Optimization of Large Size Fabricated Y-Strainers for improvement in Pressure Drop Value using CFD Analysis: A Review

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Abstract

In the Oil & Gas Industry, an efficient filtration/separation system is critical to the reliability and performance of the physical assets that process petroleum products. Optimizing the reliability of these filtration systems is essential in maximizing your operational performance. Y-Type Strainers are used in many industrial applications to protect plant machinery to damage from contaminants such as dust, scales, sand, solid particles and other possibilities. It is used to remove solids from flowing gases or fluids using straining element.

In this project a Y type strainer is considered for analysis. Design is an important industrial activity which influences the quality of the product. The strainer is modelled by using modelling software SolidWorks. By using this software, the time spent in producing the complex 3- D models and the risk involved in the design and manufacturing process can be easily minimized. So, the modelling of the strainer is to be made by using SolidWorks. Later this SolidWorks model will be imported to ANSYS WORKBENCH 14.5 for analysis work. ANSYS WORKBENCH 14.5 is the latest software used for simulating the different forces, pressure acting on the component and also calculating and viewing the results. By using ANSYS WORKBENCH 14.5 software reduces the time compared with the method of mathematical calculations by a human.

Studies on flow behaviour in strainer has led to continued effort on optimizing the strainer design. 3D, steady, incompressible, turbulent k-∈ navier stokes equations are solved numerically to predict the flow behaviour and flow coefficient. CFD helps in the design optimization process with better accuracy and considerable reduction in design lead time.

The present work aims to study the effect of pressure drop and flow behaviour across different strainer design. Based on the baseline simulation results, optimized design is suggested. The calculated pressure drop for the optimized design shows 30% improvement compared to baseline design.

Keywords: Y-Strainers, Optimization, CFD Analysis

Introduction

Strainers are closed vessels that collect solid particles to be separated while passing a fluid through a removable screen. The screens can collect particles down to 0.001 inch in diameter. They can remove more than unwanted material. They can also remove wanted materials that can be used elsewhere or in other processes. You can find strainers upstream of sensitive equipment such as meters, pumps, compressors, traps, valves and filters. Strainers and filters are basically the same thing. The difference is that a filter removes much smaller particles, particles you normally can't see. If you cannot see the material being removed, it is usually called a filter.

By doing so, the particles would not continue to the system and will have expensive pipeline equipment such as pumps, engines, valves, heat exchangers, nozzles and others protected from harmful flow contamination. Since they would be dealing mostly with liquids, they are made from copper and aluminium which are known for their corrosion resistant property. Strainers are applied both in residential and industrial facilities. They come in various designs and sizes and can even be customized according to the requirement of the application. This device can be bought in hardware. Custom designed strainers can be requested to manufacturers.

The various types of strainers work in different ways. Some can totally block the flow of liquid or filter particle while allowing the fluid to continue running. The function can be controlled through a handle. By constant use, the strainer will clog with materials that reached it and held back. To keep the system running, the materials in the strainer need to be cleared periodically. To do this successfully, one must make sure first that there is no fluid running before removing the strainer. Clearing the clog in strainers vary depending on their type.

Strainers are produced so there would be no frequent interruption on industrial processes. The advantages of using strainers to prevent clogs in pipe are efficiency in the production process since there would be no disruption on fluid passage and preservation of expensive pipes equipment as they would not be clogged with dirt and debris

You can find strainers in almost every industry: chemical, food, water, petroleum, paint and ect. Strainers come in different configurations such as Y Strainers, Simplex Strainers, Duplex Strainers and Temporary Strainers. They can be bolted, threads or welded in line.

Major findings from literature review

One the latest and most comprehensive pieces of research on the CFD of porous media was performed by Partha Kundu, Vimal Kumar and Indra M. Mishra in the accepted manuscript studied incompressible single-phase fluid percolation through different types (homogeneous and mixed isotropic) of porous media is investigated experimentally. The functional relation of pressure gradient with velocity was presented based on dimensional analysis in terms of friction factor and Reynolds number based on different characteristic length (i.e. particle diameter and permeability of porous media).

Anurag Gupta Pushpdant Jain, Prabhsah Jain [2] have studied deeply the inner hierarchy workings of concurrent engineering in the new product development process. The purpose of this paper is to develop a dynamic planning method that is innovative, efficient and flexible for new product development by using the concurrent design concept.

Saeed Ovaysi, Mohammad Piri [3] have studied a dynamic particle-based model for direct pore-level modeling of incompressible viscous fluid flow in disordered porous media. The model is capable of simulating flow directly in three-dimensional high-resolution micro-CT images of rock samples. It is based on moving particle semi-implicit (MPS) method. They modify this technique to improve its stability for flow in porous media problems.

Alexander Grahn, Eckhard Krepper, Frank-Peter Weiß [4] have studied Pressure Drop Model for the CFD Simulation of Clogged Containment Sump Strainers. The present study aims at modeling the pressure drop of flows through growing cakes of compressible fibrous materials, which may form on the upstream side of containment sump strainers after a loss-of-coolant accident

A. Grahna, E. Krepper, S. Alt, W. Kastner [5] have implemented a strainer model for calculating the pressure drop across beds of compressible, fibrous materials. The presented study aims at modelling the pressure drop of flows across growing cakes of compressible, fibrous materials and at the implementation of the model into a general-purpose three-dimensional (3D) computational fluid dynamics (CFD) code. Computed pressure drops are compared with experimentally found values. The ability of the CFD implementation to simulate 3D flows with a non-uniformly distributed particle phase is exemplified using a step-like channel geometry with a horizontally embedded strainer plate

. J. S. Andrade, Jr., U. M. S. Costa, M. P. Almeida, H. A. Makse and H. E. Stanley [6] have studied Inertial Effects on Fluid Flow through Disordered Porous Media. They had investigated the origin of the deviations from the classical Darcy law by numerical simulation of the Navier-Stokes equations in two-dimensional disordered porous media. They apply the Forchheimer equation as a phenomenological model to correlate the variations of the friction factor for different porosities and flow conditions.

K. Ann-Sofi Jonsson and Bengt T. L. Jonsson [7] have studied Fluid Flow in Compressible Porous Media: I: Steady-State Conditions. In this article a model describing fluid flow and pressure-induced variations in porosity under stationary conditions is developed. In a forthcoming article the dynamic behavior during filtration and wet pressing of compressible porous media are presented. Fluid flow through rigid porous media is generally described by Darcy’s law. The corresponding expression for compressible materials is derived in this article.

Chwan P. Kyan, Darshanlal T. Wasan, and Robert C. Kintner [8] have studied Flow of Single-phase Fluids through Fibrous Beds. A pore model for the flow of a single-phase fluid through a bed of random fibers is proposed. An effective pore number, Ne, accounts for the influence of dead space on flow; deflection number, N6, characterizes the effect of fiber deflection on pressure drop. Experimental data were obtained with glass, nylon, and Dacron fibers of 8- to 28-micron diameter and with fluids of viscosity ranging from 1 to 22 cp. A generalized friction factor-Reynolds number equation is presented.

Stephen Whitaker [9] have studied Fluid Motion in Porous Media. In attacking the problem of incompressible flow in porous media, one is confronted with the fact that the result is pretty well established-i.e., Darcy’s law gives an accurate description of the flow. Because of this, it is easy to proceed along a variety of approaches, some of which might well be erroneous or wholly intuitive, to the correct final result. We will try to avoid this pitfall in the present study and establish as carefully as possible a logical, correct route to the final result.

B. F. Ruth [10] have highlighted the Nature of Fluid Flow Through Filter Sept and Its Importance in the Filtration Equation. The results of investigations upon fluid flow through a variety of septa are summarized. It is shown that Poiseuille’s law governs fluid flow through filter septa under the conditions of pressure and rate of flow ordinarily encountered during filtrations. The proof that flow is viscous throughout the entire filtration cycle constitutes an extremely important contribution to the theory and mathematics of filtration, and establishes a firm experimental and theoretical basis for the equations developed in a previous paper.

B. P. Ruth with G. H. Montillon and R. E. Montonna [11] have studied Fundamental Axiom of Constant - Pressure Filtration. Filtration data from many sources in the literature are correlated by the use of this simple equation. This leads to the fundamental axiom of constant-pressure filtration: The time-volume curve of a properly performed constant-pressure filtration forms a portion of a perfect parabola in which the missing portion represents the theoretical course of a similar filtration which would generate a resistance equal to that already existing when the experimentally measured filtrate volume is zero.

While studying research literature it is found that there is very little amount of research is done on particularly Y type strainers. Anurag Gupta Pushpdant Jain, Prabhsah Jain [1] explain the examination of the common factors of new product planning, design & development i.e. Y- type strainer. It also states about the process involved for concept selection manufacturing & establishes criteria for new product success, the market research tools available for integrating the user/customer needs into the innovative process. But they have not worked on the improvement of pressure drop valve of the strainer. If we consider the overall length of process pipe which provide process fluid to number of equipment and to protect these equipment Y strainers are installed before the same. If we consider the overall effect of pressure drop, then this is the governing factor and we must have to keep it well within the limit or needs to be minimised through development of strainer.

Objective & Scope

The proposed work shall include the modeling of different types of Y Type Strainers using commercial software. The geometrical model shall be prepared for the varied geometrical parameter like Y-angle, Element size and shape for 40mesh i.e for 500micron etc.

To analyse the flow field (characteristics) around the Strainer for the various Y angles.

To analyse the performance & Pressure drop of Strainer by considering the various shapes.

The proposed work included following steps:

1. Study of literature review of various work reported.
2. Geometric modelling of Strainers having different Element shapes such as Cylinder type, Boat type, Monkey type.
3. CFD analysis for each of the above geometry for Y angle in upstream and downstream flow.
4. Comparison of the result obtained in above step.
5. Choosing the optimum design based on Pressure Drop.

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