patterns of oil-water in two phases. The exam objectives would discuss some of the key findings of work in the area of two-phase oil-water flow [8].

The existence of such droplets that have different dimensions and fraction like the dispersed phase in water remarkably influences the streaming behavior [9,10]. Hence, analysing its properties (such as arrangements, drop dimensions, organization, drop merging and separation and phase reversal) and the subsequent hydro-dynamic features (such as phase hold-up and pressure variation) may be helpful in developing improved oil transportation techniques and procedures. Different parameters related to dispersing flow in pipes is being comprehensively tackled with experimental studies [11].

In the last thirty years, there was a growing attention in the utilization of 3D computational fluid dynamics (3D-CFD) codes for safeguarding nuclear reactors. Consequently, harnessing such codes to forecast horizontal double phase flow processes in atomics applications, including downing, countercurrent stream reduction and pressurized thermal shock (PTS), is increasingly researched. The accessibility to circumstantial 3D data on such a process is seen as a novel parameter in reactor safety domain [12]. Experimental and geometrical conclusion rules that are a precondition in one-dimensional codes, might be substituted with materially more central closure rules in 3D-CFD. Hence, CFD may not necessarily be geometry dependent, which means that they have greater flexibility than one-dimensional codes [13]. Euler–Lagrange procedure included in (CFD) tool in ANSYS Fluent presumes the representation of discrete phase by globular particles that have mean diameters in a continual fluid phase. Due to the dispersion of oil droplets in water, they are also presumed to preserve their globularity during the whole computation and shall not witness breaking or merger [14]. The pathways these droplets may be examined through resolving the flowing domain of the water as the continual fluid phase. The behavior of such droplets can be revealed through interrelated powers of the surrounding flow fields on oil droplets [15]. The objectives of this work are to predict pressure drop for mixture of two-phase flow and predict shear stress along pipe.

2. Methodology

2.1 Verification of Current Study

Current study relevant to Australian Gippsland crude oil and it is depending totally on study of Dadvar and Heidari [11] which it was already did simulation by using ANSYS FLUENT 15 and it has been verified with experimental result, experimental work had carried out by Liu *et al.,* [12]. Therefor in current study boundary conditions of will use as primary boundary conditions and proceed to use new boundary conditions. ANSYS FLUENT 15 has used to simulate the new boundary conditions. Figure 1 shows in details whole methodology of current study.

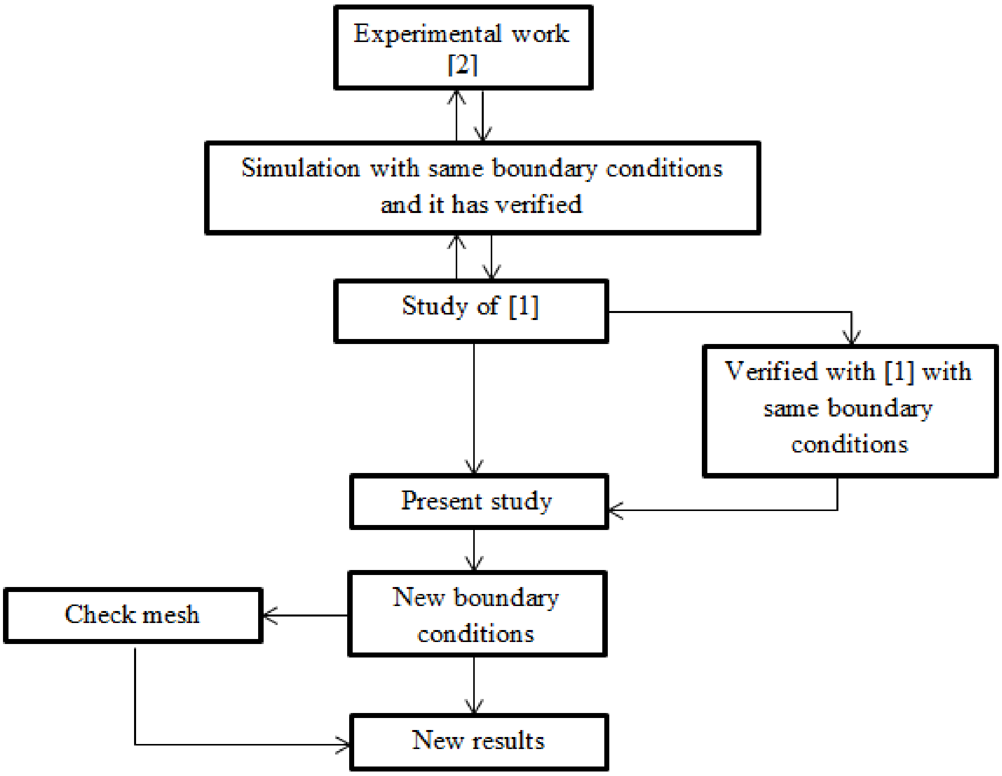

Fig. 1. Work procedure

2.2 Primary Boundary Conditions

The numerical analysis adopted by the current study is inspired by the experimental study of Sellman *et al.,* [13] conducted on oil-water double-phase dispersal flow in an upright tube with an inner diameter of ˚p= 38 mm. It was provided with a rough blender at its inlet for premixing the oil and water to reduce the flow forming length of completely dispersing flow. The study utilized tap water and Exxsol oil D140. The temperature was set at 25◦C and thermodynamic characteristics were: Density = 998 kg/m^3(water) and 828 kg/m^3(oil), viscosity = 0.993 × 10−3Pa.s (water) and 5.5 × 10−3Pa.s (oil), and oil–water interfacial tension = 20 mN/m.

2.3 Operating assumptions

Same assumptions have used in both current study which represented by Australian Gippsland crude oil – water double phase flow and study by Burlutskiy and Turangan [1] which represented by Exxsol oil D140 oil – water double phase flow and it has the following properties , pipe with a diameter ˚p= 38 mm and length L p= 3.2 m. The field has been discretized through utilizing nearly 20.000 computational cells. As requested by the Euler–Lagrange approach, cell sizes were greater than droplets dimensions. The simulating process was conducted for homogeneous oil droplets with diameters D d= {0.5, 1, 1.5, 2, 3, 4, 5, 6} mm. The oil–water combination mean speed is Um= {1.5, 2.0, 2.5} m/s and input oil fraction ˛o = {0, 0.2, 0.3, 0.4, 0.5}.

2.4 New Boundary Condition for Current Study

Australian crude oil and water have been used in present work. Liquid water is the main phase of this mixture with different fraction (cut of) ratio. Both of them form liquid-liquid two-phase flow. According to study of Bayat *et al.,* [16], Australian Gippsland crude oil hold the following properties Density (g/ml) 0.792, Viscosity (mPa.s) 1.969. Also, The oil–water interfacial tension is20 mN/m.

2.5 Mesh and Geometry

The pipe configuration and grid production were conducted through Autocad program, as the hexahedral mesh has been adopted since it capable of providing better quality solutions without requiring too many cells [17]. The meshed model utilized in this study is illustrated in Figure 2.

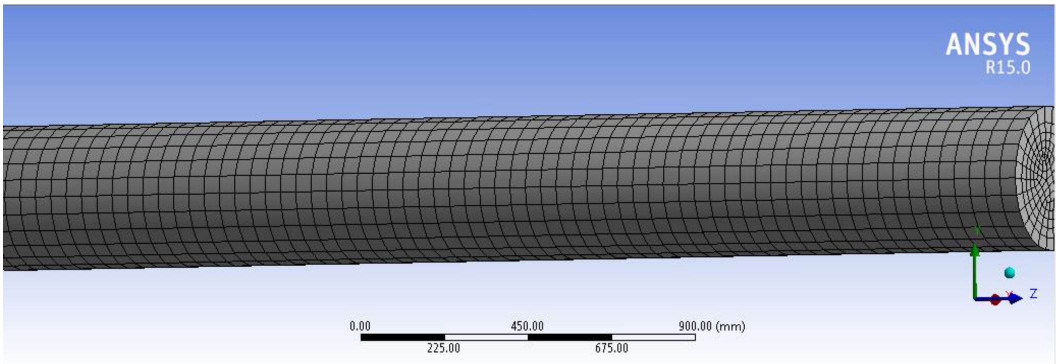

Fig. 2. Geometry and mesh

3. Results

3.1 Grid Independent Study for Current Study

A grid independent analysis has been done for the sake of getting an adequate mesh density needed to resolve a punctual flow [15]. There is a grid-independent solution if it is not altered when the mesh is refined [4]. Based on the outcomes, it is seen that the velocity is proportionate to the number of elements, and the oil–water mix average velocity is Um= 1 m/s was when number of elements was 251794. Moreover, there is no change in velocity when the number of elements increasing to 272893 and 281895. Figure 3 shows the stability of mesh.

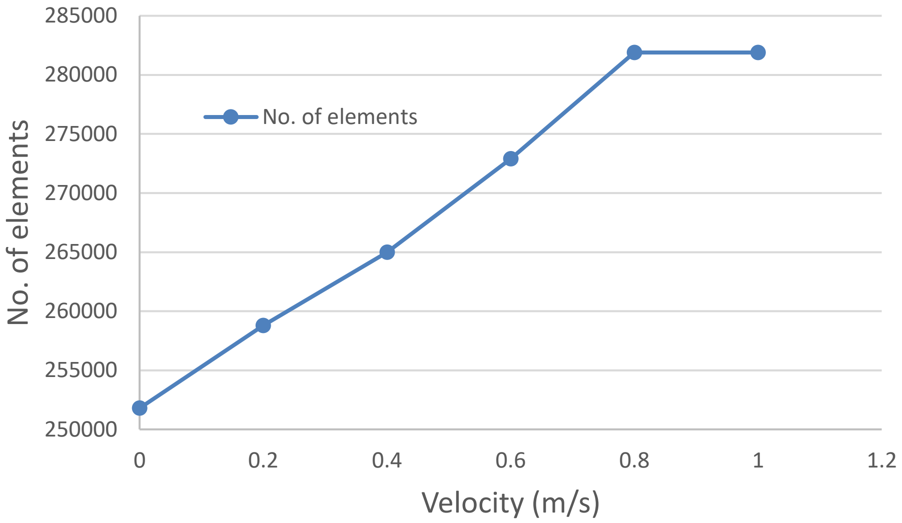

Fig. 3. Grid independent study

3.2 Lifting Strength on Pressure Drop Proportion for Mixture of Australian Crude Oil and Water

Current studies were considered in this study by presuming that the oil–water mix average velocities of 1.5, 2.0 and 2.5 m/s, where the impact of lifting force accompanied with the application of the shear-lifting force constituent in the total force equilibrium in the central equations was tested [1]. Modelling outcomes were contrasted by Burlutskiy and Turangan [1] regarding pressure drop for each unit length (on other words, pressure incline throughout the pipe).

Simulation predictions are shown in Figure 4 in which the coefficient CL was set to 0.5 and input oil fraction is 0.2. In the current flow setting, the contrast reveals that pressure drop proportions forecasted by the numerical simulation of the current study with coefficient CL = 0.5 is more than the pressure drop proportions predicted in study of Burlutskiy and Turangan [1]. The nearest match to the experimental outcomes was brought about when the diameter Dd is approximately 5 mm for coefficient CL = 0.5. When the diameter Dd of 5 mm was simulated and run for dissimilar input oil fractions ‚, the contrast of pressure drop proportion with [1,5].

Figure 5 and 6 display a mild under-forecasting for the proposed setting provided that the coefficient CL = 0.5. Depending on the case study under question, a more accurate forecasting of pressure drop proportion tends to be fulfilled if the average flow velocity was greater (greater Reynolds number). Such a finding might be correlated with the presumption linked to the utilization of Euler–Lagrange system (discrete phase model).

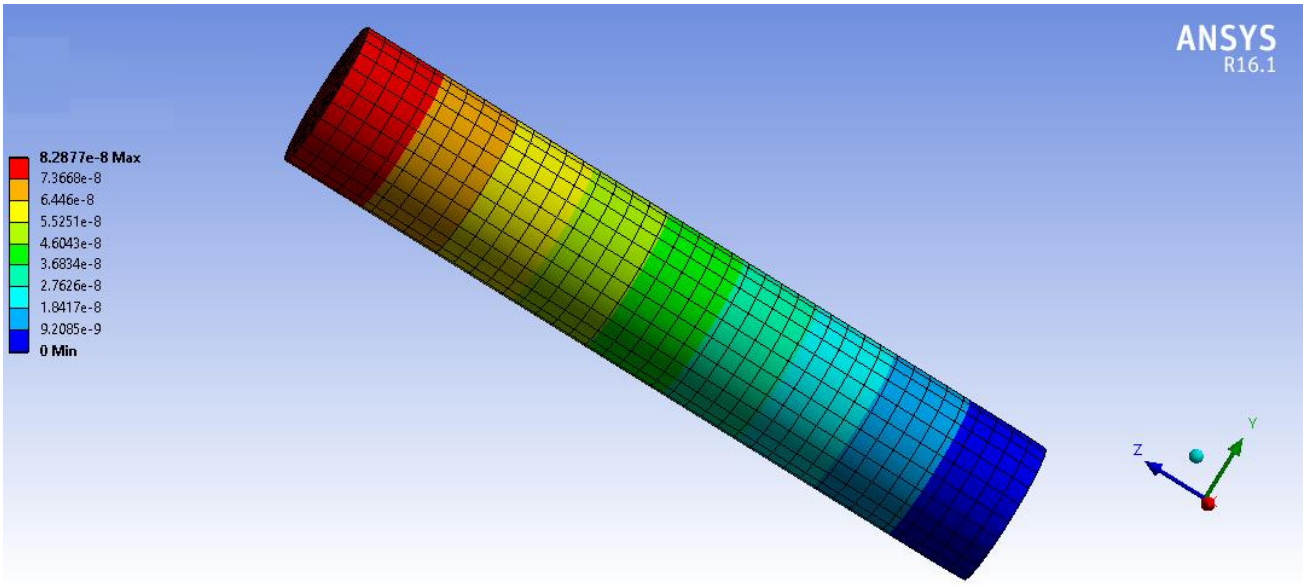

Fig. 4. Simulation of pressure drop for both water phase and mixture phase (oil and water)

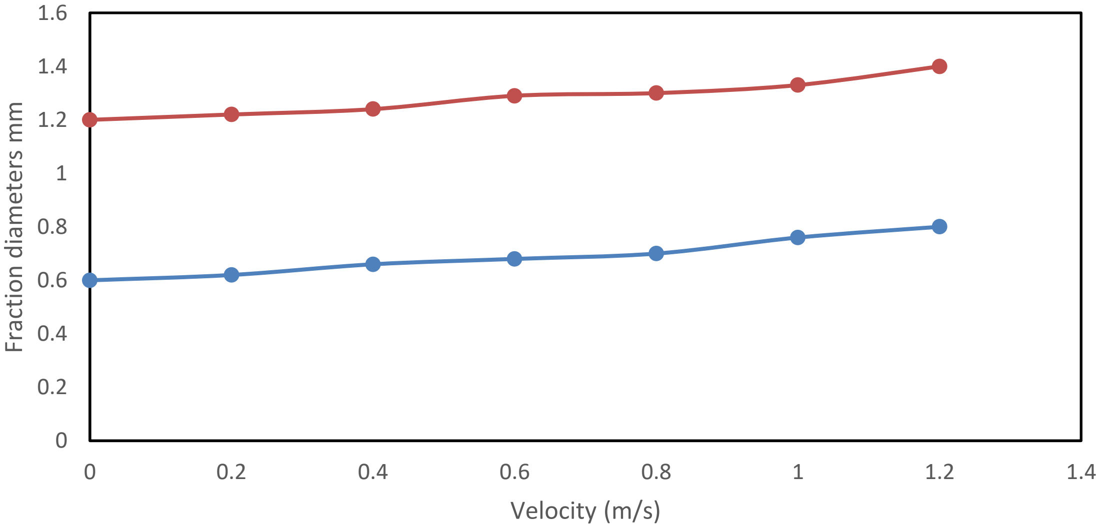

Fig. 5. Comparing the pressure drop for each unit length proportion (_*P*m/_*P*w) between present study and the predicted numerical simulations by Burlutskiy and Turangan [1] for mean flow velocity *U*m = 1.5 m/s where lift coefficient *CL* = 0.5 for various oil droplet diameters

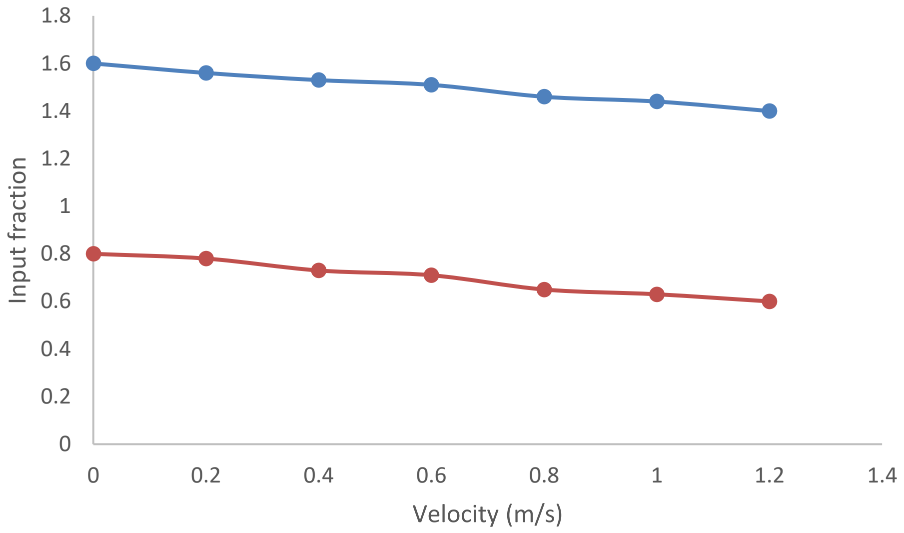

Fig. 6. Comparing the pressure drop for each unit length proportion (_*Pm*/_*Pw*) between present study and the predicted numerical simulations by Burlutskiy and Turangan [1] for average flow velocity *U*m = 1.5 m/s provided that lift coefficient *C*L = 0.5for different input oil fractions

3.3 Shear Stress for Mixture Phases

It is important to examine the impact of shear-stress upon the radial organization on the inner wall of the pipe. To this end, a data collecting line was placed at a distance length of pipe = 3.2 m from the pipe opening has been selected (see Figure 7) where the simulation results have been documented.

Scenario with shear-stress when the average flow velocity Um = 1.5,2,2.5 m/s, for input oil fraction is 0.2 and oil droplet diameter Dd = 4 because this fraction achieved good results [1]. The curve with shear-stress taken into account suggests a rather homogeneous intensity all over the pipe diameter with only a slight hint of greater oil droplet intensity close to the pipe wall. Gravitational has taken in account in present study [6].

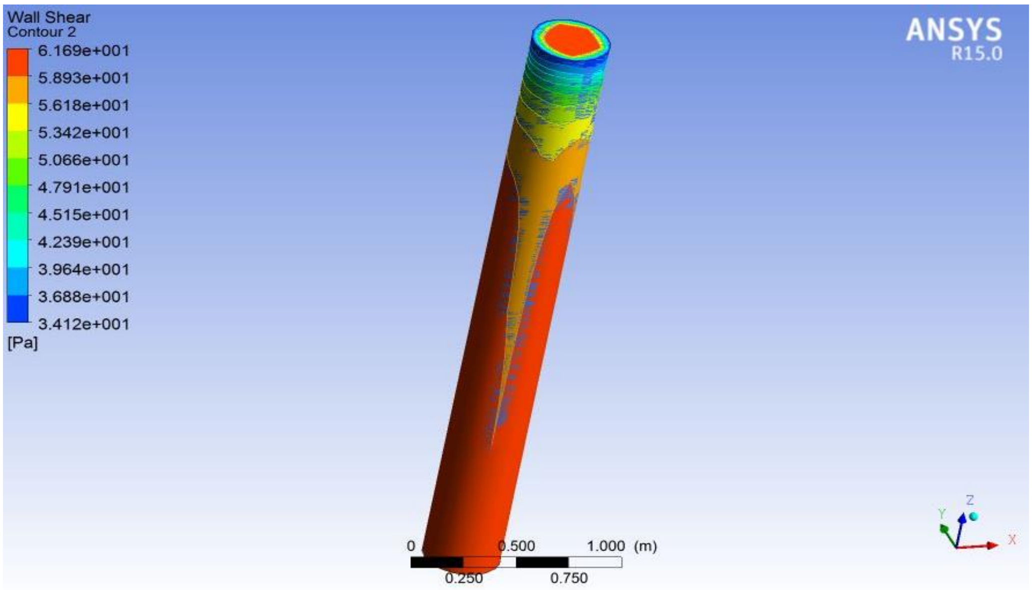

Fig. 7. Simulation shear stress for mixture two phases

A numerical simulation has predicted values of shear stress profiles in the crosswise flow path at the pipe axial advancement towards the exit. Shear stress values are mapped for the coefficient (CL) values equal to 0.5. It exerts a powerful effect on the rise of the shear stress on the top of pipe. Figure 8 show the relationship between velocities and shear stress at 0.2 oil fraction. The results show the maximum shear stress has obtained when the velocity was 2.5 m/s.

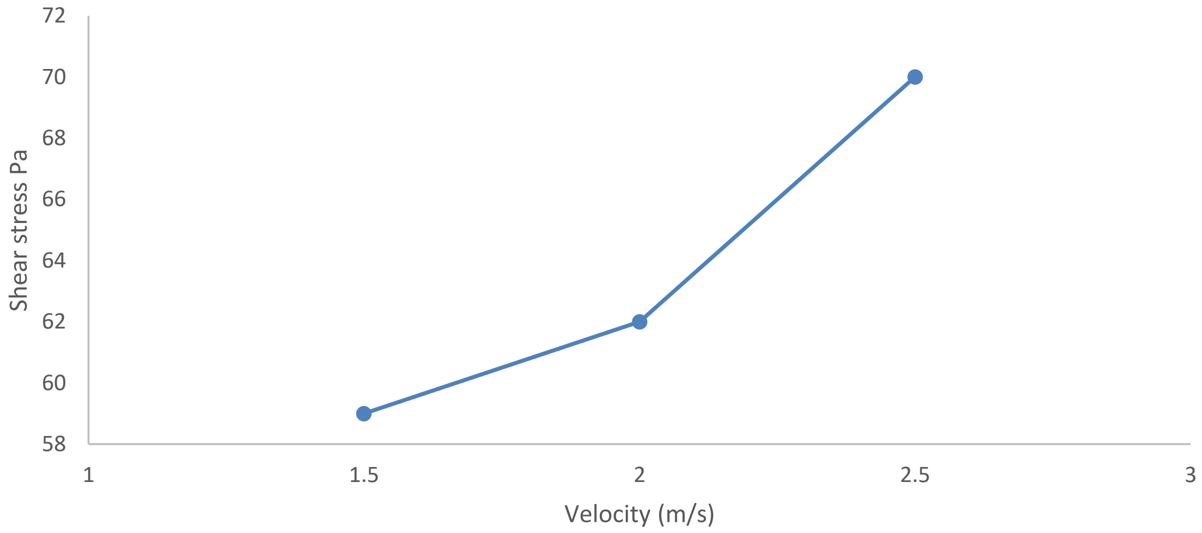

Fig. 8. Relationship between shear stress and velocity at 0.2 oil fraction

4. Conclusion

The prediction of the aerodynamic coefficients of the investigated projectiles A numerical model for Australian crude oil -water dispersing flow in a pipe has been established. The model proposes including the shear-stress as well as the drag, buoyancy and gravity in the force equilibrium equation. It has been included in the CFD code ANSYS Fluent Euler/Lagrange multi-phase solution simulations were conducted. The region of continuous phase is determined with the resolution of the robust RANS conservation equations aligned with the high Reynolds k–μ turbulence model number and standard wall function. The effect of the discrete phase (oil droplets) on the continuous fluid phase (water) is indicated using a two-way coupling method. The diameter of the oil droplet is supposed to depend on the Reynolds flow number which will be seen numerically for all case studies. When the blend speed was 1.5 m / s, the droplet diameter Dd was found to be 4 mm. Numerical simulations offer more feasible predictions for the pressure drop proportion when the elevated mixture velocity is higher than that when the mixture velocity is low and also it give good comparison between present study and numerical simulation [1]. shear stress was developed by current work for three different velocities (1.5,2,2.5 m/s) at oil fraction (cut off) is 0.2, the simulation result show that, the greatest shear stress value was at the uppermost point of pipe and it was 69 Pa.

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