# Examination Of Different Cross Section Of Drain Pipes In Distilation Column

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***ABSTRACT***

*In this paper, we will be discussing various shapes of drain pipes for tray columns for distillation (rectification). Drain pipes are used for distribution of liquid from upper trays to next trays and it is important to respect some guidelines about geometry. Three different solutions have been presented and the conclusion about the results have been made. By adopting the optimal solution for drain pipes, engineers manage to obtain constant flow through tray columns as well as safe and reliable operation, as a result. Different standpoints have been mentioned, from various authors having worked in engineering for many years.*

**Keywords:** drain pipes, geometry, distillation, tray columns, liquid.

## 1.INTRODUCTION

Engineers in their work face many challenges that they need to overcome. One of the problems that engineers face daily in their calculation are the pressure drops and the impact that geometry has on it. In almost all industrial plants or factories, there are pipes which transport either air or water. Other than geometry, some of the factors that affect the pressure drop are the type of flow (laminar or turbulent), the state of the pipe whether it has irregularities or not, the type of fluid, local impacts like bends, valves, and many other factors. The type of flow in a pipe is determined by the relationship between the inertial forces and viscous forces that engineers call Reynolds number (Re). Depending on the geometry of the pipe, the critical number for determining the flow type has a different numerical value (for circular pipes the value is 2320 or 2300 depending on the author, for square shapes, it is around 1600 [1]). There are numerous guidelines and recommendations given by different engineers that work in the field. In this paper, we will see the effect that geometry has on the velocity of the fluid, and consequently, the impact it will have on the pressure drop. In our calculation, we used the “Navier – Stokes” equation, and the law of the conservation of mass. Mathematically, the equation is written in this form[3]:

$$\rho \cdot \frac{D\vec{V}}{Dt} = -\nabla p + \rho \cdot \vec{g} + \mu \cdot \nabla^2 \vec{V} \qquad \text{(Eq.1)}$$

Where:
$\rho$ is density
$\vec{V}$ is the velocity vector
$t$ is time
$p$ is pressure
$\vec{g}$ is the gravitational acceleration
$\mu$ is viscosity.

What is important about the theory of turbulent flow is that the results are mostly generated with the use of experimental data, given that the equations aren’t yet solvable. Coefficients that are given in the equations like Bernoullies serve as an example in favour of this statement. Nowadays, the production of ethyl alcohol is one of the most important parts of the process industry. The main part of distillation process are tray columns. The number of needed trays is calculated for every distillation process separately. There are some elements such as drain pipes, bells, holes, nozzles etc. These elements are used for the distillation process. The mixture of alcohol and water flows through trays where the liquid part is flowing downward, due to gravity, while the steam part is flowing on the tray above it. For the liquid to fall down on the tray below it and not cause a clog, the design of the drain pipe must be done carefully and correctly. The thickness of the drain pipe is usually not that big since the operating pressure isn’t that high. A guideline recommended by most engineers is that the inlet area is a similar size as the outlet area. The drain pipe must be made in such a way for it not to cause an overflow, and that the liquid part must flow constantly [2]. Drain pipes used in a distillation plant have different shapes and cross section geometry. Another way of illustrating the work of the technical system is the formation of the prototype and its analysis in the laboratory. This method is one of the closest ways to check the functionality of the real technical system, but economically, very challenging, since it is expensive. With the development of computer and software techniques, the method of analysis of the 3D model has appeared. This method is affordable, quite close to the real system, and allows a large number of changes on the spot, without a lot of unnecessary elements [4].

## 2. GEOMETRY AND VISUAL CHARACTERISTICS

In our model, K-omega model was used and the fluid used was ethyl alcohol-water. The pipe was made of solid steel. Inlet speed used was 2 m/s, the number of iterations used was around 200. For different parameters, the results may differ but they should look similar to the ones that are shown in the pictures below. Something that needs to be mentioned is that the results also change depending on the tray position in the distillation tower. The models in this study was designed in SolidWorks 2020 software tool (pictures 1, 2,3) and passed through a simulation tool flow ANSYS 2021. [5].

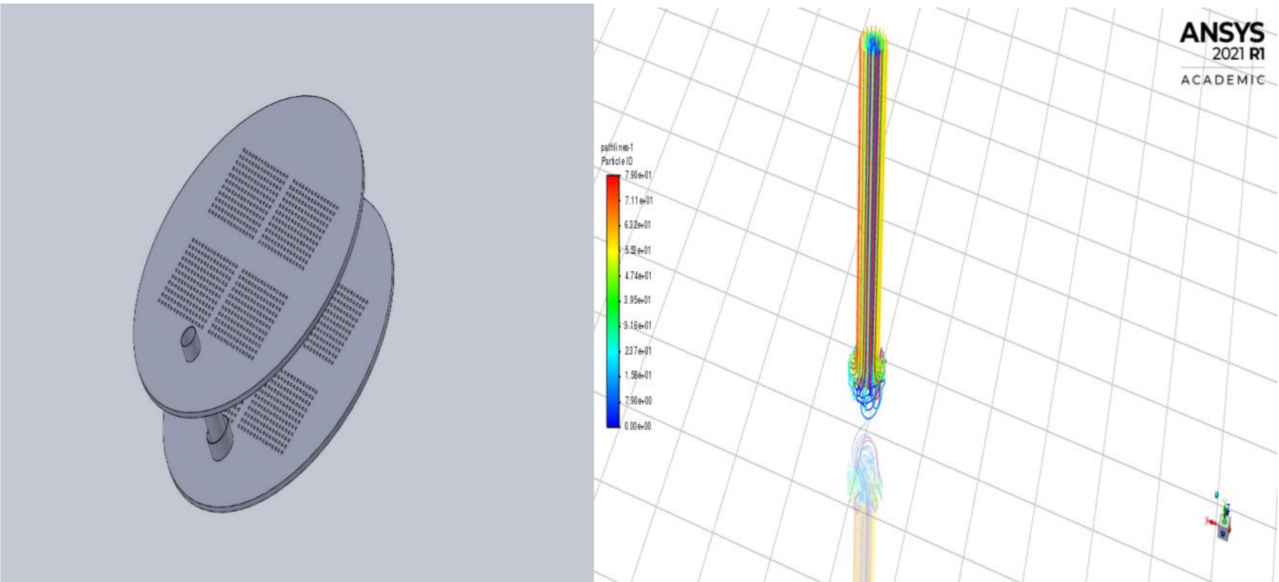


**Figure 1:** Fluid velocity in a circular shape pipe

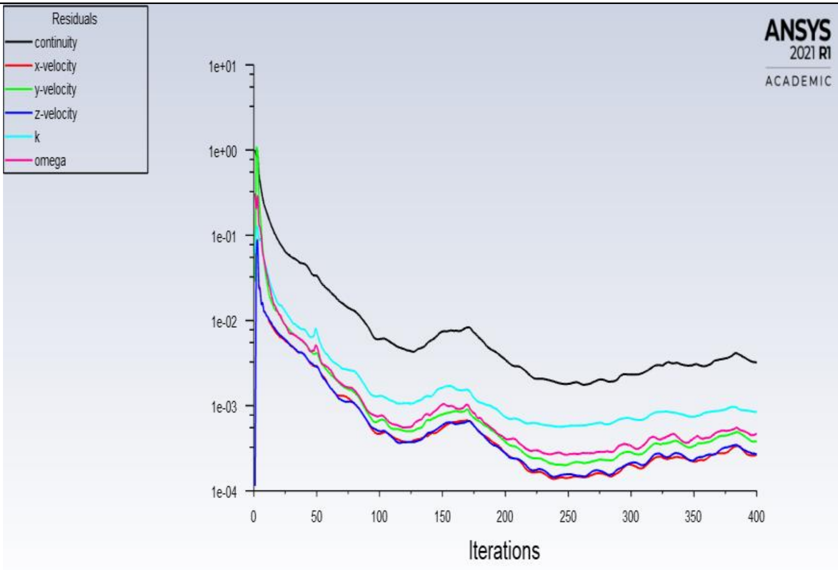


**Figure 2:** Graphic view Fluid velocity in a circular shape pipe

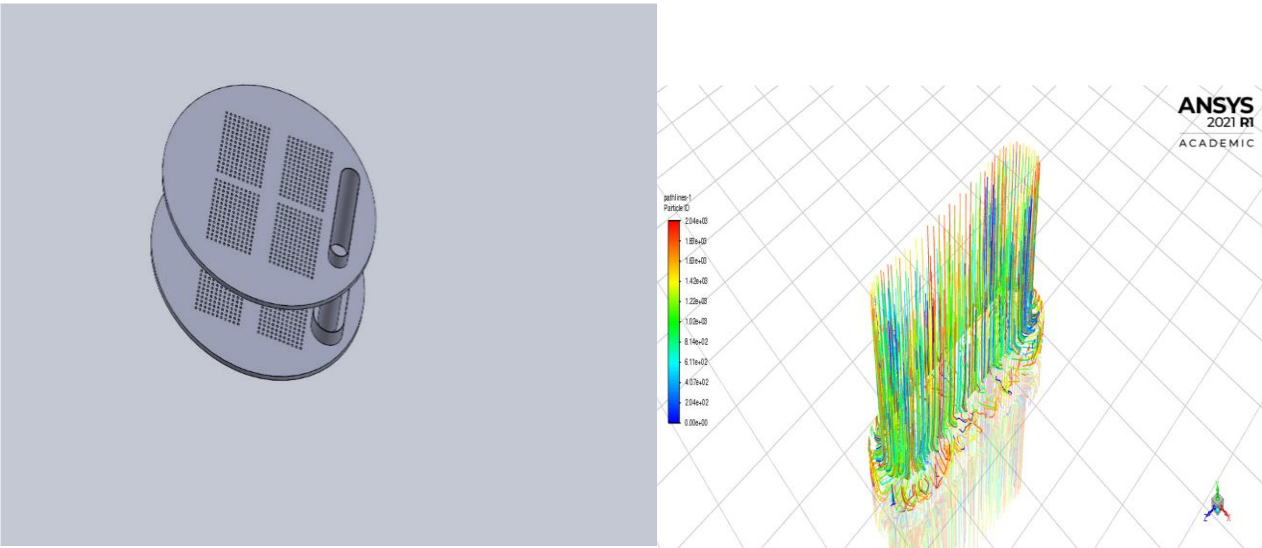


**Figure 3:** Fluid velocity in a square pipe with rounded corners

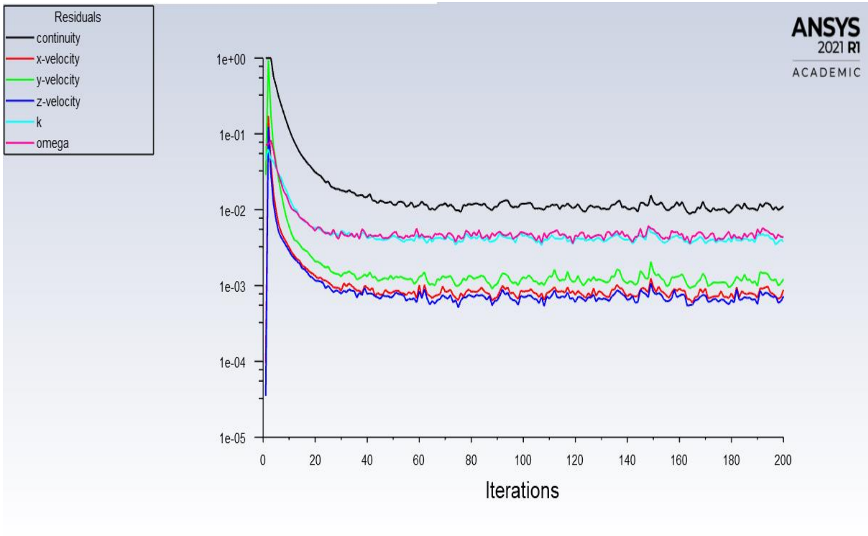


**Figure 4:** Graphic view fluid velocity in a square pipe with rounded corners

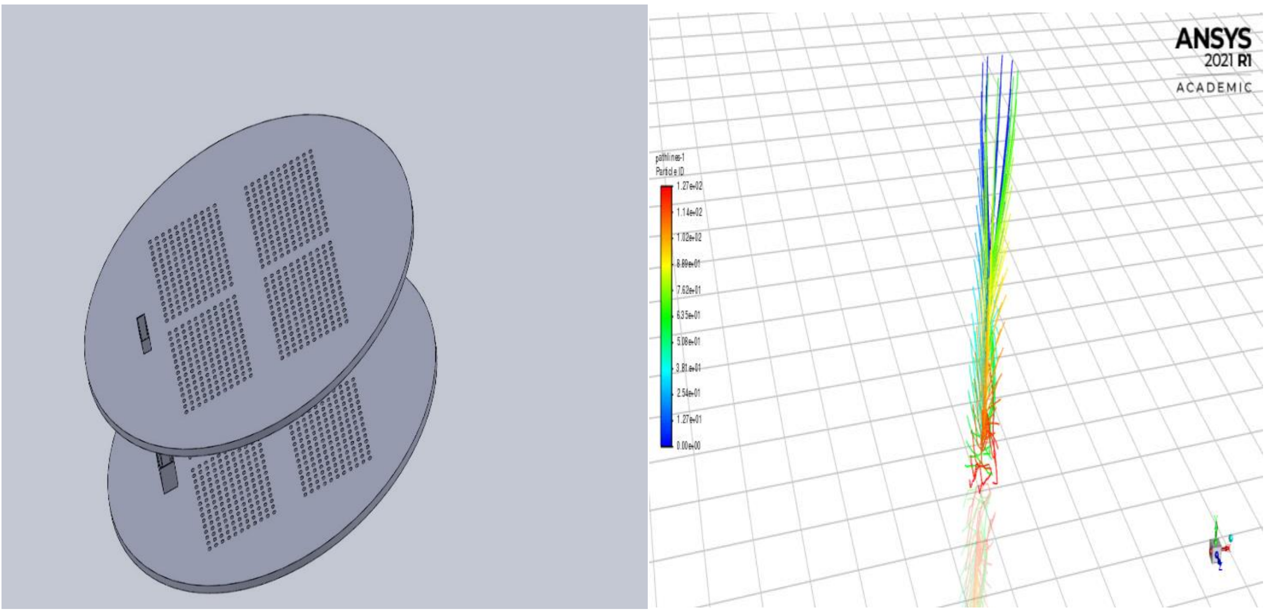


**Figure 5:** Fluid velocity in a square shaped pipe

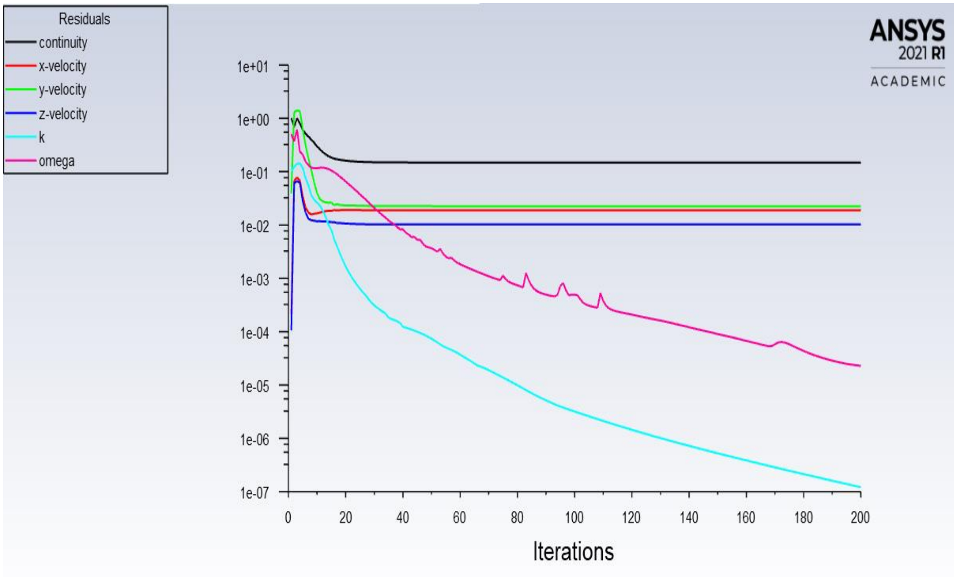


**Figure 6:** Graphic view Fluid velocity in a square shaped pipe

## 3. RESULTS

In distillation, the problem that arises is due to both liquid and steam phases flowing simultaneously. As we can see in the pictures, there are different fluid velocities depending on the geometry, the best dispersion is given when a pipe has circular geometry, second best is square geometry with a rounded corner, and lastly, the square pipe geometry. The reason lying behind this phenomenon is a uniform distribution obtained in a circular pipe. As a result of this, a circular pipes cross section will be relatively pressure resistant. Another thing worth mentioning about circular pipes is that the temperature increase will not result in geometry change (the pipe will spread or retract depending on the temperature, but the shape will stay circular). For the square geometry fluid streamline will bend causing vortexes to appear. Also, the liquid will not flow evenly and there are "dead zones" in which the liquid doesn't flow. There isn't a smooth transition when the geometry changes, and this causes the fluid flow to be uneven. If two trays are too close to each other (meaning that the drain pipes are too short), it can cause the process to overflow. Therefore, the solution that is most commonly used is the square geometry with rounded corners [6]. The reason why this is used more commonly than the circular pipe is that during the flow in a circular pipe, the liquid phase flowing can drop all at once, which may lead to the distillation process operating in modes that aren't recommended.

## 4. CONCLUSION

Geometry makes a big impact on the working condition of the plant whether it is on the tray design or the pipe shape. In this paper, the results for the three most commonly used geometry shapes are shown. It can be seen that there are many different factors and effects that need to be taken into account while designing a distillation plant. A poorly chosen geometry shape can have a dramatic influence on the working condition of the process. Due to this, numerous engineers have given their recommendations and advice on how to choose an adequate tray/pipe shape. While these recommendations are given, they are not set in stone, their purpose is to act more like guidelines rather than a rule. This method is affordable, quite close to the real system, and allows a large number of changes on the spot, without a lot of unnecessary elements**.**

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