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STRUCTURAL DESIGN AND FEM ANALYSIS OF BUTTERFLY VALVE

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***Abstract*:**

Valves are used for various purposes in hydro power projects. These valves are used for safety purposes, maintenance, shutoff and flow regulation as well as pressure regulation. One type of valve is a butterfly valve. This type of valve is used to regulate a fluid flow. Butterfly valve serves as a safety valve and also acts as a regulator in controlling the pressure of the fluid. The opening and closing of these valves can be operated either by oil hydraulic systems or by closing in weights. In turbine inlet valves, the oil pressure can be received from governing hydraulic system. An adjustable and flexible rubber or a metal type is used in sealing system in order to maintain the minimum leakage. In both the directions, the Water flow through the valve is possible. The primary objective of this thesis work is to analyze the option of fabricated variant for door and body in place of casted, reducing the material of valve body and door by structural design and FEM analysis and optimization in the material of valve component. The 3D modeling is to be performed by using CAD software for butterfly valve. Also by using ANSYS tool, the stress and displacement FEM analysis of the Butterfly valve is performed.

Keywords—hydraulic system; sealing; turbine; valve body; optimization.

I. INTRODUCTION

A butterfly valve is a valve which can be used for isolating or regulating flow. The mechanism used for the closing of the valve is in the form of the Disc. This is similar to that of the ball valve we are using regularly. This allows us for the quick shut off. Butterfly valves are generally chosen because they are less in cost when compare to the other valves, they are also lighter in weight so it can easily operated. At centre of the pipe or body of the valve the disc is placed. The disc is connected to the actuator by means of the rod on outside of the valve. The actuator is the rotating device that turns the disc parallel or perpendicular to the flow in order to shut off or on the valve. In Butterfly valve the disc is always present in the flow of the water this is not present in the ball valve. The pressure drop is always present in the flow as the disc is always present along the flow without depending upon the valve position. This type of the valve is related to the family of valves called quarter-turn valves. In operation, the valve is either fully open or closed when the disc is rotated a turn i.e.Quarter turn. The Disc in the valve is known as the "butterfly" so it is called as the Butterfly Valve. The disc is a metal disc mounted over a rod. The valve is closed; the disc is turned perpendicular to the flow that blocks the passage of the water through the valve. When the valve is completely opened the disc is parallel to the flow so that unrestricted passage of the fluid. This can also open incrementally to regulate the flow of the fluid.

1.1 Parts of Butterfly Valve:

The different parts of butterfly are:

Body: The body of the butterfly valve is made up of the cast iron, stainless steel and carbon steel. The cast iron is the material that is highly used in the body of the valve. The butterfly valve is made available in two types that are in wafer and lug style. Wafer style valves are installed “sandwiched” between pipe flanges so it is easily replace and install. However, replacing a wafer valve takes place only when the conveying line is drained. The body of the valve is mounted between the two pipes of the flow.

Seat: Resilient seated valves are one of the seat commonly used in these types. Inside of the valve body is made of elastomeric seat material. The seat is made up of the material EPDM, Buna, Teflon, natural rubber, carbon. The selection of the seat material depends on temperatures, pressures and material handled. The seat of the valve is cannot be repaired it should be replace with the new one. Some precision seats can be repairable.

Disc: The function of the disc is to regulate the flow of the material or fluid within the conveying line. The disc is controlled by the actuator. Disc material should meet the conditions that are as the valve is always present in the flow it should be corrosion resistance. stainless steel, ductile iron, carbon steel is the material used for the disc of the valve. The property of the material should be As the disc is directly in the material flow stream, care must be taken in specifying the proper material of construction and disc shape. Some discs are designed to allow increased flow patterns through the piping.

Stem: The stem is the component that attaches the centre of the valve and the actuator. As the actuator turns the stem moves along which the disc also moves. Depending on the application of the valve and size of the valve the stem may be one piece or two piece construction. Material used passes through the centre of the valve, attaches to the actuator, and positions the disc for material flow control and shut off. Depending on the application and valve size, stem may be one or two-piece construction. Material used is Carbon steel and different grades of carbon steel.

Actuator: actuator is the type of component that mounted over the body of the valve. Different types of actuators are present in butterfly valves. The different types are: manual handle, gear, pneumatic, electric and electro-hydraulic. Actuators may be enclosing by separate Housings for underground applications.

Material:

The most commonly used material for butterfly valve disc is carbon steel, stainless steel, austenitic stainless steel. Stainless steel is the highly used material in the valve.

1.2 Problem statement for present project:

The Disc of the butterfly valve is always in the water so the material used has the poor corrosion resistance; this can be overcome by surface protection methods such as paint, by paint it can be provide the thick media over the disc so that corrosion does not takes place from inside of the disc material. Therefore cost of the disc is more initially.

The Disc using in the valve is flat, due to the flat surface the stress and displacement on the disc are high. The stress induced on the flat is high which leads to the failure of the valve.

1.3 Objective:

- Design of the present Butterfly valve in CAD Software i.e...CATIA V5.
- Analysis of the valve with different materials using ANSYS Software.
- Best material is chosen comparing with present material.
- Design of disc is changed from flat to reduce stress and displacement.
- Again analysis is done with the material we have chosen with new disc design.
- Best material and design is the final outcome of the project.

II. DESIGN OF BUTTERFLY VALVE USING CATIA SOFTWARE

2.1 Introduction to CATIA:

CATIA V5 is the software that enables to generate the complete digital representation of the product that is being designed. Industrial standard pipe work and complete wiring definition is also done in additional to the general geometry tools there also ability to generate by integrated design disciplines. Collaborative development is also supported in this software.

Industrial design concepts which they use in the downstream process of the product design are also available in the number of conceptual design tools of the software. The design of the product in industrial is undergoes the different modules in the software. The different modules of the CATIA V5 software are explained below.

2.2 Modules of CATIA V5:

- Sketcher
- Part Modelling
- Surfacing
- Sheet Metal
- Drafting
- Manufacturing

- Shape designs

2.3 Design model:

A. Design considerations for Flat Disc:

Thickness of the Disc: 6 mm

Radius of the Disc: 96.9 mm

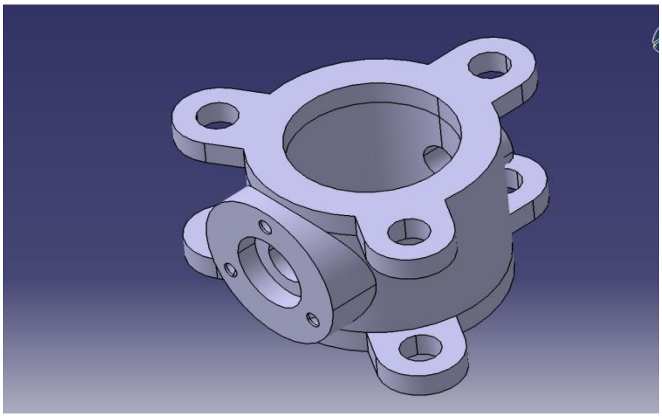

Fig 1. Body of Valve

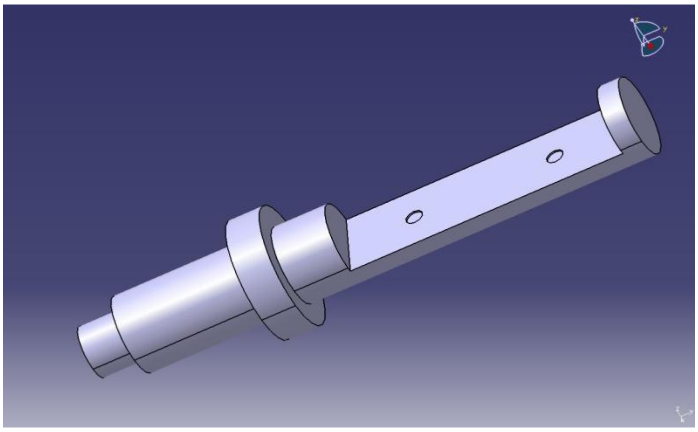

Fig 2. Shaft of Valve

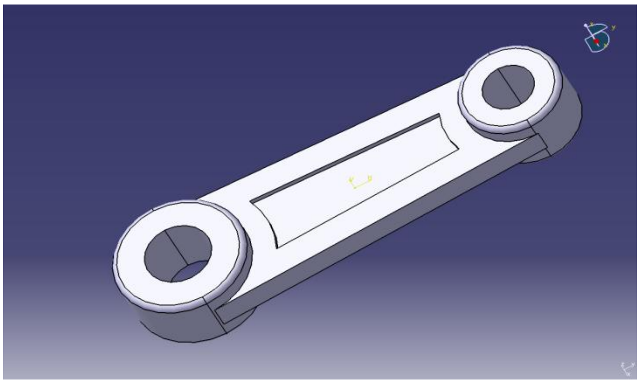

Fig 3. Connecting rod

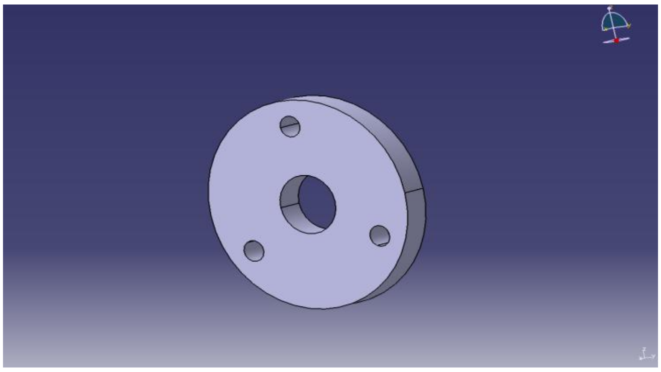

Fig 4. Disc

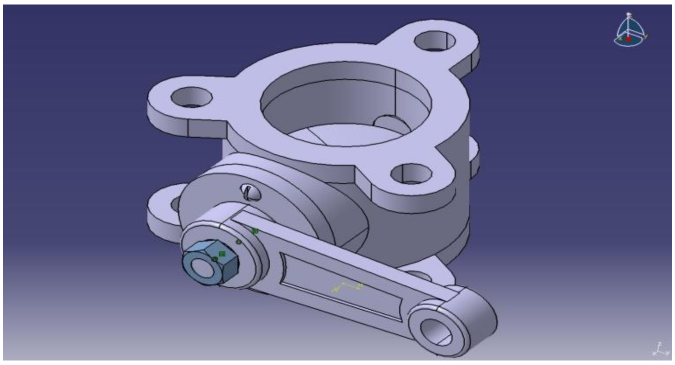

Fig 5. Assembly of Butterfly Valve

2.3.1 Design of Disc of existing Valve:

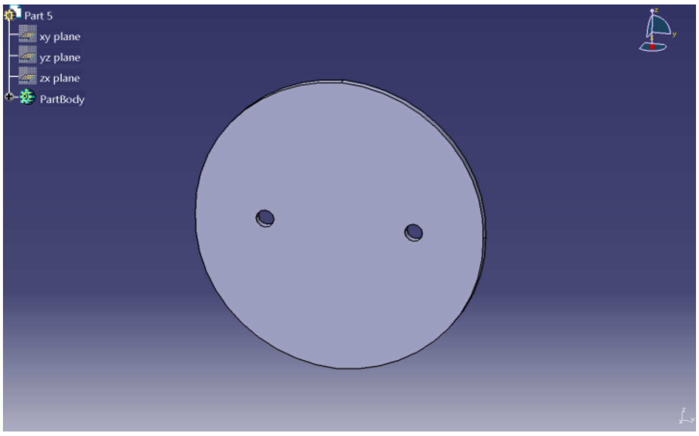

Fig 6. Design of Disc in CATIA V5

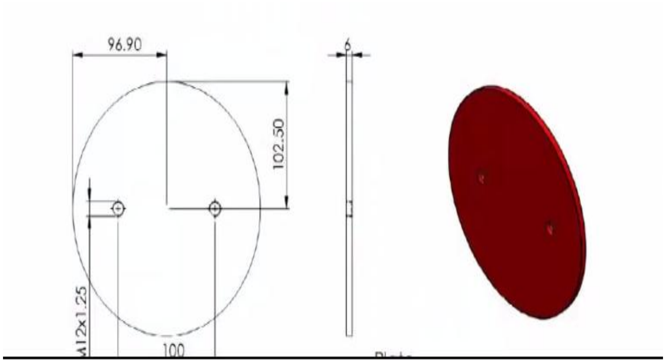

Fig 7. 2D drawing of Disc

2.3.2 Design of new Disc of Butterfly Valve:

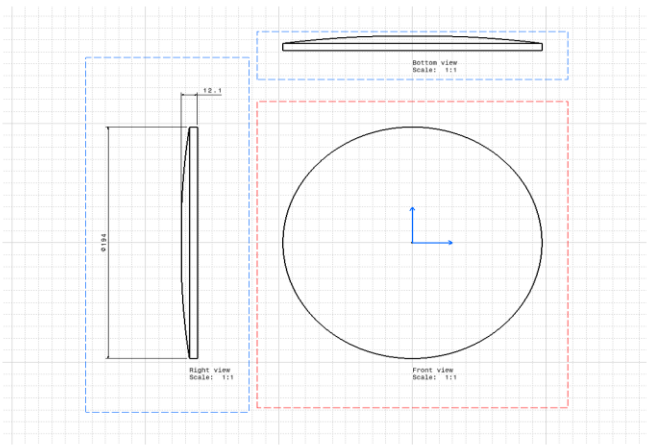

Fig 8. 2D drawing of new Disc

In New design the flat disc is changed to the curved flat. Radius of the disc is 96.9mm. The thickness of the disc is 6mm at the edges and the thickness at the middle is 12mm.

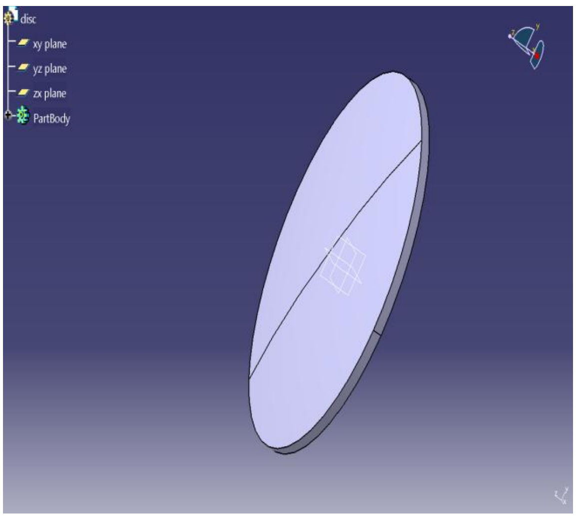

Fig 9. New design of disc in CATIA V5

III. ANALYSIS

The analysis is performed on the Butterfly valve to determine the stress and displacement at particular pressure that act on the disc using ANSYS tool to get the optimized result.

3.1 Introduction to ANSYS:

The ANSYS program developed and maintained by the Swanson analysis system Inc. ANSYS is self-contained general purpose finite element program. the program contain design model imported from other design software, meshing the model and analysis is performed. Main purpose is to achieve the optimized solution for the engineering problem.

The following steps can be performed by ANSYS finite element analysis software:

- Enable us to design the model or import the designed model from the other software.
- Enable us to apply the operating loads or other design conditions they are operating.
- Enable us to know the stress, strain and displacement. We can also know the temperature distributions along the model.
- Enable us to optimize the design, material to reduce the production costs.
- Enable us to do prototype testing in environments if possible.

The ANSYS program has a compressive GUI which mean graphical user interface. The main function of the GUI is to be the user friendly, interactive access commands, easy documentation and also provides the material references. A menu is shows on the screen as the software opens to navigate the user in the easy way through this ANSYS software. In ANSYS software the input can be given by both mouse and keyboard or individually. To the new user a graphical representation is shown, so that the user can easily navigate in the software and easily go through the software. In ANSYS software multiple windows pull-down menus, dialog boxes, tool bar and online documentation can also performed which makes user to understand easily.

3.2 ANLYSIS OF DESIGN MODEL:

To perform analysis the assembly module in the CATIA is imported into ANSYS. The analysis is performed in the ANSYS by changing the material of the disc. Firstly analysis is performed with the existing material of disc with the existing and new design then the analysis is performed with the chosen material for the both the design.

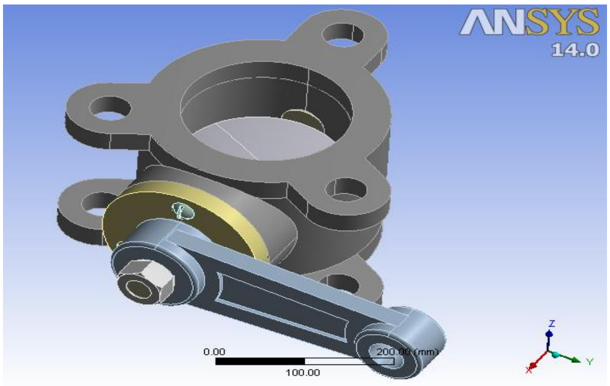

Fig 10. Imported model from CATIA V5.

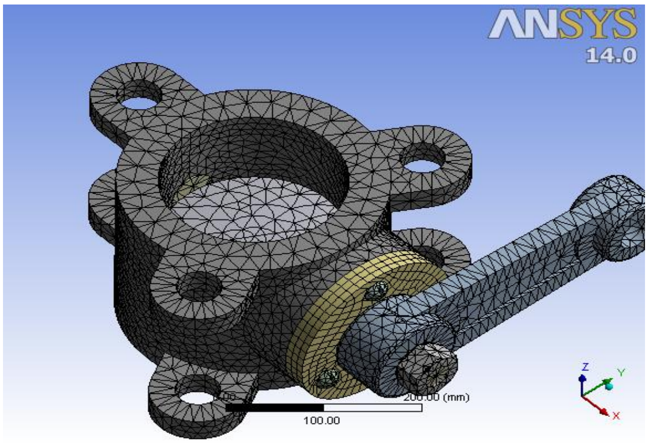

Fig 11. Meshing model.

3.3 Structural Analysis Carbon Steel Disc:

Analysis is performed with existing material Carbon Steel. Properties of Carbon Steel used for Disc are:

- Density : 7850 kg/m3
- Young's modulus : 200e3 MPa
- Poisons ratio : 0.3

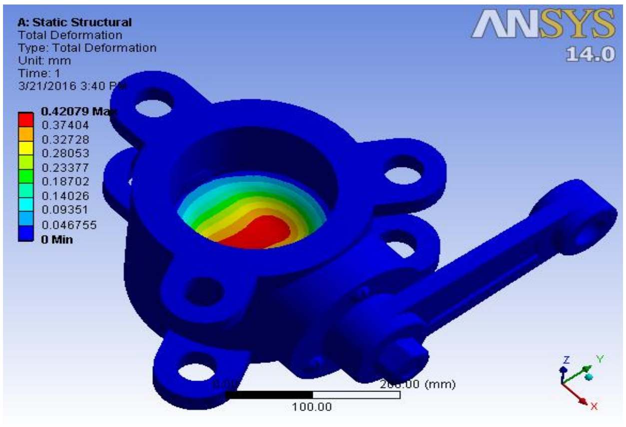

Fig 12. Displacement

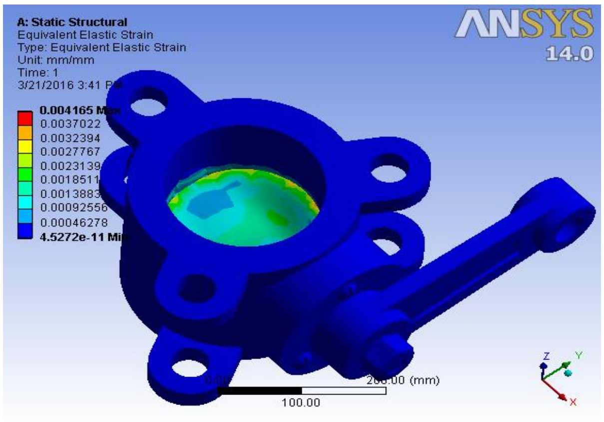

Fig 12. Strain

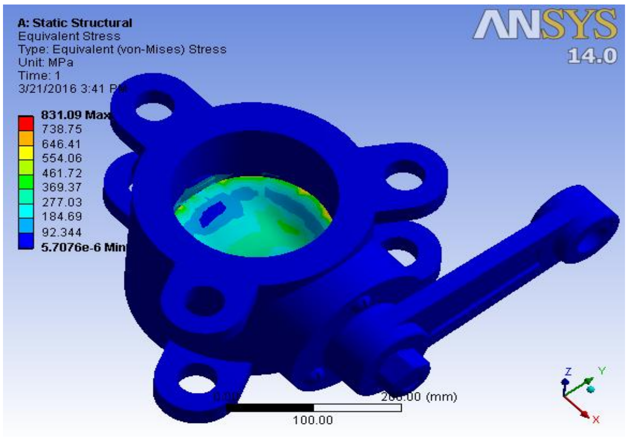

Fig 13. Stress

3.4 Material we are chosen for analysis is:

3.4.1 Titanium bronze disc:

The important factors of Titanium bronze is:

- Light weight.
- Excellent corrosion resistance.

- Having the highest strength-to-weight ratio of any metal.
- They are particularly resistant to corrosion by seawater, in particular in systems where hypochlorite is present to prevent bio fouling.

In a similar manner to stainless steels, titanium alloys gain their corrosion resistance by the development of a protective oxide layer on its surface. The main disadvantage of titanium alloys is their cost. The material is also difficult to process due to its highly reactive nature. Special casting techniques are required to prevent reaction with oxygen during melting and pouring.

3.4.2 Nickel aluminum bronze disc:

Nickel aluminum bronze is a copper-based alloy containing approximately 10% aluminum, 5% nickel and 5% iron.

The important factor of nickel aluminum bronze:

- Provides excellent corrosion resistance, particularly in seawater environments.
- They also strongly resist the formation of a bio-film, which can cause increased corrosion problems in stainless steels.
- Nickel aluminum bronze cost nearly equal to the cost of the basic grades of the stainless steel.

The above shows that many different materials can be used in valve construction. The ultimate choice depends on several factors including service conditions, cost and required life expectancy. When we take the galvanic corrosion issues into the account then Nickel Aluminum bronze is strongly recommended.

3.5 Structural analysis of Titanium Bronze Disc:

Analysis performed with new material Titanium bronze for disc. Properties of Titanium Bronze used for Disc are:

- Density : 7850 kg/m^3
- Young's modulus : 210e^3 M Pa
- Poisons ratio : 0.3

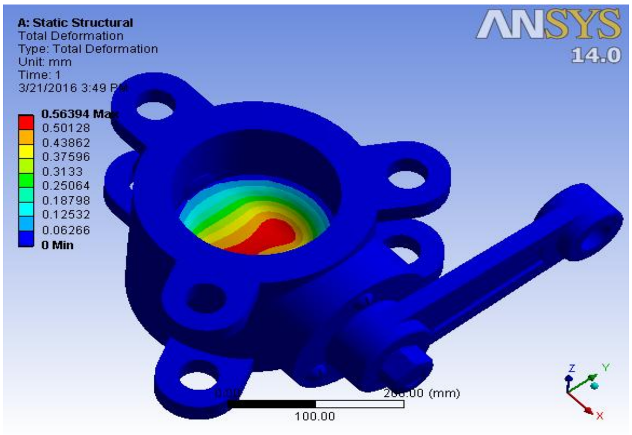

Fig 14. Displacement

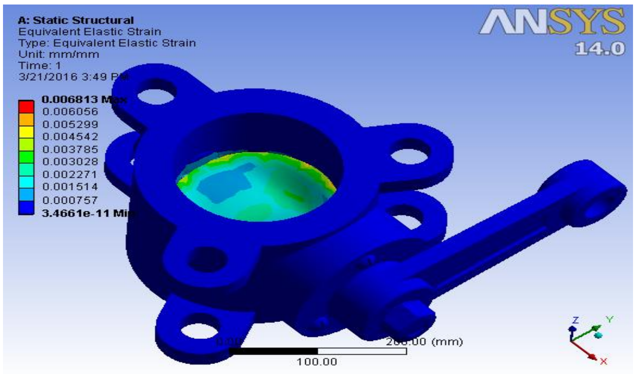

Fig 15. Strain

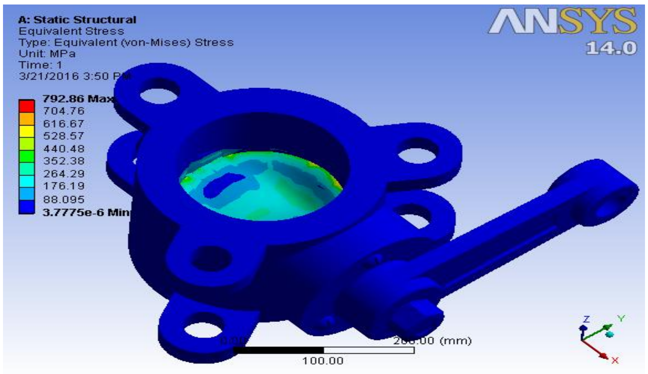

Fig 16. Stress

3.6 Structural Analysis of Nickel Aluminium Bronze Disc:

Analysis performed with new material Nickel aluminum bronze for disc. Properties of Nickel Aluminum Bronze used for Disc are:

- Density : 7690 kg/m^3
- Young's modulus : 117 e^3 M Pa
- Poisons ratio : 0.34

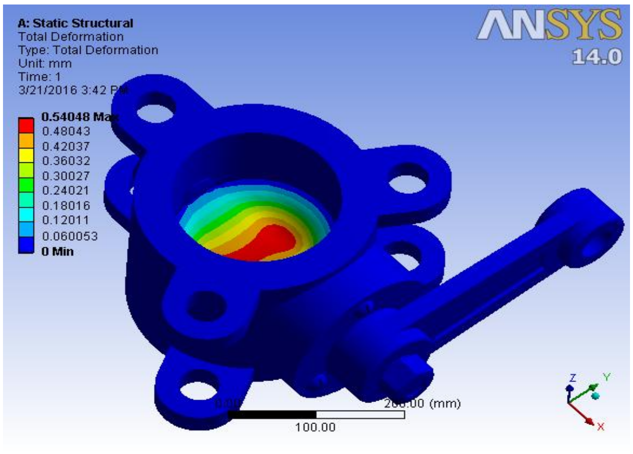

Fig 17. Displacement

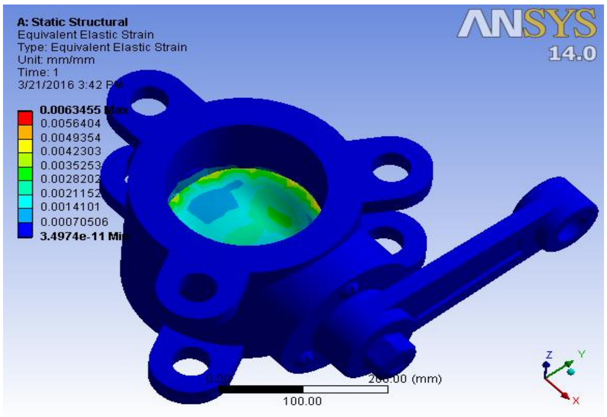

Fig 18. Strain

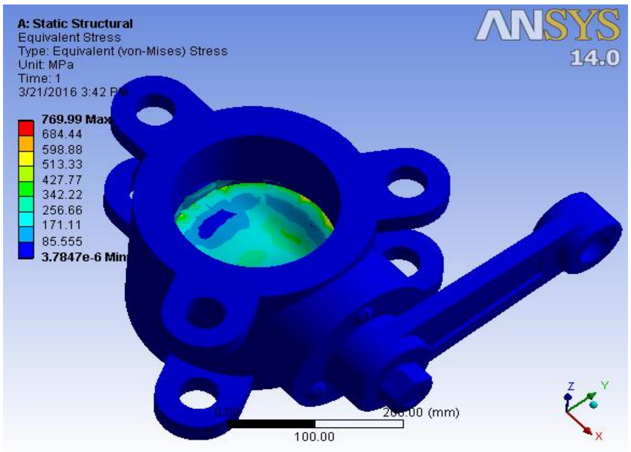

Fig 19. Stress

IV. Results:

4.1 Weight of butterfly valve with existing design:

- Titanium bronze : 92.1924 kg
- Nickel aluminum bronze : 93.574 kg
- Carbon steel : 93.604 kg

4.2 Weight of butterfly valve with new design:

- Titanium bronze : 93.82 kg
- Nickel aluminum bronze : 94.67 kg
- Carbon steel : 94.73 kg

Table:

Material	Displacement (mm)		Stress (Mpa)		Strain	
	min	max	min	max	min	max
Carbon steel	0	0.42	$5.70e^{-6}$	831.09	$4.52e^{-11}$	0.0042
Titanium bronze	0	0.56	$3.77e^{-6}$	792.86	$3.46e^{-11}$	0.0068
Nickel Al bronze	0	0.54	$3.78e^{-6}$	769.99	$3.49e^{-11}$	0.0063

Table1. Comparison of results

V. Conclusions:

From the results it is concluded that the results obtained with new design is best than previous or existing design.

As shown in results the stress value find out with help of carbon steel is 831.09MPa where as stress value obtained with the nickel al bronze is 769.99MPa. And stress value obtained with titanium bronze is 792.86MPa. And also displacement value obtained with carbon steel is more than nickel al bronze and titanium bronze. So from results it is concluded that the best material used for butterfly valve amongst three is nickel Al bronze.

References

[1] Ogawa, K. and Kimura,T. Hydrodynamic characteristics of a butterfly valve – prediction of torque characteristic. ISA Trans., 1995, 34, 327–333. Proc. IMechE Vol. 223 Part E: J. Process Mechanical Engineering JPME236 © IMechE 2009 Downloaded from pie.sagepub.com at DONG A UNIV LIBRARY on July 11, 2011 Analysis and optimization of butterfly valve disc 89.

[2] Huang, C. D. and Kim, R. H. Three-dimensional analysis of partially open butterfly valve flows. Trans. ASME, J. Fluids Eng., 1996, 118, 562–568.

[3] Huang, C. D. and Kim, R. H. 3D analysis of partially open butterfly valve flows. Trans. ASME, J. Fluids Eng., 1996, 118, 562–568.

[4] Park, J. Y. and Chung, M. K. Study on hydrodynamic torque of a butterfly valve. J. Fluids Eng., 2006, 128(1), 190–195.

[5] Danbon, F. and Solliec, C. Aerodynamic torque of a butterfly valve – influence of an elbow on the time-mean and instantaneous aerodynamic torque. J. Fluids Eng., 2000, 122(2), 337–344.

[6] Caillé, V. and Laumonier, J. Effect of periodic aerodynamic pulsation on flow over a confined butterfly valve. Expl Fluids, 1998, 25(4), 362–368.

[7] Wojtkowiak, J. and Ole´skowicz-Popiel, C. Investigations of butterfly control valve flow characteristics. Found. Civil Environ. Eng., 2006, 7, 328–395.

[8] Rao, S. S. Engineering optimization: theory and applications, 3rd edition, 1996, pp. 806–814 (John Wiley & Sons, Inc.).