Erosion rate prediction in single and multiphase flow using CFD

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Abstract: *Predicting the erosion in multiphase flow is a complicated procedure. Erosion is the material degradation from the material wall, due to the impact of some particle. In this a CFD approach is using to study about the effect of sand particle motion through carrier fluids such as methane, methane-oil, mixed gases. The investigation of erosion process in the single and multiphase flow is analyzing through CFD package ANSYS Fluent 6.0.The area where material degradation more prone can be investigate. Apart from this erosion rate is also calculated through API recommended standards and comparing the values from CFD and numerically. Along with the pressure drop, the forces impinging on the bend section is also calculating.*

Key Words: Erosion rate, pressure drop, CFD, Turbulent, DPM.

1. INTRODUCTION

Erosion is a complicated phenomenon mainly happening in the oil and gas transport lines and slow process that is affected due to the several factors in operational conditions and well conditions. It can significantly affect the damage the pipeline and also reduces the life of the pipeline. Measuring the erosion when it is progresses is very difficult and plant operators should have a good quality calculation of the internal condition of the pipework in their whole systems. This will make erosion management and controlling difficult Depending on the production conditions and geography of the well, solid particles, which are mainly sand and highly erosive, which is present in the flow. But in corrosive flow, liquid droplets which are a major factor especially in high velocity gas streams. The sand particles that trapped or entrained in the produced gas from the reservoir may contain very small particles that are hardly separable by physical means. In this paper a methodology is presenting to estimate the erosional rate in production and transportation facilities and their components due to the impingement and collision of sand particles of different sizes (microns).

1.1 PARAMETERS OF THE FLUID FLOW

The material degradation of material due to impact is highly depending on the particle impact velocity and sand diameter. It will generally agree that the erosion rate is directly proportional to the particle impact velocity .In the cases that erosion problem that the particle impact velocity will very close and near to the velocity of carrier fluid carrying particle. Therefore erosion is very bad in the cases where fluid flow velocity is the high. The small increase in carrier fluid velocity will cause subsequent increase in the penetration rate. In the fluid here we considering have mix of gases, single phase methane gas and methane-oil multiphase fluid. On the contrary, in low viscosity- low density fluids particles tend to travel in straight lines, impacting with the walls when the flow direction changes. Particulate erosion have more chance to occur in gas flows when compared to oil due to the change in the viscosity

1.2 FORCE EXERTED ON A PIPE BEND

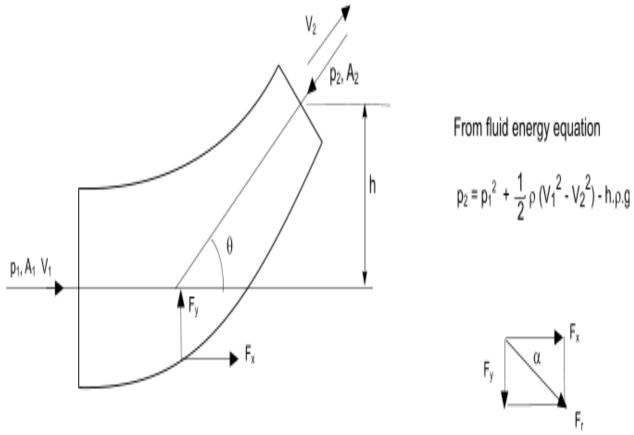

Figure 1: Force diagram of bend

The average velocity, pressure and the area of flow at the inlet section (1) and the outlet section (2) are V1, A1, P1 and V2, A2, P2 respectively. Let the forces Fx and Fy are the component forces acting on the fluid by the pipe bend in the x and y directions respectively. the other l forces acting over the fluid in the control volume area P1A1 acting over the section (1) and P2A2 over the section (2).Now the momentum equation is written as :

$$P_1A_1 - P_2A_2 cos\theta + F_x = \rho Q(V_2 cos\theta - v_1)$$

From this equation we can find Fx
Similarly Fy can be determined from the momentum equation in the y direction.

$$-P_2A_2 sin\theta + F_y = \rho Q(V_2 sin\theta - 0)$$

If we know about the Fx and Fy, the total resultant force F exerted by the pipe bend on the fluid can be measure radially. The force exerted by the fluid on the pipe-bend will be equal in magnitude but opposite in direction to F.

2. METHODOLOGY

The methodology that following in this thesis is basically through the software. A 90 degree bend is modelling in the ansys design modeler. The model is discretized through hex hedral meshing. The model is then uploading into the ANSYS fluent and analyzing through different conditions.

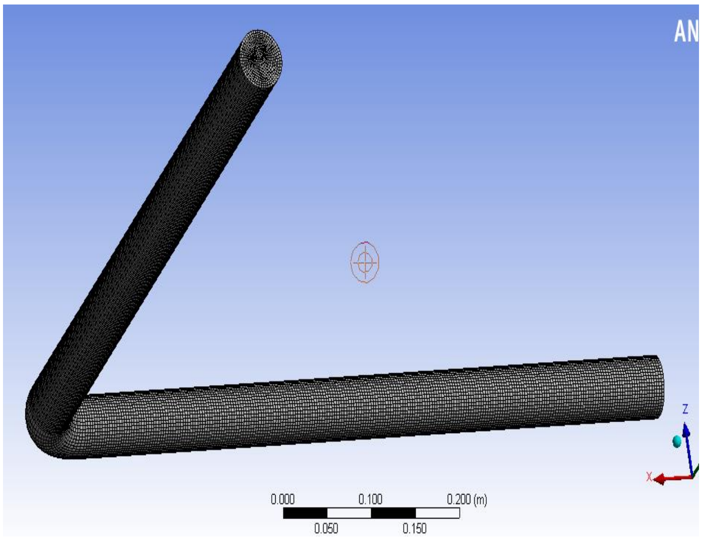

Figure 2: Mesh window

The dimensions that used for the mesh generation are

Physics preference: CFD
Initial size seed: Active assembly
Smoothening: Medium
Transition: Slow
Span angle center: Fine
Min size: 1.6273e-004
Max size: 3.2546e-002
Max face size: 1.6273e-002
Sizing: 2.e-002
Min edge length: 0.159590 meter

<u>Statistics</u>

Nodes	Elements
257664	245448

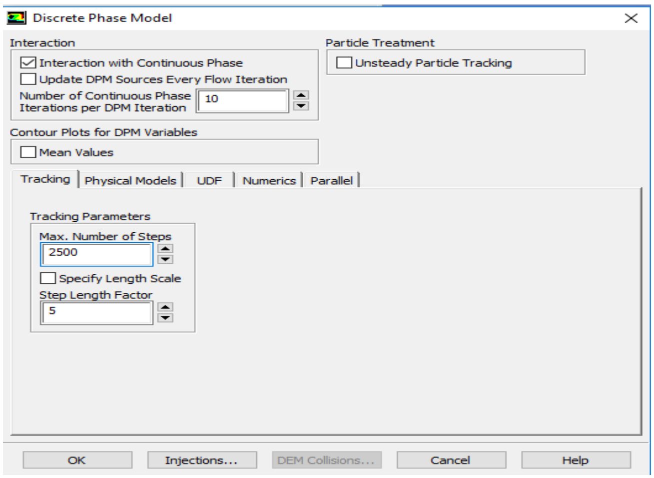

Figure 3 : Discrete Phase Model

In above window the flow is considering as turbulent, But in the case of multiphase flows we selecting the multiphase selection and picking the Eulerian Model and selecting the eulerian parameters as DDPM (Dense Discrete Phase Model).The no: of phases is assigning here. Generally implicit formulation is providing here. The fluid that considering in this model are oil, gas and a mix of gases, oil is more viscous than gas, so we selecting the viscous model and considering the flow is turbulent. K-epsilon Realizable is the model we selecting and providing a standard wall function. In the discrete phase model window we are the physical model should be Erosion, because the flow of fluid is in continuous phase.

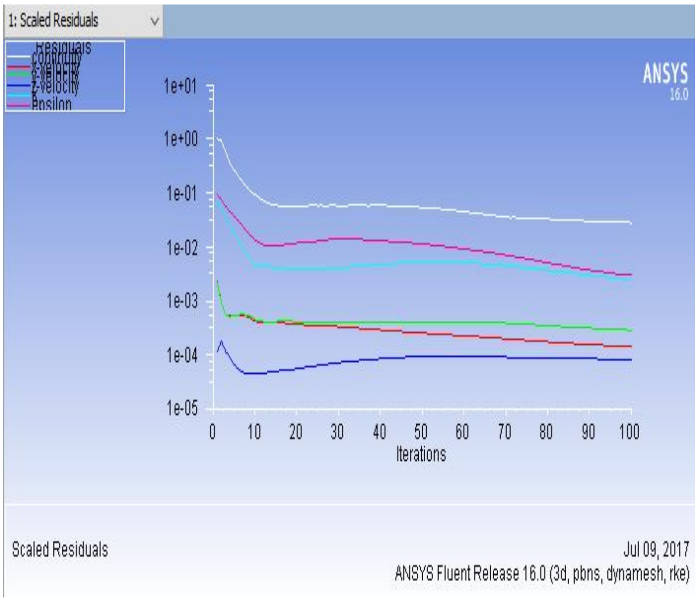

Figure 4: Iteration of Results

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RESULTS

METHANE

Sand dia	12	20	28
150	1.4526E-11	1.436E-11	1.436E-11
250	2.889E-11	2.793E-11	2.809E11
400	4.230E-11	4.1185E-11	4.0706E-11

METHANE – OIL

Sand diameter	12	20	28
150	1.0659E-11	1.053E-11	1.064E-11
250	1.937E-11	1.689E-11	1.676E-11
400	2.449E-11	2.609E-11	2.416E-11

MIXED GASES

Sand diameter	12	20	28
150	1.424E-11	1.456E-11	1.4845E-11
250	2.216E-11	2.688E-11	2.9053E-11
400	4.11E-11	4.269E-11	4.278E-11

Table 1: Erosion rates of Methane, oil, and mixed gases

3. CONCLUSIONS

In the investigation part, three different cases were carried out. Sand sizes of 150,250,400 microns sand particles carried at a velocity of 12, 20, 28 m/s .each case were studied in gas, gas-oil mix and mixed gases. In the mixed gas (methane, hydrogen, butane, carbon dioxide), the erosion rate is higher, in the single phase (methane) erosion rate is less compared to mix gases. DPM is used for the injection of the sand particles .constant velocity, mass flow rate and pressure used at a time for the prediction of erosion. The erosion rate is very less in multiphase (oil and gas) flow. In the dense phase erosion is less due to the small drag force. Hybrid initialization is used for the solution initialization After 500 iterations the solution converged into results,

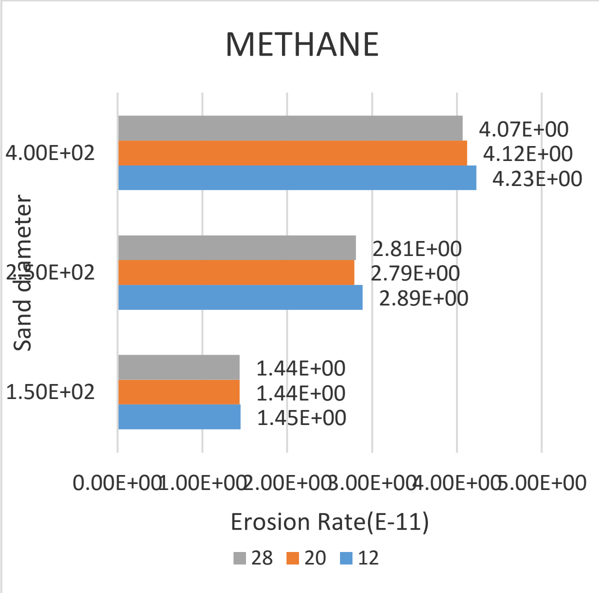

Figure 5 : Methane erosion rate variation

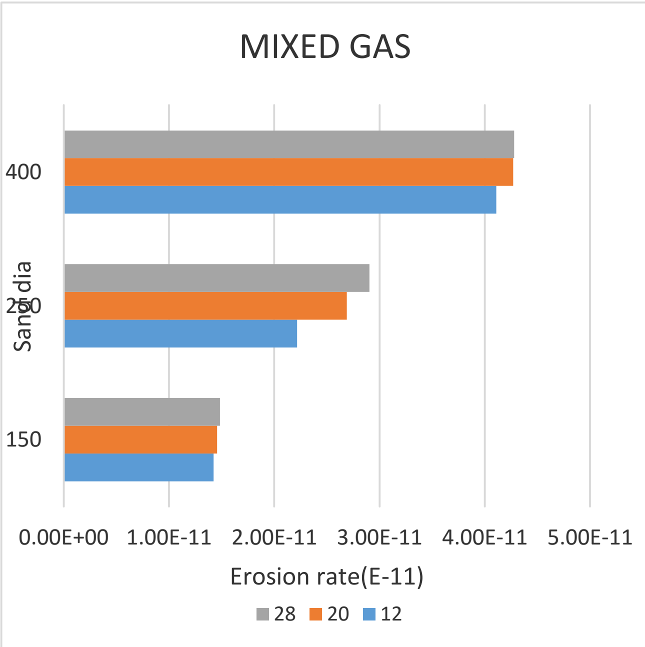

Figure 6 : Mixed gases erosion rate variation

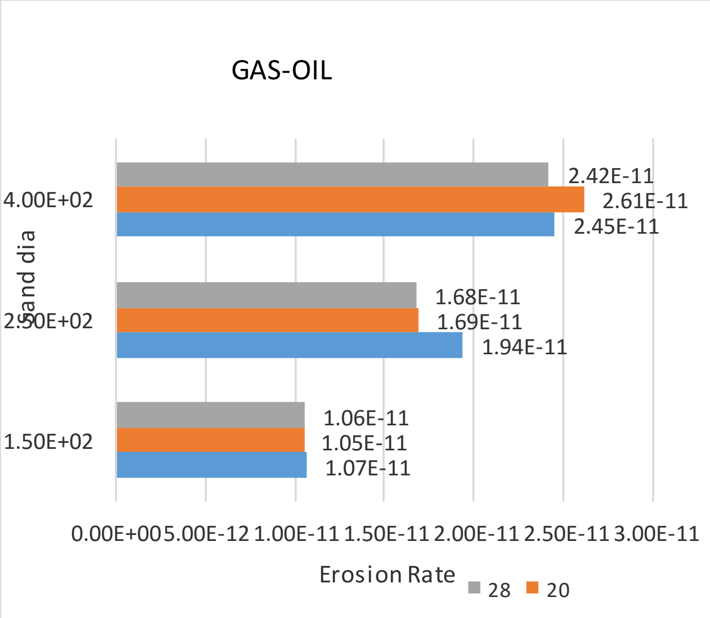

Figure 7 : Gas-oil erosion rate variation

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