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Characteristics of Decompression Tank Internally Pressurized With Water Using OpenFOAM

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Abstract. Decompression tank is a tank in which pressurized with water. In its application decompression tank can be reservoir tank and water storage tanks which are closed. In the simulation the value of compressibility is very important for the case decompression tank. The method used is the numerical simulations using OpenFOAM software to know the results of observation the value of the pressure, density, and velocity magnitude. Simulations will be performed by varying the value of the water compressibility 4.54e-06 4.54e-07, and 4.54e-08. Before performing simulations on the main case decompression tank then first performed by grid independent test to validate the simulation results from the study by another researcher. From the results of experiments with variation of compressibility of water it can be seen that a good comparisons with numerical simulation and previous studies show the capability of this method. The greater the value compressibility water then the pressure distribution generated more widely and rapidly spreadas well as the velocity distribution. However for the distribution of the speed with greater compressibility of the velocity distribution will become more varied and occurs only in a small area.

INTRODUCTION

Currently in developing countries around the world a lot of technology growing and modern. One of them is a technology that is often used for research namely the technology of internal and external flow characteristics, fluid flow in a tank and such as the cases that encounter every day.

Storage tank becomes an important part of a process of chemical industry since the storage tank is not just a place in the storage of products and raw materials but also maintain the smooth availability of products and raw materials as well as to maintain the product or raw materials from contamination (such as contamination can degrade the quality of products or raw materials).

In general products or raw materials contained in the chemical industry in the form of liquid or a gas but it is possible also in the solid form (solid). Storage tank can have a variety of shapes and types. Each type has advantages and disadvantages as well as the usefulness of each. In general the storage tank can be divided into two when classified based on the pressure (internal pressure) : atmospheric tank and pressurized tanks.

The object of this study is a decompression tank that addresses a tank which contains pressurized fluid. Conditions rapid opening of the valve pipe with a tank containing pressurized fluid obtained through numerical simulation using OpenFOAM software.

The simulation results can be a pressure distribution contour in a liquid when the initial conditions to the condition of creeping pressure distribution. In addition to the simulation results are also expressed in the form of quantitative: magnitude speed and pressure throughout Y direction.

There are some previous studies on fluid flow simulations using OpenFOAM software [[1] , [2], [3] , [4] , [5] , and [6]. Research decompression tank by using OpenFOAM has also been done by [7] with a different discussion. Use of this OpenFOAM software can provide information regarding the phenomenon / flow characteristics in a tank which contains the pressurized water.

THEORY

Governing equations

Thus problem requires a model for compressibility φ in the fluid in order to be able to resolve waves propagating at a finite speed. A barotropic relationship is used to relate density ρ and pressure p are related to φ.

- Mass continuity

$$\frac{\partial \rho}{\partial t} + \nabla.(\rho U) = 0 \tag{1}$$

- The barotropic relationship

$$\frac{\partial \rho}{\partial P} = \frac{\rho}{K} = \varphi \tag{2}$$

- Equation (2) is linearized as

$$\rho \approx \rho_o + \varphi(P - P_o) = \varphi \tag{3}$$

where ρ_o and P_o are the reference density and pressure respectively such that $\rho(P_o) = \rho_o$

- Momentum equation for Newtonian Fluid

$$\frac{\partial \rho U}{\partial t} + \nabla.(\rho U U) - \nabla.\mu \nabla U = -\nabla P \tag{4}$$

NUMERICAL METHOD

For the case of decompression tank internally pressurized.

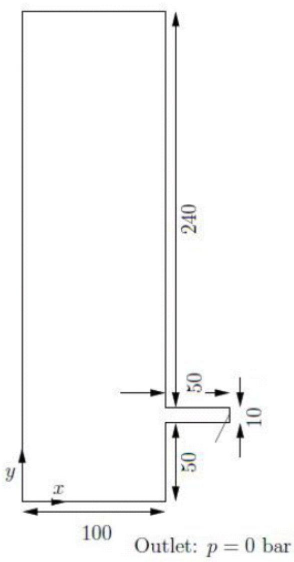


Figure 1. The geometry of Decompression Tank Internally Pressurized

Boundary conditions

- outerWall is specified the wall condition;
- axis is specified as the symmetryPlane;
- nozzle is specified as a pressureOutlet where p = 0 bar.
- front and back boundaries are specified as empty.

Initial conditions U = 0 m/s, p = 100 bar.

Transport properties: Dynamic viscosity of water μ = 1.0 mPas

Thermodynamic properties

- Density of water ρ = 1000 kg/m3
- Reference pressure p_o = 1 bar
- Compressibility of water $\psi = 4.54 \times 10{-}7\ s^2/m^2$

RESULTS AND DISCUSSIONS

Validasi

Grid independent test

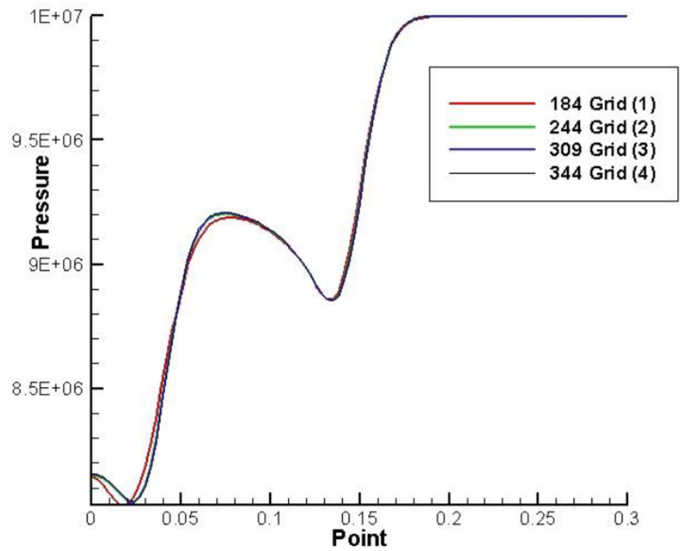
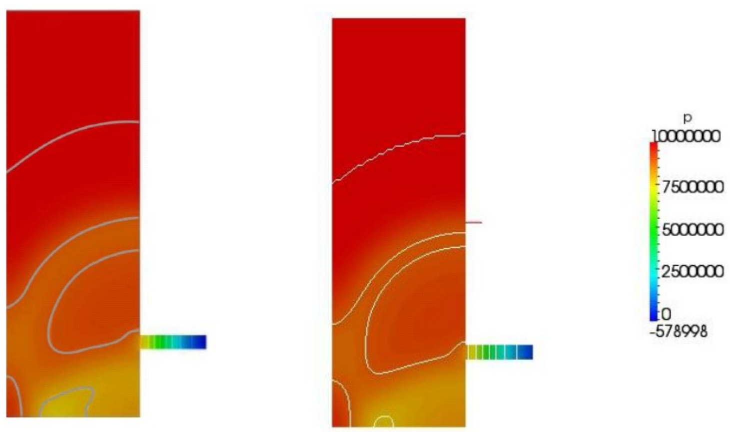


Figure 2. Grid independent test

From Figure 2 above shows that the more the mesh grid used trend that produced virtually no change which means that the grid is used optimally enough to simulate this case. Grid used in this study was 344.



(a) Chen huang [8] (b) Present study

Figure 3. Comparisons between the current study and previous research

Figure 3 is a comparison between previous investigators and researchers now. From the results of the simulation shows that the contour of the pressure distribution when compared with the results of previous studies by [8] shows the similarity of the contours of pressure. Thus, the simulation is correct and feasible to carry out simulations with different variations of compressibility.

Flow characteristics with compressibility 4.54e - 07 for a certain time variation in terms of pressure distribution

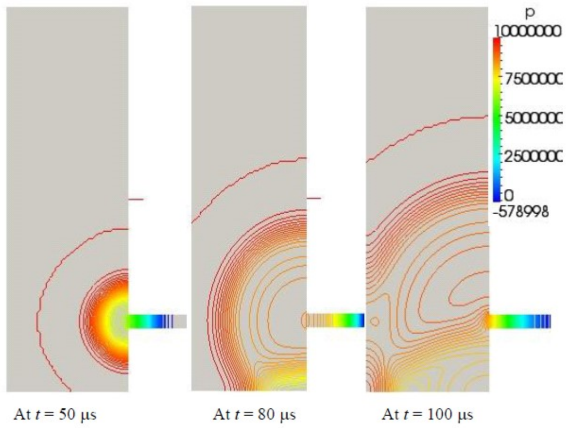


Figure 4. View of propagation of pressure on decompression tank with compressibility 4.54e - 07

In the initial condition the tank has a pressure of 100 bar. When valve is opened full water will come out. In areas close to the valve will decrease the pressure. This is because the fluid moves from high pressure to low pressure close to the valve. In Figure 4 shows that the variation of pressure occurs in most of the region.

Flow characteristics with compressibility 4.54e - 07 for a certain time variation in terms of velocity magnitude

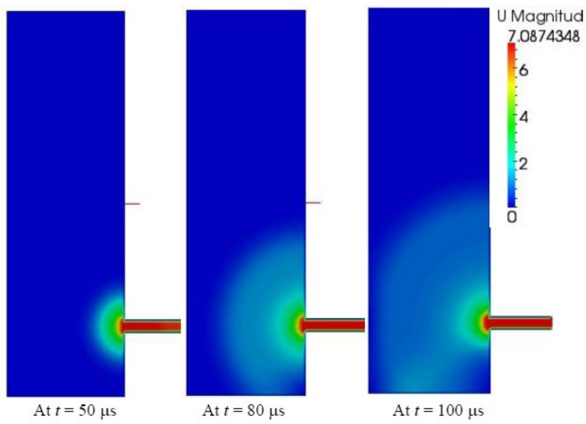


Figure 5. View of propagation of velocity on decompression tank with compressibility 4.54e – 07

The picture above is a picture of the propagation velocity magnitude during the time change. At ψ = 4.54e - 07 was obtained propagation of magnitude speed which shows the magnitude of the speed at decompression tank with compressibility equal to 4.54e - 07. In Figure 5 the maximum magnitude of velocity is = 7.0874348 m / s which occurred at the exit pipe. Speed variation detected only in a small area only.

The flow characteristics different compressibility and variations in time in term of the pressure distribution

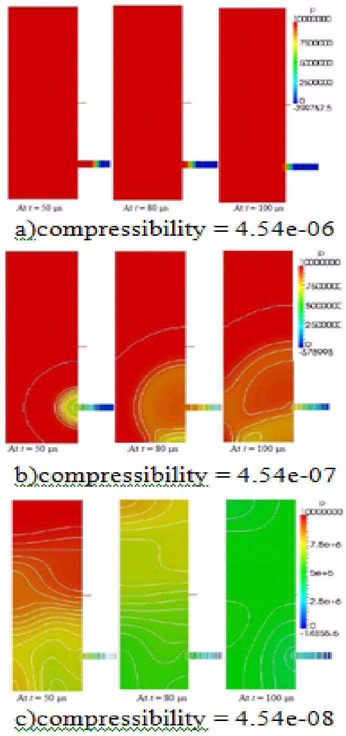


Figure 6. Plot of graphs display the data of pressure with time variation and the compressibility of the fluid

From Figure 6 it is shown that with the larger compressibility flow the pressure contours are likely to change and the longer it will be more random the contour of the pressure distribution . In addition to that pressure distribution detected covering most of the territory.

The flow characteristics different compressibility and variations in time in term of the velocity magnitude

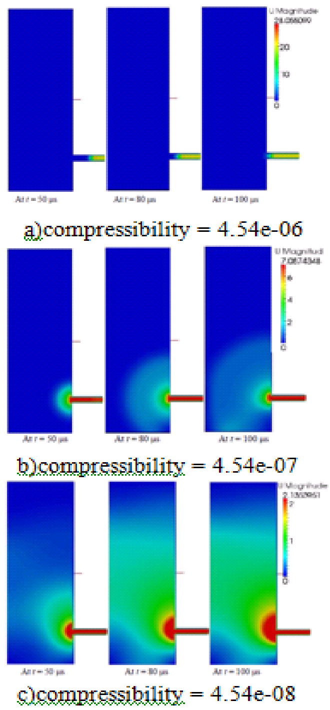


Figure 7. Plot of graphs display the data of velocity with time variation and the compressibility of the fluid

The color of contour lines are varied according to velocity magnitude. From the Figure 7 can be seen that with the larger compressibility flow the contour speed will also tend to change and the longer it will be more varied but its distribution tends to be consistent and stable.

CONCLUSIONS

So in this study can be concluded as follows :

1. Validation results obtained from numerical simulation and other research results have great similarities to contour and pressure distribution . This proves that the step from the simulation is already appropriately so worthy to be used for simulation study.
2. Pressure distribution will increasingly move propagates in accordance with the addition of time. If compared with the variation of fluid compressibility it will be seen that with the greater compressibility of the pressure distribution and contour tends to vary randomly. In addition to that the distribution controlled almost the entire region.
3. As for distribution velocity magnitude will also move to spread corresponding increase in time. If seen from a comparison of compressibility fluid it seems that with greater compressibility, the more varied the velocity distribution and the contour tend to be stable and consistent .

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