CFD Analysis of Erosion dueto impact of 50 μm Sand Particlesona3-D180DegreeU-Bend Using DPM Erosion Model

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***Abstract*—**Air along with sand particles of density 1500kg/m^3 and 50 micron in diameter are used in this analysis with mass flow rate is 1kg/in. A180 degree bend is numerically simulated using FLUENT 6.2. The meshing software used is GAMBIT2.2. The Discrete Phase Model is used for analyzing the erosion due to particle impacton a three dimensional 180 degree U-Bend with pipe diameter of 0.50inches. Erosion in U-Bend is acommon phenomenon in pneumatic conveyor and other fluid handling equipment's. The turbulent flow structures are investigated. And them agnitude and location of erosion in a U- Bend determined.

Keywords— Erosion, 180^{o} bend flow, Discrete Phase Model, CFDsimulation,pneumaticconveyor.

I. INTRODUCTION

The existence of bends is undeniablyneeded in piping Systems. Development of flexibility of a system for transportation of fluids and solids from one place to another is forced by the bends. Not only a pipe offers flexibility, but also a pipe bend with a specific shape, i.e. a U-bend, also providescompactness and effectiveness for the purpose of transferring heat that is achieved when the properties of the pipe become balance in heat exchangers, like cooling ducts and pneumatic conveying dryer applications.

Evaporators and condensers which are also used in air conditioning system or refrigeration are finned-tube heat transporters inside which the parallel straight tubes area connecter using return bends or fittings also called as curved pipe fittings. The analysis of multiphase flow and its solutions to problems of the flow are in popular demands in the engineering field. The specific stimulus originates from the oil and gas production industries. Bends are especially a common element in any piping structure used for water-oilbased flow application like petroleum production. The oil-water flow patterns in bends are affected by complex parameters, such as centrifugal forces, and secondary flows. For proper usage and prevent any damage in the fluids a better U-bend design is frequently required for specific fluids.

II. PROBLEM DESCRIPTION

The analysis software FLUENT 6.2 was used for analyzing the flow structure. Finite volume approach is used. Fluent is used since itallows a vast variety of discretization schemes for each governing equation.
The Discrete Phase Modelerosionmodelto analyzetheerosiondueto particleimpactonathree dimensional180degreeU-Bendwithpipediameterof0.50inches. ErosioninU-Bendisacommonphenomenoninpneumaticconveyorand otherfluidhandling equipment's.
In the near wall region, the gradient of quantities is significantly high and] fine grids are need close to the wall to capture the flow effects. This finer grid structure cause the computer to take more time for calculation and more memory is used due to this and it is also expensive in terms of complexity of equations. However it is unavoidable.

III. GEOMETRY

Theconfigurationconsistsofa0.50inch(12.5mm)diameter pipewithU bend.Thelengthof thepipeat theendoftheU-Bendis2.5inches(62.5mm)long(5timespipe diameter)asshown in Figure1.

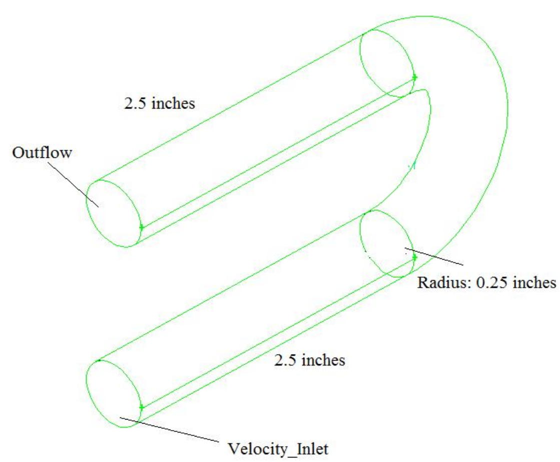

Figure 1. U-Bendgeometrywith0.5inchdiameterpipe

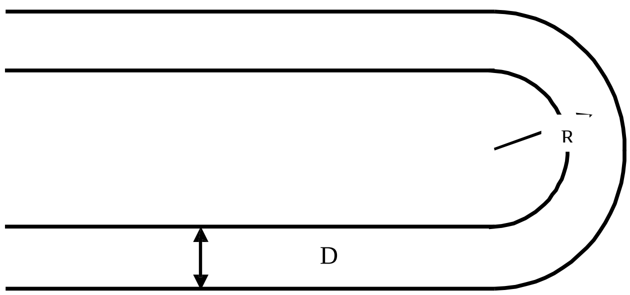

Figure2.2DSchematicviewof180°curved pipe.

IV. M E S H

The computational grid of 88959 cells were generated and used for analyses. The meshing software Gambit 2.2 was used to generate the fine grid.

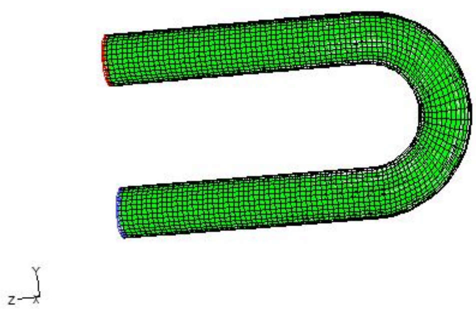

Figure3: Gridof U-Bend

Four cells along with an adjacent cell wall distance of 0.8millimeters. The growth factors of 1.10.The above factors are chosen to improve the performance of the wall function and to achieve the obligation of y+, the dimensionless wall distance. The dimensionless distance y+ is defined by:

$$y^{+} = \frac{\quad}{\quad}$$

Further volumes are added at both inlet and outlet of the bend to generate a 3-D mesh. A 3-D mesh is used for a 3-D geometry so as to consider the effect of secondary flow paths. 2-D geometry fails to completely account for the gravitational effects.

V.MATHEMATICAL MODEL

The k-epsilon (2 eqn) viscous model is chosen for flow analysis.The Discrete Phase Modelerosionmodelto analyzetheerosiondueto particleimpactonathree dimensional180degreeU-Bendwithpipediameterof0.50inches.InteractionwithContinuousPhase is enabled and the NumberofContinuousPhaseIterationsper DPMIterationis set to5. MaximumNumberofSteps is set to 10000for TrackingParameterswith a steplengthfactorto5. PhysicalModelsare set for Erosion/Accretion. Operatingpressure is set to 101325Pascal. Injectiondirectionsare intheinlet directionoftheelbow

Parameters	Value
Z- Velocity	-15.24m/s
Diameter	50e-06m
TotalFlowRate	1kg/sec

DiscreteRandomWalk model is used for the TurbulentDispersion for StochasticTracking and the number of tries is set to 10.

VI. B O U N D A R Y CONDITIONS

Air flowsinthepipewithentrainedsolidparticlesat15m/snormalvelocityandthe outletis assumedtobeanoutflowboundary.Turbulent,isothermal,andsteadystateconditions willbeconsideredtosolvetheflowfield.Solidparticleswith 1500kg/m^3density(i.e.sand)are releasedfromtheinlet of thepipewithaninitial velocityof15.24m/sassumingnoslipbetween theparticleandfluid.50micronparticlediameterisusedinthisanalysiswithmassflowrateis1kg/s. Thenormalandtangentialreflectioncoefficientforthewall boundaryisapolynomialfunction oftheparticleimpactangle.Thediameterfunctionisadefine datavalueof $1.8e^{-9}$.Thevelocity exponentfunctionisset toa constantvalueof2.6.The TurbulenceIntensity is set to 5%andHydraulicDiameter to 0.0127m.

Coefficient	Value
1	0.993
2	-0.0307
3	4.75e-04
4	-2.61e-06

Table 1: Values of the DiscretePhase Reaction

Coefficient	Value
1	0.998
2	-0.029
3	6.43e-04
4	-3.56e-06

Table 2: Polynomialvalues

Point	Angle	Value

1	0	0
2	20	0.8
3	30	1
4	45	0.5
5	90	0.4
6	135	0.5
7	150	1
8	160	0.8
9	180	0

Table 3: Values for the impactAngleFunction for Piecewise-linear

VII. SOLUTION

- The RelaxationFactors are set as 0.7forPressureand0.3forMomentum. Turbulence
- DissipationRate is set as 1e+5m^2/s^{3}for and thecalculation is started for 400-500iterations.
- Solution converges in 400-500iterations

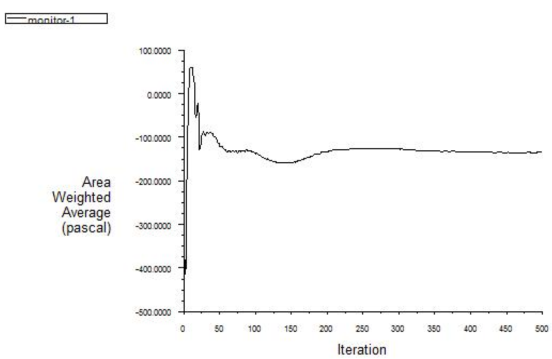

Figure 4. Graph showing convergence history of Static pressure on outflow

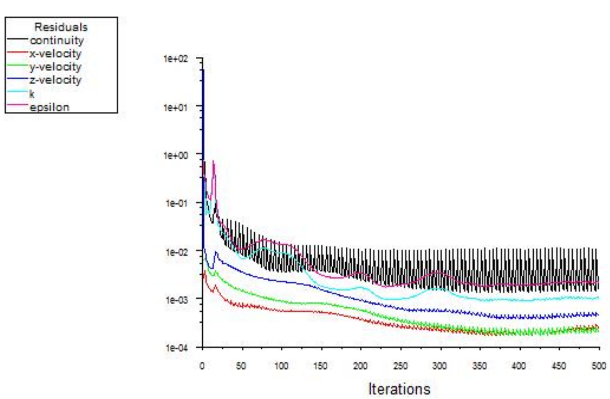

Figure 5. Plot of Scaled Residualsvs. No. of Iterations

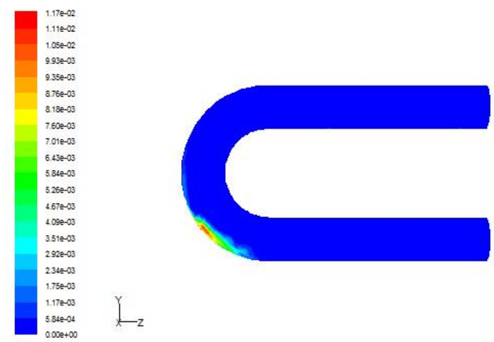

Figure 6. Contours of Discrete phase model erosion (kg/m^2-s)

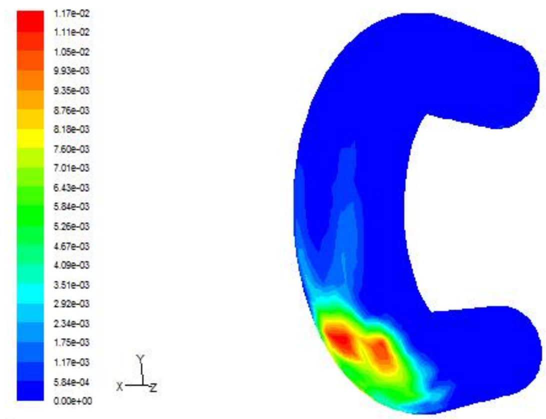

Figure 7. Isometric view of contours of Discrete phase model erosion (kg/m^2-s)

VIII. CONCLUSIONS

Thefollowingconclusiveremarksresultfromouranalysis. As farasthefluiddynamicanalysisisconcerned:

- Air along with sand of density 1500kg/m^{3}and 50micronparticlediameterisusedinthisanalysiswith massflowrateis1kg/in 180° bend is numericallysimulated
- Erosion dueto particleimpactonathree dimensional180degreeU-Bendwithpipediameterof0.50inches is investigated and the turbulentflow structureofsuchsystem usingDiscrete phase model andstandard k-εtwoequations viscous model is analyzed
- U-bend causes animportantphenomenonto occur:an accumulationof denseparticles(sandin thisstudy) along theouterwallsoftheU-bendandthe beginning ofthedownstreampipe.Thiswillbringtomindthe corrosion issue caused by dirtin productionpipelines.
- Gravitational settlingisthemaineffectatlow velocity values,whilethecentrifugalforceismore importantat

highvalues.

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