Tuijin Jishu/Journal of Propulsion Technology
ISSN: 1001-4055
Vol. 45 No. 3 (2024)

Design and Analysis of Feed Check Valve Using Cfd

Md. Arfaz, Dr. J. Murali Naik, Dr. N. Jeevan Kumar

M. Tech Scholar Department of Mechanical Engineering

Associate Professor Department of Mechanical Engineering, muralinaik.mech@gmail.comHOD& Professor, Mechanical Engineering Department Holy Mary Institute Of Technology And Science

Abstract: Feed check valves are used as flow control equipment in many industries. The Feed check valve is fitted to the boiler, slightly below the working level in the boiler. It is used to supply high pressure feed water to the boiler and also to prevent the returning of feed water from the boiler if the feed pump fails to work the parameter for the performance of control valve analysis is flow coefficient. There is an experimental method to calculate the flow coefficient value of the valve, but the setup for the experimental validation is not readily available as these valves work at high pressure. Due to the progress of the flow simulation and numerical technique (CFD), it becomes possible to observe the flows inside a valve and to estimate the performance of a valve. The Feed check valve is fitted to the boiler, slightly below the working level in the boiler. It is used to supply high pressure feed water to the boiler and to prevent the returning of feed water from the boiler if feed pump fails to work. With rapid advancement in the area of flow simulation, CFD and thermal Numerical technique, the flow characteristics of the feed check valve can be studied effectively. Water is working fluid here and at different fluid inlet velocities compared (i.e. 20m/s, 30m/s, 40m/s and 50m/s) In this paper modeling and 3-dimensional flow simulation of a feed check valve is carried out using CATIA software and simulation done in ANSYS software to understand the inside flow characteristics and to determine prominent factors such as Pressure drop, Valve co- efficient. In the final phase, the discharge of the valve for a constant pressure drop of 1 bar is determined and flow patterns are visualized.

Key words: feed check valve, CATIA, ANSYS, CFD

1.1 VALVE

1.2 INTRODUCTION

1.3 pressure drop Ideal for quick shut-off, since a90° turn completely shuts off, compared to

A **valve** is a device or natural object that regulates, directs, or controls the flow of afluid (gases, liquids, fluidized solids, or slurries) by opening, closing, or partially obstructing various passageways. Valves are technically fittings but are usually discussedas a separate category. In an open valve, fluid flows in a direction from higher pressure to lower pressure. The word is derived from the Latin *valve*, the moving part of a door, in turn from vulvar, to turn, roll. Industrial uses for controlling processes, residential uses such as on/off and pressure control to dish and clotheswashers and taps in the home Even aerosol spray cans have a tiny valve built in. Valves are also used in the military and transport sectors. In HVAC ductwork and other near- atmospheric air flows, valves are instead called dampers. In compressed air systems, however, valves are used with the most common type being ball valves.

Fig 1.1 Valve

1.4 Valves can be categorized into thefollowing types.

The ball valve, for on-off control withoutmultiple 360° turns for other manual valves.

- Butterfly valve, for on-off flow control in large diameter pipes
- Choke valve, a solid cylinder placedaround or inside a second cylinder withmultiple holes or slots, inside housing. Shifting the solid cylinder exposesmore or fewer holes. Used in oil and gas wellheads, where the pressure drop is high. (Not to be confused with engine choke valve, below.)
- Diaphragm valve or membrane valve,controls flow by movement of a diaphragm. Used in pharmaceutical applications.
- Gate valve, mainly for on–off control, with low pressure drop.
- Globe valve, good for regulating flow. Uses a cylinder movement over a seat.
- Knife valve, similar to a gate valve, butusually more compact. Often used for slurries or powders on-off control.
- Needle valve for accurate flow control.
- Pinch valve, for slurry flow regulationand control
- Piston valve, for regulating fluids thatcarry solids in suspension.
- Piston valve (steam engine)
- Plug valve, slim valve for on–offcontrol but with some pressure drop.
- Solenoid valve, an electrically actuated valve for hydraulic or pneumatic fluid

1.5 Applications

Valves are found in virtually every industrial process, including water and sewage processing, mining, power generation, processing of oil, gas, and petroleum, food manufacturing, chemical and plastic manufacturing, and many other fields. People in developed nations use valves in their daily lives, including plumbing valves, such as taps for tap water, gas control valves on cookers, small valves fitted to washing machines and dishwashers, safety devices fitted to hot watersystems, and poppet valves in car engines. In nature there are valves, for example one-way valves in veins control the blood circulation, and heart valves controlling the flow of blood in the chambers of the heart and maintaining the correct pumping action.

1.6 Feed check valve

Feed Check Valves are one of the most important components of boiler which control the flow of water from feed pump to the boiler and further prevent the backflow of water from boiler to pump when the boiler pressure is more than the pump pressure or when feed pump stops working. A control valve is a mechanical device that controls the flow of fluid and pressure within a system or process. A control valve controls system orprocess fluid flow and pressure by performing different functions like stopping and starting fluid flow, varying (throttling) the amount of fluid flow, controlling the direction of fluid flow, regulating downstream system or process pressure, relieving component or piping over pressure .There are many valve designs andtypes that satisfy one or more of the functions identified above. A multitude of valve types and designs safely accommodate a wide variety of industrial applications.

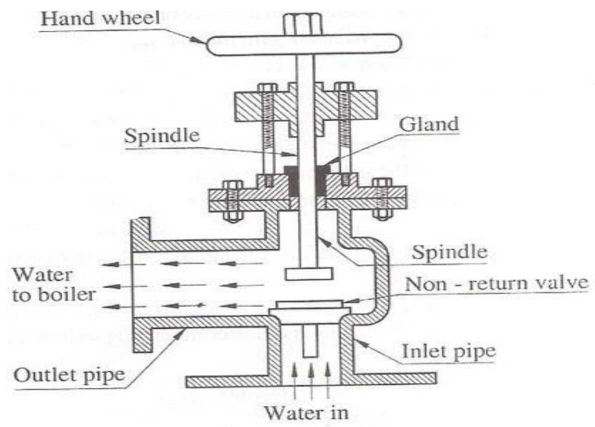


Fig 1.2 Feed Check Valve

Feed valves are key components of hydraulic control systems. Design solutions in the form of cartridge-type inserts are becoming increasingly more popular as they allow the designer to create the housing according to individual needs and their own idea. Flow channels and seats for mounting inserts inside the housing can be made by casting or directly drilled by machining. Cast housings are usually made of cast iron or less commonly aluminum alloys. The most popular cast iron housings, in which the individual flow channels are created in the casting technology, are mainly used in large-scale production due to the relatively low cost per unit. Cast iron housings also have other advantages, such as the possibility of making flow channels with more advanced geometry and thus allowing lower flow resistance ormore compact design.

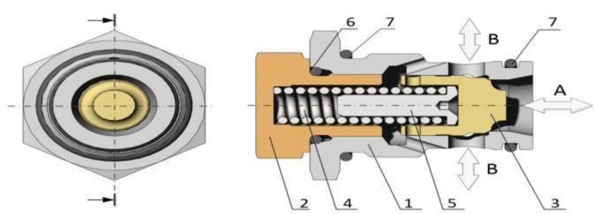


Fig 1.3 Feed Check Valve Cross Sectional View

1.7 Function

It is used to control the supply of water to the boiler & to prevent the escaping of water from the boiler when the pump pressure is less or pump is stopped.

1.8 Working:

- Under normal working condition, the pressure on the feed pump side (connected to elbow) is more than the boiler side pressure.
- This pressure difference lifts the checkvalve. To allow the feed water to enterthe boiler, the feed valve is lifted manually.
- Hence, the feed water may enter the boiler. In order to control the supply offeed water to the boiler, the position ofthe feed valve is controlled. In the event of failure of feed pump, the pressure on the water sump side reduces.

Here are different material made valves such as the **Bronze Accessible Feed Check Valves** and stainless steel valves. Dependingon the difference in the application requirements, these materials are used. The **Series 5470 Accessible Feed Check Valve** is one such type of specification. The series indicates the input output size, flow volume, pressure capacity and many other properties of the valves. The **High-PressureSeries 5490 Accessible Feed Check Valve** is used in high pressure systems such as boilers, heat exchangers and other hydraulic operationswhere low pressure valves are used for low risk operations. The **Sant CI 5A Cast IronAccessible Feed Check Valve** is available from us for sale as well. As we are a leading manufacturer and supplier, please contact usfor the different types of valves such as the **High Temperature Boiler Accessible Feed Check Valve** and others along with the prices.

1.9 Check Valve

A **check valve** controls the flow direction of fluids and is available in various configurations depending on the application. Single-configuration check valves are designed to prevent back flow in only one direction. Double-configuration check valves control flow bi-directionally by diverting fluid to multiple outlets consecutively. Single-configuration check valves are normally closed - meaning they require positive pressure differential to allow flow - with various termination options including luers, bond sockets, bond posts, andbarbed designs.

A double check valve or double check assembly (DCA) is a backflow prevention device designed to protect water supplies from contamination. It is different from the two-way check valves (sometimes erroneously referred to as double check valves) used in air brake systems on heavy trucks which select from the highest pressure source. It consists of two check valves assembled in series this employs twooperating principles: firstly one check valve will still act, even if the other is jammed wide open. Secondly the closure of one valve reduces the pressure differential across the other, allowing a more reliable seal and avoiding even minor leakage.

1.10 Dual check valve

A dual check backflow preventer is similar to a double check valve in operation. It has two independent spring-loaded check valves.However, dual check valves usually do not include shutoff valves, may or may not beequipped with test cocks or ports, and is generally less reliable than a double checkvalve.Operation of feed check valve

Air-actuated control valves each with a 4–20 mA "I to P" converter integral to a valve positioner. In this example each positioner is comparing the valve stem travel against control signal, and applying any correction. The opening or closing of automatic control valves is usually done by electrical, hydraulic or pneumatic actuators. Normally with a modulating valve, which can be set to any position between fully open and fully closed, valve positioners are used to ensure the valve attains the desired degree of opening.

Tuijin Jishu/Journal of Propulsion Technology
ISSN: 1001-4055
Vol. 45 No. 3 (2024)

Fig 1.4 Operation of Feed Check Valve

2 Related Study

Design and Analysis of Feed Check Valve as Control Valve Using CFD Software the Feed check valve is fitted to the boiler, slightly below the working level in the boiler. It is usedto supply high pressure feed water to boiler and also to prevent the returning of feed water from the boiler if feed pump fails to work.With rapid advancement in the area of flow simulation, CFD and Numerical technique, the flow characteristics of the feed check valve can be studied effectively. In this paper modeling and 3-dimensional flow simulation of a feed check valve is carried out using CATIA FLOW SIMULATION software to understand the inside flow characteristics and to determine prominent factors such as Pressure drop, Valve co-efficient. In the final phase, the discharge of the valve for a constant pressure drop of 1 bar.

3 MethodologyIntroduction To Cad

Computer-aided design (**CAD**) is the use of computer systems (or workstations) to aid in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design,improve communications through documentation, and create a database for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations. The term **CADD** (for Computer Aided Design andDrafting) is also used.

CATIA parametric modules:

- Sketcher
- Part modeling
- Assembly
- Drafting

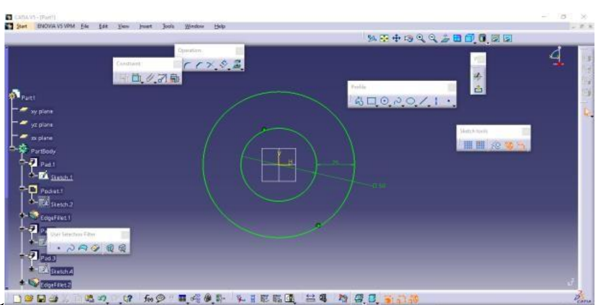


Fig 3.1 Feed Check Base

Feed check valve model designed in CATIA software. In CATIA software we have mainly 4 modules

The modules are:

1. Sketcher
2. Part
3. Assembly
4. Drafting

Here sketcher is used to develop the 2d drawings. The part module is used to convert the 2d drawing into 3d modeling. Assembly is used to combine the different parts. In capillary tube we have a main modules andsub modules.

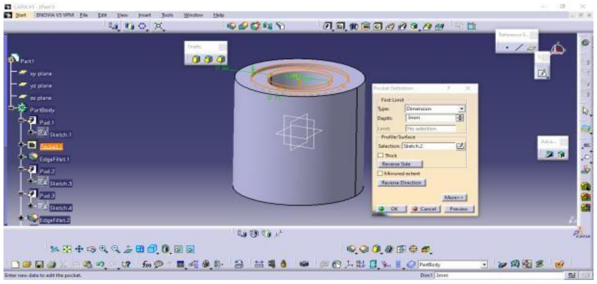


Fig 3.2 Feed Check Valve Pad Operation

In part module we have sketch based features tool bar and operational tool bar by using this tools we remove the material using pocket 20mm length.

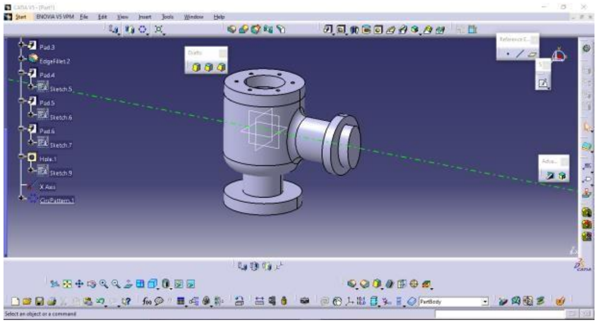


Fig 3.3 Feed Check Valve 3d Model

Outer Diameter with 30mm and inner diameter 20 height 35mm length feed check valve modeled in CATIA software.

4. CFD ANALYSIS OF FEED CHECKVALVE

FLUID – WATER

AT DIFFERENT VELOCITIES (20M/S,30M/S, 40M/S AND 50M/S)

PRESSURE 100 Pa TEMPERATURE 350K

4.1 Fluid Dynamics

ANSYS Fluent, CFD, CFX, FENSAP-ICE,

and related software are Computational Fluid Dynamics software program equipment used by engineers for design and evaluation. This gear can simulate fluid flows in digital surroundings — for instance, the fluid dynamics of deliver hulls; gasoline turbine engines (including the compressors, combustion chamber, mills and afterburners); aircraft aerodynamics; pumps, lovers, HVAC systems, mixing vessels, hydro cyclones, vacuum cleaners, etc.WATER PROPERTIES

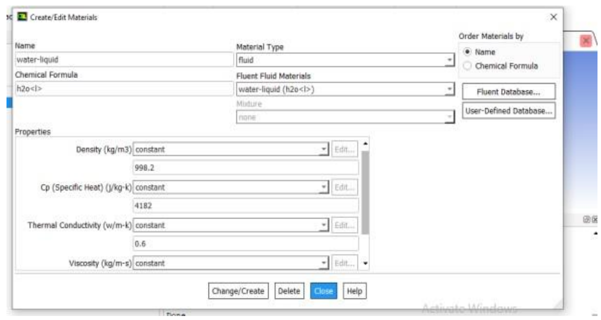


Fig 4.1 Water Properties

By using fluid fluent analysis, we done the CFD analysis in fluid fluent analysis we have5 steps to get the results.

1. Geometry
2. Meshing
3. Setup
4. Solution
5. Results

4.2 INLET 20 M/SCFD Analysis

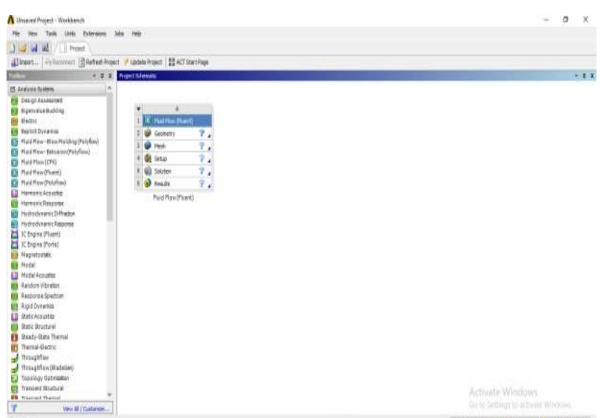


Fig 4.2 CFD Analysis

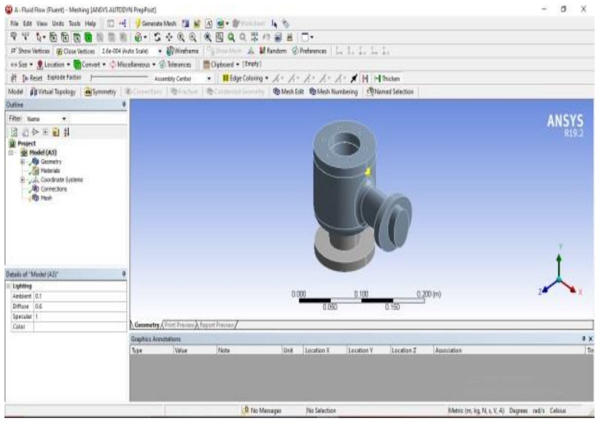


Fig 4.3 Import Geometry

The model is designed with the help of CATIA and then imported on ANSYS for Meshing and analysis. By the CFD analysis denotes in order to calculating pressure drop, velocity drop, mass flow rate and heat transferrate.

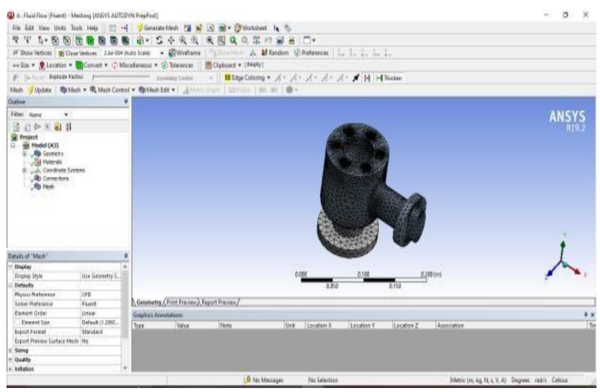


Fig 4.4 Meshing

The model is designed with the help of CATIA and then imported on ANSYS for Meshing and analysis. The analysis by CFD isused in order to calculate the pressure profile and temperature distribution. For meshing, thefluid ring is divided into two connected volumes. Then all thickness edges are meshed with 360 intervals. A tetrahedral structure mesh is used. So, the total number of nodes and elements is 6576 and 3344.

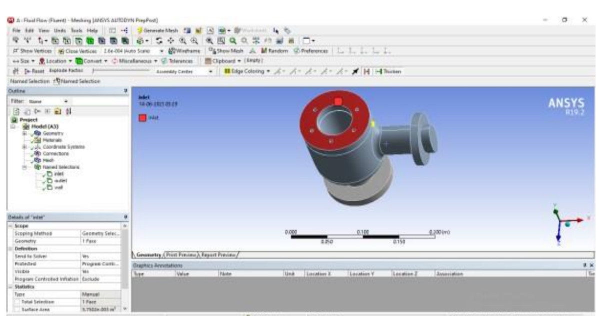


Fig 4.5 Boundary Conditions

Tuijin Jishu/Journal of Propulsion Technology
ISSN: 1001-4055
Vol. 45 No. 3 (2024)

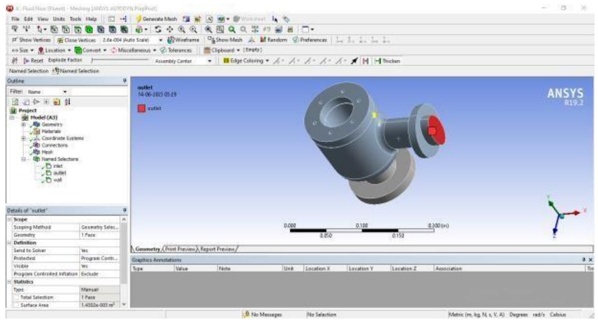


Fig 4.6 Outlet

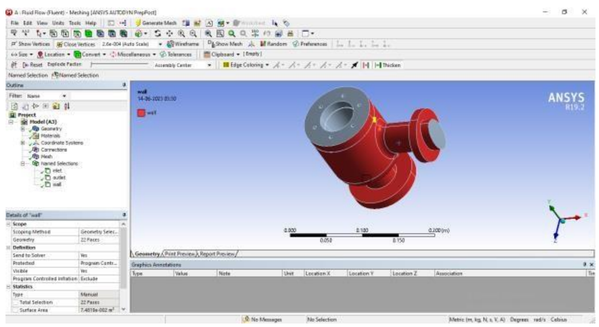
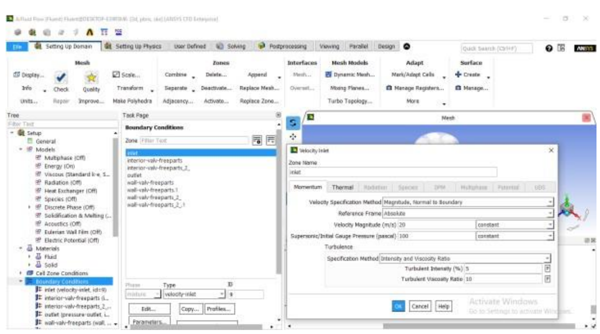


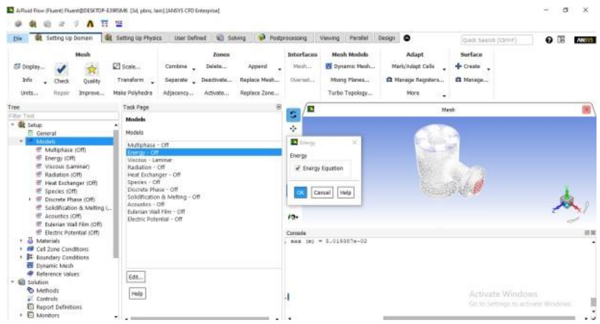
Fig 4.7 Wall

After completion of the meshing, boundary conditions and flow rates are applied. User can define temperature and convection in various ways. This helps the user to keep track of fluid flow cases. The boundary condition is the collection of different temperatures, inlet velocities and any other condition required for complete analysis. Thermal conditions temperature 30^0c are applying outer and inner surfaces respectively as shown in figure mention one end as inlet.After completion of meshing, we can start the setup step. In this step we on the energy equation and apply the flow.



Inlet velocities and any other condition required for complete analysis. Velocity 20m/s are applying outer and inner surfaces respectively as shown in figure and named as outlet.

4.3 Run calculation



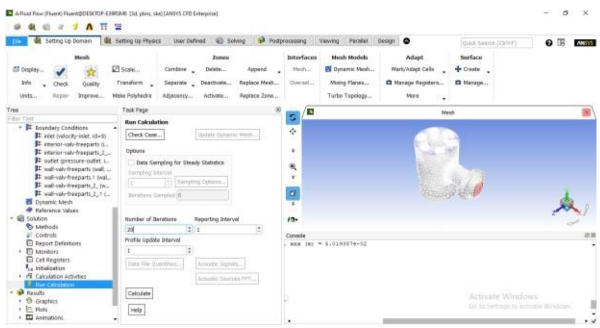


Fig 4.8 Run Calculation

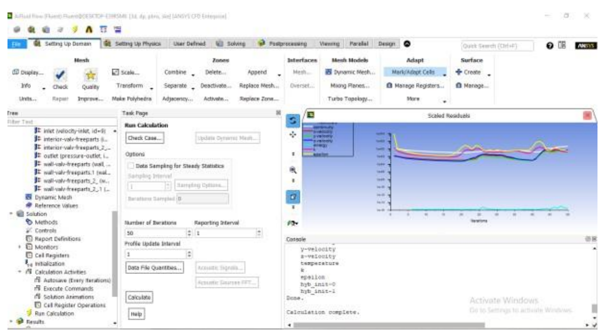


Fig 4.9 Iteration

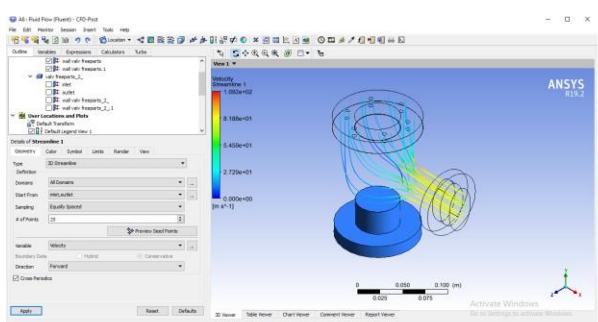


Fig 4.10 Velocity

According to the above contour plot, the maximum velocity of the air at edges of the feed check valve and minimum velocity between around the boundary edges and radiator helical tubes edges. According to the above contour plot, the maximum velocity is 1.092e+02w/m^2-k and minimum velocity is 2.29e+01m/s.

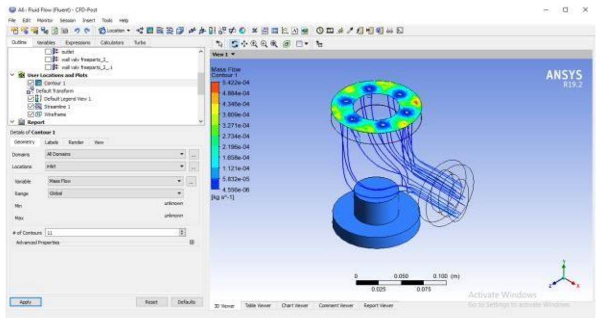


Fig 4.11 Mass Flow Rate

According to the above contour plot, the maximum mass flow rate of the air at edges of the feed check valve and minimum mass flow rate between around the boundary edges and feed check valve edges. According to the above contour plot, the maximum mass flow rate is 5.422e+04w/m^2-k and minimum mass flow rate is 4.556e+06m/s.

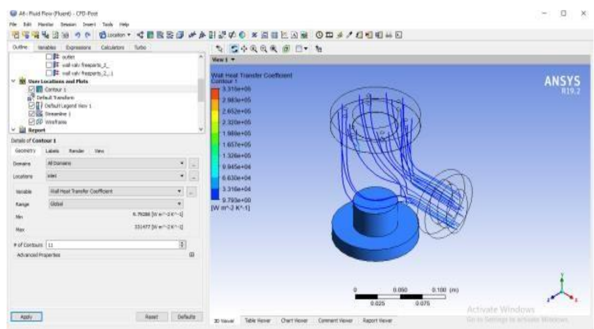


Fig 4.12 Heat Transfer Coefficient

4.4 Thermal analysis of feed check valveMaterial copper alloy

Boundary conditions

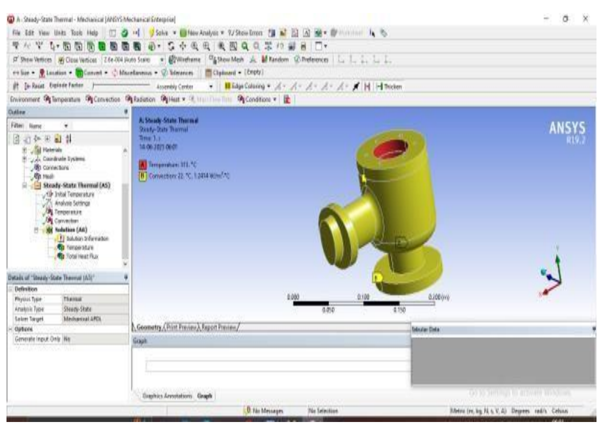


Fig 4.13 Boundary Conditions

Tuijin Jishu/Journal of Propulsion Technology
ISSN: 1001-4055
Vol. 45 No. 3 (2024)

Users can define temperature and convection in various ways. This helps the user to keep track of thermal cases. The boundarycondition is the collection of different temperatures, constraints and any other condition required for complete analysis.Thermal conditions temperature 313^0c are applying outer and inner surfaces respectivelyas shown in figure.

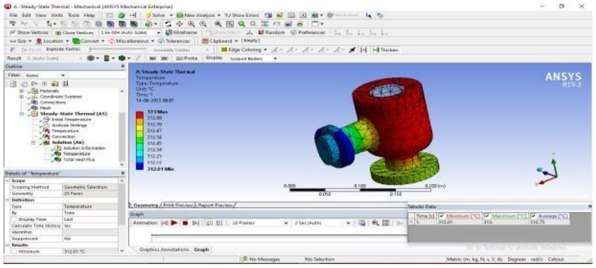


Fig 4.14 Temperature Distribution

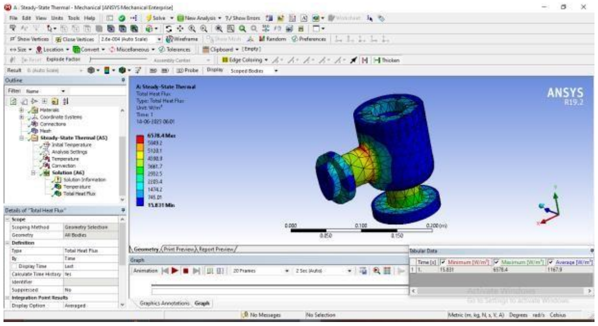


Fig 4.15 Heat Flux

According to the above contour plot, the maximum heat flux at applying the inlet temperature According to the above contour plot, the maximum heat flux is 1.1332 max and minimum heat flux is 85.828.

5.1 Result Table

Table 5.1 CFD Analysis Result Table

Fluid	Inlet velocity (m/s)	Velocity (m/s)	Mass flow rate **(kg/s)**	Heat transfer co efficient **(w/m2-k)**	Pressure drop (pa)	Temperature distribution (k)	Density m^3
Water	20	1.092e+02	5.422e+04	3.315e+05	4.517e+03	3.500+02	1.225e
	30	1.514e+02	8.132e-04	4.670e+05	1.074e+04	3.500+02	1.225e
	40	2.020e+02	1.084e-03	5.316e+05	1.919e+04	3.500+02	1.225e
	50	2.527e+02	1.355e-03	8.479e+02	2.978e+04	3.500+02	1.225e

Table 5.2 Thermal Analysis

Material	Inlet temperature (^{0}c)	Temperature distribution (^{0}c)	Heat flux (w/mm^2)
Aluminum alloy	313	313	6555.9
	413	413	8808.8
Copper alloy	313	313	6578.8
	413	413	8839

CFD and Numerical technique, the flow characteristics of the feed check valve can be studied effectively. Water is working fluid here and at different fluid inlet velocity's

compared (i.e. 20m/s, 30m/s, 40m/s and50m/s) In this paper modeling and 3- dimensional flow simulation of a feed check valve is carried out using CATIA softwareand simulation done in ANSYS software to understand the inside flow characteristics and to determine prominent factors such as Pressure drop, Valve co-efficient. In the final phase, the discharge of the valve for aconstant pressure drop of 1 bar is determined and flow patterns are visualized. Byobserving CFD analysis velocity and heat transfer rate co-efficient values are increasing by increasing the inlet velocity.

6. Conclusion

CFD and Numerical technique, the flowcharacteristics of the feed check valve can be studied effectively. Water is working fluid here and at different fluid inlet velocity's compared (i.e. 20m/s, 30m/s, 40m/s and50m/s) In this paper modeling and 3- dimensional flow simulation of a feed check valve is carried out using CATIA software and simulation done in ANSYS software to understand the inside flow characteristics and to determine prominent factors such as Pressure drop, Valve co-efficient. In the final phase, the discharge of the valve for aconstant pressure drop of 1 bar is determined and flow patterns are visualized. By observing CFD analysis velocity and heattransfer rate co-efficient values are increasing by increasing the inlet velocity By observing thermal analysis copper alloy have more heat flux compare to the aluminum alloy So weconcluded that at inlet velocity 50m/s is better compare to the inlet velocity 20m/s, 30m/s,40m/s and copper alloy material is better for feed check valve.

References

[1]. V. J. Sonawane, T. J. Rane, A.D. Monde,R.V. Vajarinkar, P. C. Gawade, "Design and Analysis of Glob Valve as Control Valve Using CFD Software" IOSR-JMCE, ISSN (p): 2320–334X, PP: 63-71.

[2]. Swagelok Valve Sizing Technical Bulletin, December 2007.

[3]. R.C.Patel, C.J. Karamchandani, "Element of heat engines" Vol 1, Chapter 8, Steam Boilers.

[4]. H.Kursat Celik, Allan E.W. Rennie, DavutKarayel, Ibrahim Akinci, "Determination of flow parameters through CFD analysis for agricultural irrigation equipment: A case study for a mini valve", Journal of Agricultural machinery science, Vol 7(3), 231-239.

[5]. Marine Hydrodynamics 2.20, Lecture 9, Massachusetts Institute of Technology, Mechanical Engineering Department.