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Flow analysis of Tesla Valve

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ABSTRACT

This report focuses on the analysis of different Tesla Valves and the effect the change in the angle between the conduits has on its overall diodicity. The 3D designing was done using CATIA whereas the computational analysis was done with the fluent software from ANSYS. The input flow velocity was considered as 10 m/s. The restriction of flow in only one direction using this valve shows promise in its application in Pulse Jet Engines in the future. The effect of the change in the angle of the Tesla Valve has been analysed and studied. The comparative results with different angles between the conduits are provided.

I INTRODUCTION

Fluid flow is an important concept in many modern projects due to its ability to transfer kinetic energy and also the chemical potential energy of the fluid itself. A valve is a good example of an important component, but most require moving parts and many modern projects use sensors and motorized electronics to operate.

The Tesla Valve is a very reliable solution because it requires no moving parts. It can be easily manufactured and installed efficiently at many sizes and in a variety of environments with a variety of materials. Pulse jet engines and microscopic plumbing have used tesla valves thanks to these characteristics. Although it doesn't guarantee fluid restriction within the undesired direction, few non-intelligent (i.e., censored and motorized) valves can.

A Tesla valve, called by Tesla a valvular conduit, may be a fixed-geometry passive check valve. It allows a fluid to flow preferentially in one direction, without moving parts. The device is known as after Tesla , who was awarded U.S. Patent 1,329,559 in 1920 for its invention.

The use of a Tesla valve is very rare these days. The main reason behind this is due to the cost of the tesla valve. The price of a tesla valve is more when compared to a normal valve which is used in a pulsejet engine. Unlike a normal valve, the tesla valve requires less maintenance. This is because a tesla valve does not have any moving parts. This is one of the main reasons why a tesla valve is more efficient when compared to a normal valve. A normal valve on the other hand has a lot of moving parts. This can result in excessive maintenance cost after extensive usage.

In the aviation industry the tesla valve can be used in a pulsejet engine.

Tesla's unique solution was for a drag which required no moving parts and was simple to construct. It is often made from any non-porous material. A one-way valve requires the restriction of fluid be due some source to some target in an undesired direction, while not restricting the flow within the desired direction (where the source and target are switched). The Tesla Valve doesn't entirely obstruct fluid flow in one direction however, so it's not a fool-proof system.

The Tesla Valve when compared to a normal valve is expensive, But on the longer road, It is very cost efficient.

II LITERATURE REVIEW

1 .Design and operation of a Tesla-type valve for pulsating heat pipes - S.F.de Vries, D.Florea, F.G.A.Homburg, A.J.H.Frijns

The new Teslakind valve has been efficiently designed to provide pulsating heat pipe flow (PHP) and increase thermal resistance. Its capacity and frequency have been verified by 1-stage laminar flow simulation and conventional 2-stage float experiment. Symmetrically integrated into PHP's single flip, reducing differences to provide more comprehensive behavioral information about PHP. PHP's two transparent heated floors, one with a valve and the other without a valve, are synthetic and have been studied for buoyancy performance and general thermal performance. The generated diodes result in a 25% rhythm difference in the unique swimming direction. In addition, adding a valve results in a thermal resistance of less than 14%.

2. Heat transfer and fluid flow characteristics in multi staged Tesla valves -Scott M. Thompson ,D. Keith Walters &Tausif Jamal

The use of Tesla valves for flow control and rectification in micro and microfluidic applications is very attractive because they are passively operated and their design has no moving parts. The efficiency of this kind of valve can be improved by their sequential arrangement, namely the multi-stage Tesla valve (MSTV).In this study, the effect of the entered Reynolds number (25-200) on the flow straightening and thermal enhancement capabilities of individual Tesla and MSTV valves (up to 10 stages) was numerically investigated using fluid dynamics. According to the simulation results, the power-law dependence of MSTV design and performance in Nusselt number, Darcy friction coefficient, pressure diode and thermal diode was obtained and demonstrated. The structure of the valve is explained by the branching, stagnation, and mixing mechanism of the flow; for Re = 200, an average Nusselt number of up to 7.1 is observed. The ability of the Tesla valve to act as a miniature, thermal diode, and/or check valve heat exchanger can benefit a variety of flow/temperature control applications.

3. Numerical Study of Diodicity Mechanism in Different Tesla-Type Microvalves - A. Y. Nobakht, M. Shahsavan

Microvalves are one of the most important components of microfluidic systems and micropumps. In this paper, the FLUENT computational fluid dynamics package is used to simulate the three-dimensional flow of an incompressible fluid through a Tesla microvalve. The process is laminar and uses the SIMPLE algorithm. The second wind resistance method has been implemented. Discretized convection term. The diode mechanism of three different miniature valves was examined in detail. The influence of several series of Tesla-type miniature valves on the behavior of diodes has also been studied. Numerical analysis shows that the diode mechanism appears in the T-junction and side channel.

If you remove the water inlet and outlet, you can add 2 diodes. Analysis of the pressure field shows that the pressure drop at the return connection is much greater than the pressure drop in the flow. The numerical results obtained are compared with the results of the experimental process. Note the results and the good agreement between them.

4. Performance Simulations of Tesla Microfluidic Valves - S. Zhang, S. H. Winoto, H. T. Low

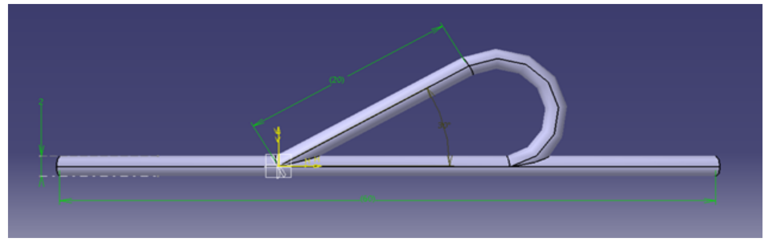
A three-dimensional parameter model of the Tesla valve is proposed. The geometric relationship is derived for optimization research, and based on this model, performance research is carried out on the diode, pressure and flow characteristics of valves with the same hydraulic diameter and different aspect ratios (valve sizes). Cross section) in the range of 0.5 to 4 3D computer simulations show that for the same hydraulic diameter, the form factor of the unit leads to a higher diode Reynolds number. Aspect ratio when Reynolds number is greater than 500 Research on the pressure and flow characteristics of Tesla valves shows that Tesla valves with high aspect ratios provide more flow control options.

4. Parametric study on Tesla valve with reverse flow for hydrogen decompression - Zhi-jiangJin, Zhi-xinGao, Min-ruiChen, Jin-yuanQian

For hydrogen fuel cell electric vehicles, the charging distance is very important. Storing hydrogen under high pressure can significantly extend the charging time. The hydrogen needs to be depressurized before it enters the fuel cell. The Tesla valve can be used for pressure reduction, because it is a check valve with no moving parts, and there is a large pressure drop between the inlet and the outlet of the return flow to obtain a better pressure drop setting file structure for the Tesla valve Parameters such as hydraulic diameter, valve angle and inner curve radius are all checked within the input speed range. The results show that the hydraulic diameter is small, and the inner bending radius is small and large. The angle of the valve results in a higher pressure drop at high inlet speeds, while at low inlet speeds (less than 100 m), the pressure drop of various design parameters hardly changes. In addition, after the exit of the elbow, there is a negative pressure zone that needs attention. This work can be cited by other applications where Tesla valves are used for hydrogen pressure reduction in hydrogen fuel cell electric vehicles.

III DESIGN

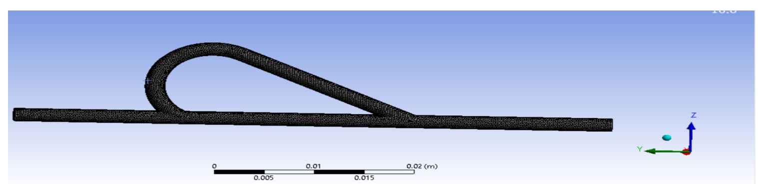
The design of the Tesla Valve is a modified version of a general tesla valve designed for better flow for our parameters. Three different tesla valves with three different divergent angles for the nozzle of the scramjet. The design work has been done on CATIA due to its agility in two dimensional surface designing. The design of the tesla valve with a divergence angle of 30° has been displayed below in figure 3.1. Similarly the other designs for 45°, 60° and 75° have been designed to be used in the simulation of the flow in ANSYS fluent



3D Design of the TESLA VALVE with 30° divergence angle

IV ANALYSIS

The analysis is done on ANSYS fluent in which the computational work has been done. The tesla valve design has been analysed in order to verify the capacity of the modified tesla valve design and flow physics. The most important part of the process was the efficient mixing of fuel and air. This was done by analysing the design and the point where turbulence is recorded which enables the maximum and efficient mixing of fuel with air.The 3 dimensional Tesla Valve designs are meshed using the inbuilt mesh tool in ANSYS. The analysis is performed on all four tesla valve design each of which has different divergent angles



Mesh for Tesla valve with 30° divergence angle

V OBSERVATION

The computational analysis has been performed to simulate the effect of air in four different tesla valves. They are observed using contours and graphical representation of the data obtained.

30° TESLA VALVE:

The analysis for the tesla valve with a 30° divergent angle is performed and the results are observed.

ANALYSIS FOR NORMAL FLOW:

The tesla valve is analysed for 30° degree configuration and various parameters such as velocity and pressure. The variations in each of these parameters are obtained by contours.

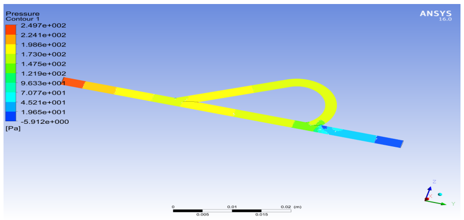


Fig 4.5 Pressure contour for tesla valve model (30°)

The pressure contour shown in fig 4.5 shows the pressure in the tesla valve. As we can see the pressure and velocity is at the highest at the inlet of the valve and lowest at the outlet. The difference in pressure is extremely noticeable in the normal flow direction of the valve.

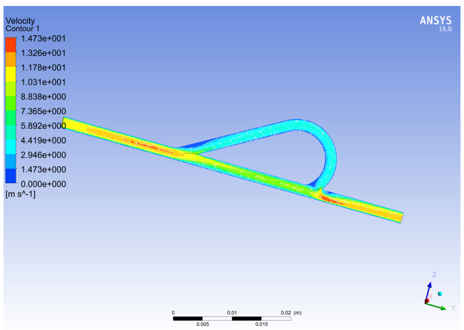


Fig 4.6 Velocity in tesla valve model (30°)

ANALYSIS FOR REVERSE FLOW:

The tesla valve is analysed for 30° degree configuration with the flow reversed and various parameters such as velocity and pressure. The variations in each of these parameters are obtained by contours. As we can see the pressure and velocity are highest at the inlet and lowest at the outlet. The difference in pressure is less noticeable in the reverse flow direction when compared to the normal flow direction.

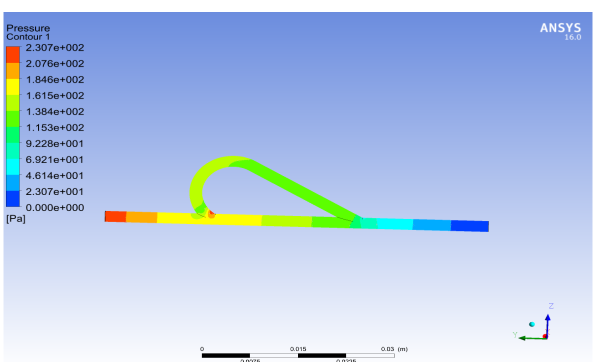


Fig 4.7 Pressure contour for tesla valve model (30°)

The pressure contour shown in fig 4.7 shows the pressure in the tesla valve. As we can see the pressure and velocity is at the highest at the inlet of the valve and lowest at the outlet. The difference in pressure is extremely noticeable in the normal flow direction of the valve. The velocity contour shown in fig 4.8 shows the pressure in the tesla valve

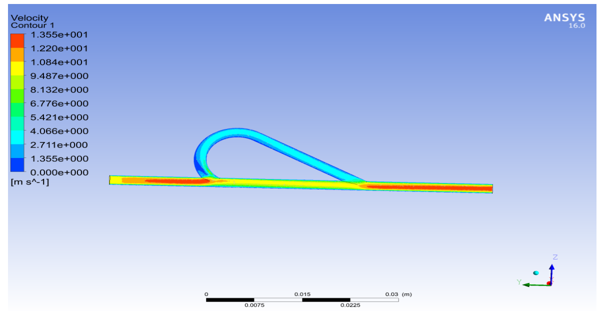
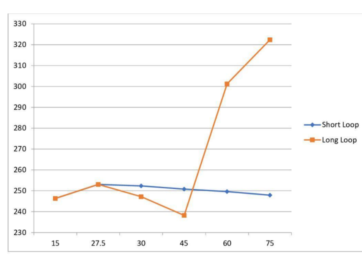


Fig 4.8 Velocity in tesla valve model (30°)

VI RESULTS

The flow analysis on different Tesla Valve models with different angles have been performed. Each of these Tesla Valves have conduit divergent angles of 15°, 30°, 45°, 60° and 75°. The obtained results from the computational data from the fluent results were analysed and compared which gave us multiple findings. The most important parameters such as velocity and pressure were collected and observed. These factors are all analysed for each different model of the Tesla Valve in both the desired and undesired directions. With the data from the analysis we realize that there are two major factors in determining the design to get the highest possible pressure difference between the inlet and the outlet with just one loop. These factors are: (i) **The angle of the diverging conduit with the main conduit.** (ii) **The length of the conduit.** In order to design a Tesla valve which is able to give the highest possible pressure drop between the inlet and outlet we have to design it based on the two factors given above. And the Tesla valve we designed using the above two conditions was the 27.5° Tesla Valve. This Tesla valve has the minimum possible angle with the maximum possible length such that we get the highest possible pressure drop between the inlet and outlet



X axis indicates angle between the diverging conduits
Y axis indicates the pressure drop between the entrance and exit of the conduit

VII CONCLUSION

The flow analysis on different Tesla valves with different dimensions is performed. They are analysed for the pressure and velocity across the inlet and outlet of the valve. With the data from the analysis we realize that there are two major factors in determining the design to get the highest possible pressure difference between the inlet and the outlet with just one loop. These factors are: (i) **The angle of the diverging conduit with the main conduit.**(ii) **The length of the conduit.**

VIII REFERENCES

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