Design and Analysis of Air-Oil Separator Assembly

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Abstract: The air oil separator has attracted increasing attention due to its size, rapid construction and high separation efficiency. This study investigated its gas–liquid two-phase flow and separation characteristics numerically and mechanical design of AOS by using PV-Elite software. A numerical model of two phase flow in the separator was proposed using the Multiphase analysis in ANSYS Fluent. The distribution of pressure, and velocity in the gas-phase flow field was obtained, and the oil droplet movement was traced. Separation efficiency was also studied and the diameter distributions of oil droplets at the inlet and the outlet of the separator were considered by a review of various researchers. The oil film distribution and flow pattern on the wall of the separator were visualized. The variation of oil–gas two-phase flow in the air oil separator was compared under various inlet flow rates. Based on the results, we are able to understand the design and analysis of AOS, and the performance of the separator was investigated numerically

IndexTerms **- Air oil separator (AOS), Ansys Fluent, PV-Elite, DPM, Screw compressor.**

I. INTRODUCTION

The use of compressed air is an integral feature of every industrial firm compressors and vacuum pumps are used in the construction industry, mechanical engineering and highly sensitive sectors such as foodstuffs, pharmaceuticals and electrical engineering industries. Kirloskar Electric Screw air Compressor unit is a complete package type driven by both electric Motor and diesel engine. It is single stage, oil injected, rotary screw type with all components full piped, wired and mounted on a common base; it is very self-contained air compressor package. Rotary screw compressors are relatively simple machines. Two twin rotors rotate in opposite directions drawing in air. As they rotate, the space between them decreases and compresses the air. The pressure ratio is determined by the length and pitch of the screw, as well as the form of the discharge port. Because the rotary screw compressor does not have any other valves or mechanical parts, they can operate at high speeds and produce a large flow rate. Air oil separators are the important quality components in the compressed air processing chain. There are two parts in Air oil separator 1. Air oil separator element. 2. Air oil separator Tank.

Lubricated rotary screw air compressors mix oil with the intake air to lubricate the compressor's screws. After the air is compressed an air/oil separator separates compressed air from compressor oil. The compressor lubricant collects at the bottom of the separator tank and the compressed air continues to the air receiver. A standard rotary screw separator reduces the lubricant entrained in the compressed air to 2-3 ppm. Under normal operating conditions an oil separator's service life is 4,000 to 6,000 operating hours. Purification of air we breathe carries contaminants. Airborne particles, water, microbes, and chemical gases enter compressors. At a state these contaminants become concentrated and more destructive.

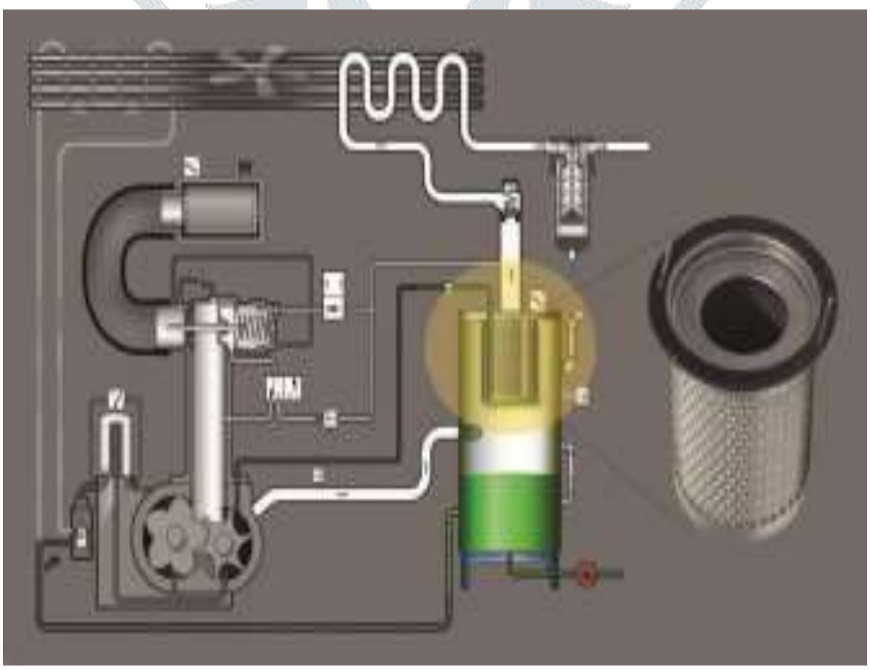
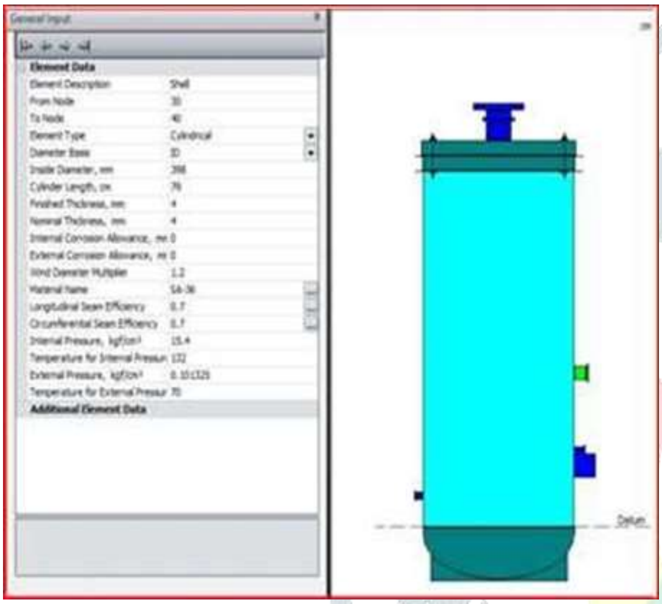


Figure 1. Schematic Diagram of Air oil Separator.

II. MECHANICAL DESIGN OF AOS USING PV-ELITE SOFTWARE

PV- Elite is a complete solution for vessel and heat exchanger design, analysis, and evaluation. Users of PV- Elite have designed equipment for the most extreme uses and have done so quickly, accurately, and profitably. PV Elite makes defining pressure boundary conditions for vessels and exchangers easy, even for load sets that require significant data input. PV Elite streamlines data entry by breaking the input down into sensible subsets. Help on any input item is only a keystroke away. PV Elite's graphical representation of analysis models helps ensure confidence in the input and results. With PV Elite, you can view and manipulate analysis models with complete ease. PV Elite performs calculations in accordance with ASME Section VIII Divisions 1 & 2, PD 5500, and EN 13445. Rules from API 579 (Fitness for Service) are also included for evaluating the current state and remaining life of existing vessels.

To simplify inspection requirements, PV Elite lists the most important equations, such as required thickness and maximum allowable working pressure (MAWP), and also groups results by type (e.g., internal pressure, external pressure, bending stress, nozzles, and flanges). It summarizes overall results where it identifies the element or detail controlling the overall vessel MAWP. PV Elite is a global package with international code rules plus extensive region-specific content. Vessel material definitions, piping and steel component data, local wind loads, and local seismic loads of many regional markets are all included.



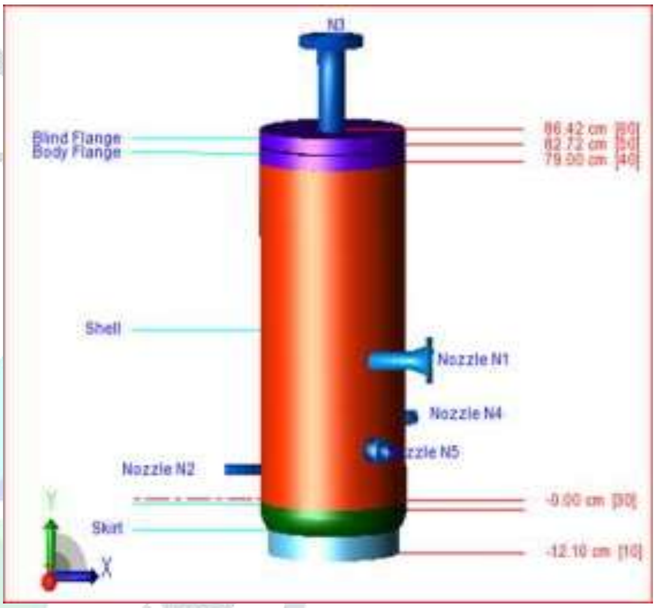


Figure 2. PV Elite Shell Design Input Screen. Figure 3. PV Elite Design Geometry

Allowable thickness depends on the nominal thickness, corrosion allowance, head diameter and shell diameter. The same equation would appear in the output screen whenever analysis menu was run. The similar step was conducted on different elements such as on shell, nozzle, dish end, skirt, flange and also nozzle. Saddle is only available on horizontal type of pressure vessel and for vertical one the term is leg. Weight of each element and the total weight of pressure vessel had also calculated. The output of analysis can be presented in many features. It can be in the form of table, or export to word processor in the form of final report. Since this research have not completed yet, the output would be presented as they are generated.

III. CFD ANALYSIS OF AOS

Analysis of flow of air oil mixture from inlet of air oil separator assembly to separation of air flow and oil flow. Discharge of pressurized air to application we required flow path and separation efficiency of newly developed air oil separator assembly. We also interested to process of inside of Air oil separator assembly. Effect of droplet size in the separator efficiency. We have to done CFD analysis by using ANSYS 18 software. Using ANSYS 18 we are able to learn and finding out the profile of air and oil flow with required input data.

There are following CFD Methods for Two-Phase Flow Modelling the two-phase flow (oil – air) requires primarily to recognize and define the continuous primary phase and the dispersed secondary phase. The secondary phase forms bubbles (air) or droplets (oil) which interact with the primary phase flow. The quantity describing the presence of a phase at any point in the flow domain is the volume fraction. It is defined as the ratio of the volume occupied by the phase under consideration in an arbitrary small control volume around the point.

Currently there are two approaches for the numerical calculation of multiphase flows: Euler-Lagrange approach and Euler-Euler approach.

In Euler – Lagrange Approach the method also referred as Lagrangian tracking method, treats the fluid as a continuum by solving the time-averaged Navier-Stokes equations while the dispersed phase is solved by tracking a large number of particles, droplets or bubbles through the calculated flow field. In order to capture the multiphase flow by using a Lagrange tracking method, the secondary (dispersed) phase should occupy a low volume fraction the size of the particles should be small compared to the characteristic length of the flow and the surface effects should be considered of low importance. The Discrete Phase Model (DPM) implemented in FLUENT is an Euler Lagrange approach model that tracks individual particles of the secondary phase in a continuous flow of the primary phase.

In the Euler – Euler approach to a multiphase flow problem, the carrier phase and the dispersed phase(s) are considered as interpenetrating continua for which flow equations are solved. It is assumed that the volume of one phase cannot be occupied by another phase this assumption is expressed by the volume fraction of the phase. Three models of this kind are implemented in FLUENT, the Volume of Fluid model, the Eulerian model and the Mixture model.

A structured mesh was chosen for the geometry of the problem, consisting mainly of hexahedral cells. Excess time and effort were needed compared to the "unstructured mesh approach" but the results are considered as more accurate and reliable. The geometry was split in domains. Most of them were similar in geometry to a "skewed cube", and the structured meshing with hexahedra was straightforward. The cylindrical domains included in the geometry were meshed with hexahedra using the o-type technique, and the domains similar to a "bent" spine, were meshed with spine-cells.

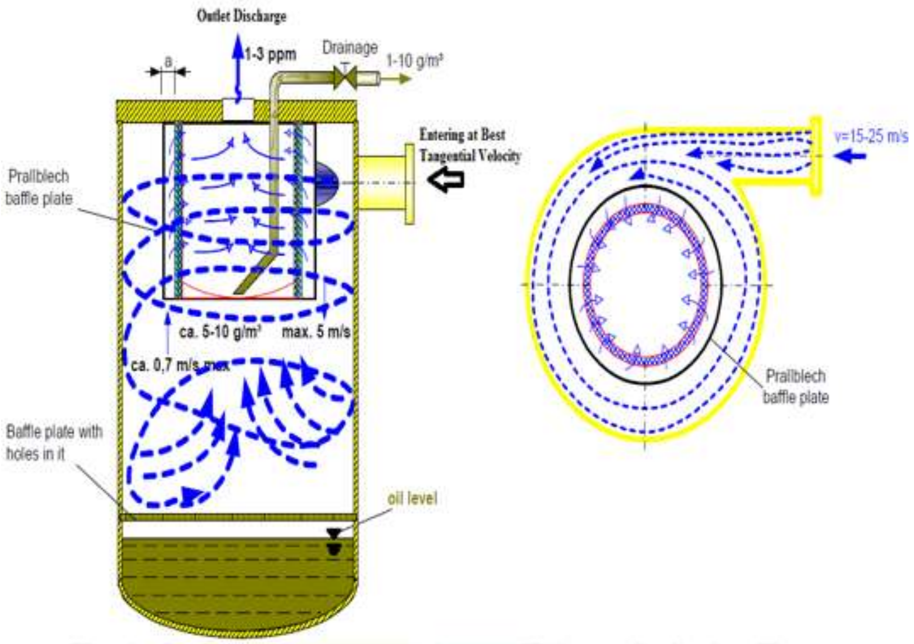


Figure 4. Schematic of Air oil Separator Assembly

IV. RESULTS AND DISCUSSION

The investigation was carried out in the oil–gas cyclone separator shown in Figure, entered tangentially through the inlet, and rotated through the inner and outer cylinders. Due to the centrifugal force, droplets moving to the wall were separated, and the remaining droplets followed the discharge gas to escape through the outlet.

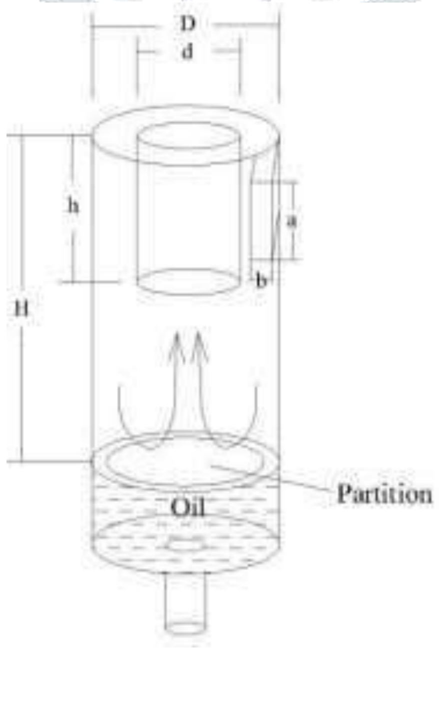


Figure 5. Structure of the oil–gas separator.

Boundary condition for the gas-phase flow field, the constant velocity inlet and pressure outlet boundary were used, and the wall was regarded as a no-slip boundary. For the oil droplets phase, a constant inlet velocity at the inlet boundary was also used, and the value was kept the same as that of the gas-phase field. The outlet was defined as ‘escape’, meaning that once the oil droplets came to the outlet, they were free; the wall was defined as a trap boundary, meaning that once the oil droplets came to the wall they were separated from the inlet mixture.

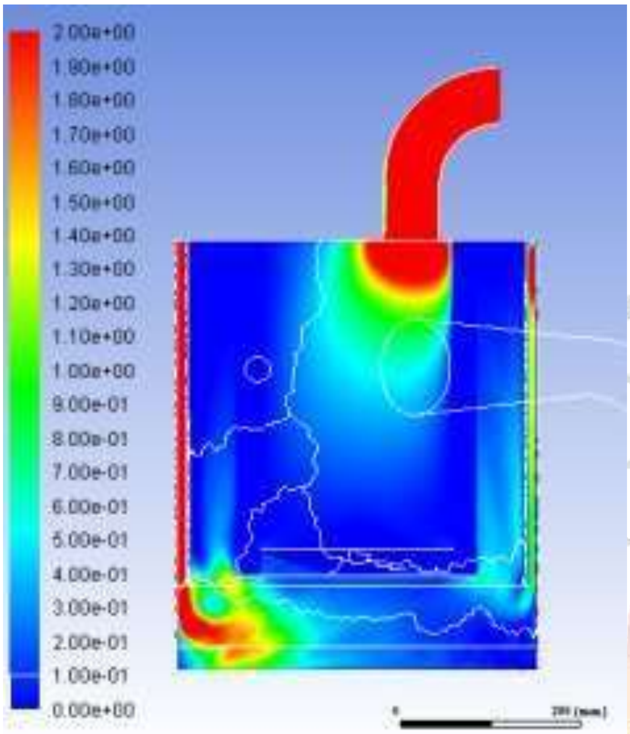


Figure 6. Velocity Counter at plane Z.

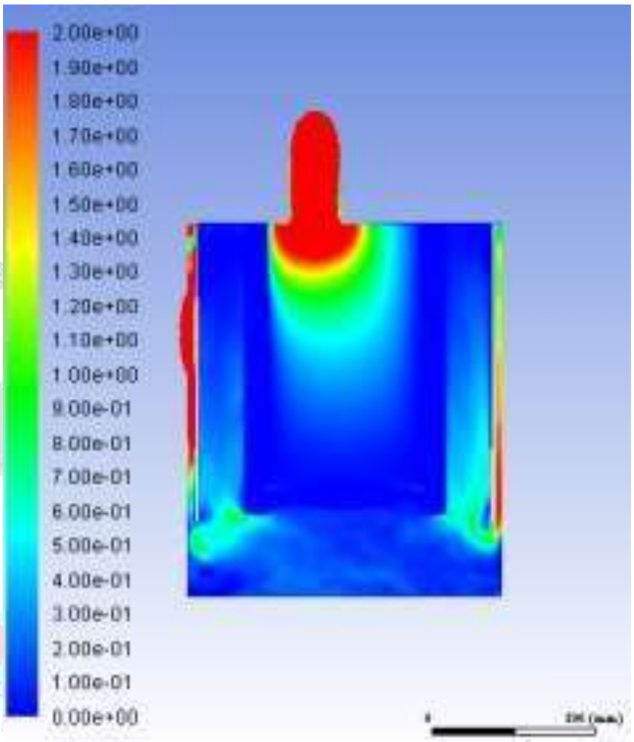


Figure 7. Velocity Counter at plane X.

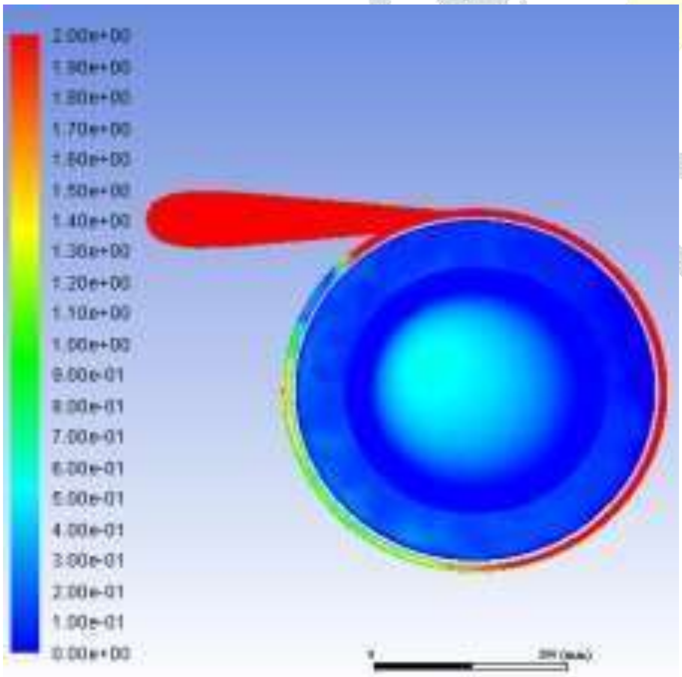


Figure 8. Velocity Counter at plane Y

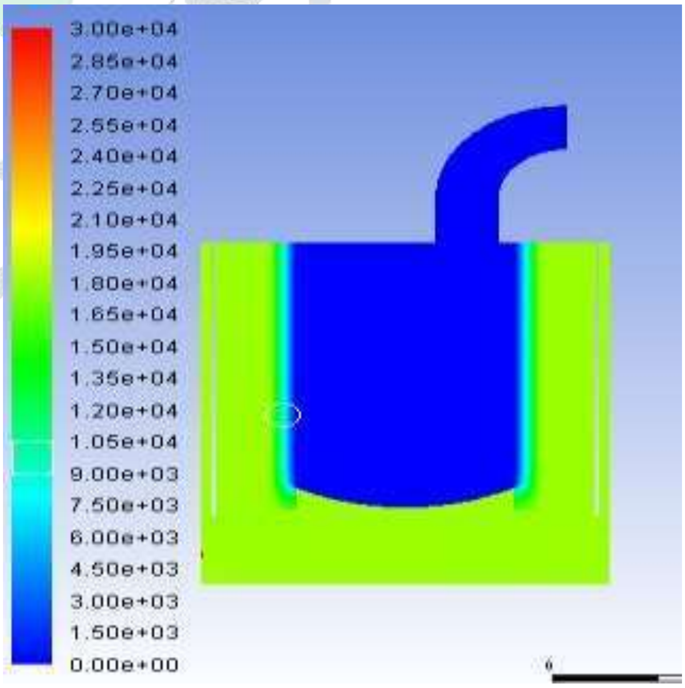


Figure 9. Pressure Counter at plane Z

The total velocity and the tangential velocity increased gradually from the inlet to inner skirt at start; after reaching the element and oil level side, they decreased and reached the lowest values at the central axis. Judging from the velocity field distribution in

Figure 6 to 8, we know that the potential energy of gas continuously converts to kinetic energy. Regarding velocity, the total velocity and the tangential velocity changed very little along the height direction of the separator.

The total pressure drop is not much and increased gradually from the inlet to inner skirt at start; after reaching the element and oil level side, they decreased and reached the lowest values. Judging from the pressure field distribution in Figure 9. We also observe the DPM concentration nothing but oil concentration in figure 10. We observe the parameters and finalized the process for numerical model. At the outlet velocity may increasing due to narrow hose fittings.

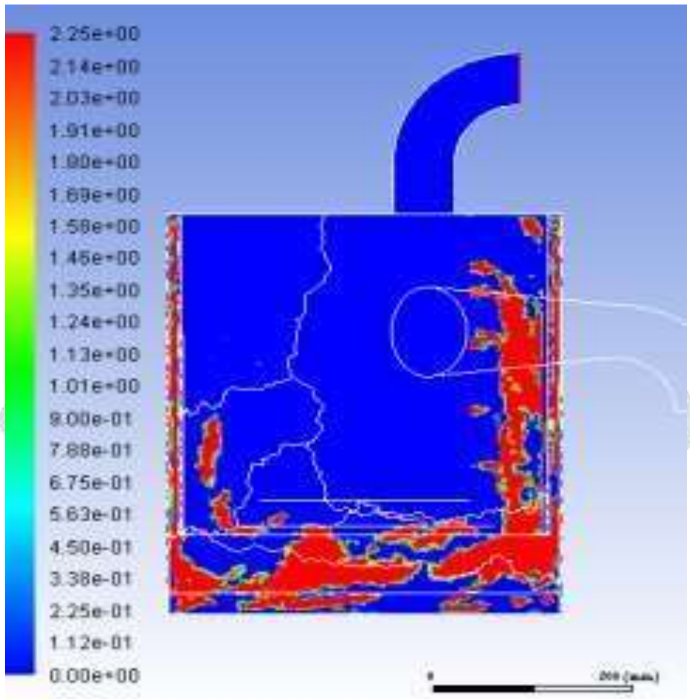


Figure 10. DPM Concentration Counter at plane Z

V. CONCLUSION

Mechanical design of air-oil separator tank (pressure vessel) has been done using graphical based software. Drawing process was very easy and input parameter can be entered in the same screen. Research can be explored to take into account other parameters. The behaviors of pressure vessels in case of fluctuating load could be a challenging matter for future research. In this section, important conclusions of present work should be described.

(1) The two-phase flow simulation model in the oil– gas separator was built using the Euler– Lagrange method. The distribution of the gas flow field and oil droplets trajectories were obtained.

(2) The distribution of the oil film on the outside wall of the separator was visualized. According to the oil film distribution and the flow pattern, the wall was divided into seven different regions.

(3) The results showed that static pressure loss increased with the increase of inlet velocity, while separation efficiency initially increased, and then decreased, with the increase of inlet velocity. There exists a maximum value of separation efficiency affected by inlet velocity; and avoiding the generation of small oil droplets is an effective way to improve separation efficiency.

(4) A structure was proposed, which took into account the geometry factors that affect the separation efficiency.

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