

Design and Analysis of Butterfly Valve Disc Using Aluminium (1100) and Al-CNT4% Composite Material

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Abstract

Aluminium (1100) is an extensively used material in the application of water line and drainage applications. If the aluminium (1100) surface contacts the water, an oxide layer will be formed and it prevents the corrosion of aluminium (1100) when compared to other metal and also it has less weight. But due to their low melting point and low hardness that will wear and deformed easily and cannot be used for high pressure applications. The metal aluminium (1100) will not meet all the required properties suitable for various engineering applications. The present study uses aluminium alloy or aluminium composite material which has the higher melting point and hardness compare to aluminium (1100). In the present study butterfly valve which is commonly used for water line application was designed by using Pro-E software and analyzed its deflection using Ansys software. For the analysis, two materials such as aluminium (1100) and aluminium carbon nanotube 4% was used and compared these two materials deflections, improvements in behaviors are noted. The results of the study indicates that deflection of Al-CNT4% composite is around 7 times lesser than aluminium (1100). Al-CNT4% is more stable than the aluminium (1100) for the application of butterfly valve disc.

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INTRODUCTION

In our practical applications commonly we use cast iron for water line and sewage application. The cast iron is higher density. So its weight is more, therefore it is a very big problem for transport and handling these metals. Instead of these we use PVC pipes, but commonly it cannot withstand high pressure. Aluminium (1100) is very good material for easy handling because of its low density and also aluminium (1100) has high corrosion resistance. Major drawback of aluminium (1100) is it deforms more, so it cannot withstand high pressure to overcome these behaviors we use aluminium composite which has an enhanced mechanical and thermal properties compare to aluminium (1100). Bayraktar *et al.*, (2010) developed a new aluminium matrix composite reinforced with iron oxide (Fe_3O_4) by using microwave sintering programme; he found that the density of the composite is increased compared to ordinary electrical sintering process (Bayraktar *et al.*, 2010).

Butterfly Valve

A butterfly valve is a valve which can be used for isolating or regulating flow. The closing mechanism takes the form of a disk. Operation is similar to that of a ball valve, which allows for quick shut off. Butterfly valves are generally favoured because they are lower in cost to other valve designs as well as being lighter in weight, meaning less support is required. The disc is positioned in the centre of the pipe, passing through the disc is a rod connected to an actuator on the outside of the valve.

Rotating the actuator turns the disc either parallel or perpendicular to the flow. Butterfly valves are used in all types of pressure applications (Graham Brett *et al.*, 2011).

Metal Matrix Composite

A metal matrix composite (MMC) is a composite material with at least two constituent parts, one being metal. The other material may be different metal or another material, such as a ceramic or organic compound. MMCs are made by dispersing a reinforcing material into metal matrix. For example of carbon fibers are commonly used in aluminium matrix to synthesize a composite. This composite having superior properties of carbon fibers and aluminium. So this composite poses low density and high strength (Eswai *et al.*, 2006).

Carbon Nano Tubes

Carbon nanotubes (CNT) are allotropes of carbon with a cylindrical nano structure. Nanotubes have been constructed with length to diameter ratio up to 132,000,000:1. These are significantly larger than any other materials. These carbon nanotubes are having extraordinary thermal conductivity and good mechanical, electrical properties. So it is applied in nanotechnology, electronics, optics and other fields of material science and technology (Balamurugan *et al.*, 2012).

Eswai *et al.*, (2006) conducted his research on dispersion carbon nanotubes in aluminium powder. By his

results he concluded that mechanical alloying was a promising technique of mixing carbon nanotube with aluminium. SEM results showed that individual nanotubes were well embedded in the aluminium matrix. So here if we want to mix the aluminium (1100) with carbon nanotubes, we should use stir casting method.

Balamurugan *et al.*, (2012) conducted experiments on Aluminium (1100) and they mixed Aluminium (1100) with different percentage (2%, 3% and 4%) of Carbon nano tube using stir casting method. After that they found Aluminium (1100) with 4% of Carbon nanotube (Al-CNT4%) composite properties are increased when compared to Aluminium (1100). They concluded that hardness was increased by 12.75%, yield tensile strength was increased by 25% and Al-CNT4% was thermally more stable than aluminium (1100).

In an another experiment which is conducted by Balamurugan *et al.*, (2012) on Aluminium (1100). In their experiment they mixed Aluminium (1100) with different percentage (5%, 10%, 15% and 20%) of silicon carbide using stir casting method. Finally, they found that Aluminium (1100) with 10% of silicon carbide composite hardness is 18% higher than that of Aluminium (1100) and Aluminium (1100) with 15% of silicon carbide composites showed ultimate tensile strength of about 36% higher than that of aluminium (1100).

MATERIALS AND METHOD

Aluminium (1100) and Al-CNT4% were used for design and analysis of butterfly valve. The aluminium (1100) has density of 2700 kg/m³, elastic modulus of 80 GPa, poisson ratio of 0.33, thermal conductivity of 218 w/mk and coefficient of thermal expansion of 23.6x10⁻⁶/°C at 20-100°C.

According to Balamurugan *et al.*, (2012) physical and thermal properties of Aluminium with carbon nano tube, the coefficient of thermal expansion of aluminium (1100) is 0.045x10⁻⁶/°C at 413°C using automated dilatometer equipment, yield stress is 38.4 MPa and the properties of Al-CNT 4% composite is 0.009x10⁻⁶/°C at 387°C using automated dilatometer equipment, yield stress is 48 MPa. So these details are used for our analysis purpose using Ansys software.

Experimental Procedure

The experimental procedure was having two steps, first was butterfly valve design by using Pro-E software and second was analysis of the valve by using Ansys Software (Laxmikanth *et al.*, 2012) with different material like Aluminium (1100) and Al-CNT4% composite

Design of Butterfly Valve: Butter fly valve having six major parts. The parts are given below.

1. Disc
2. Stem
3. Bolt and nut
4. Body
5. Bush
6. Butterfly valve was designed by using using Pro-E

Disc: Disc is the major portion of butterfly valve to regulate the flow of liquid. It is commonly made of aluminium or cast iron. Disc edge is individually processed through machining and hand buffing for

smooth edge, providing a bubble tight shut off and maximum seat life. Figure 1 shows the diagram of butterfly valve disc. The diameter and thickness used for the butterfly valve disc was 100mm and 20 mm respectively.

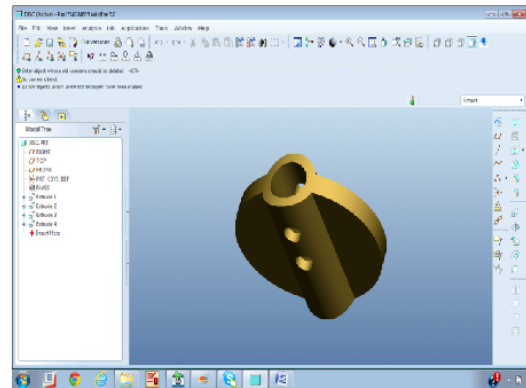


Figure 1: Butterfly valve disc.

Stem: stem extends through disc and aligns socket in body. Stem end has standard dimensions for operator interchangeability. The stem diameter which is used in our study was 30mm.

Bolt and Nut: stainless steel bolt and nut securely holds the disc to stem. O ring seal prevents the leakage in stem area and creates positive connection. The bolt size which is used for the design was M10

Body: The outer body was built with flanges for fixing the bolt and nut. So it is able to fix the required pipe line. Body machined to high tolerances. Guaranteed standard dimensions for interchangeability of parts and actuators. The inner diameter of body was 105mm, outer diameter of body (Flange) was 150mm and the thickness of body was 40mm.

Bush: Bush protects the disc from side thrust. They are made up of impact and corrosion resistant material. Commonly the bush is made by flexible material like Rubber and Elastomers. Figure 2 shows complete assembly of butterfly valve. The inner diameter of bush was 100mm, outer diameter of bush was 105 to 106 mm and the thickness of Bush was 30mm.

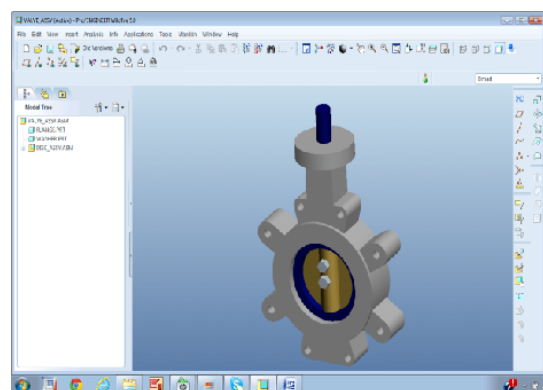


Figure 2: Complete assembly of butterfly valve.

Analysis of Butterfly Valve

The analysis of butterfly valve has two stages. First stage is we want to analysis with aluminium (1100) next we want to analysis Al-CNT4% composite. The ANSYS 12.0 software was used for the analysis purpose.

Aluminium (1100) Analysis

Al-CNT4% Composite Analysis

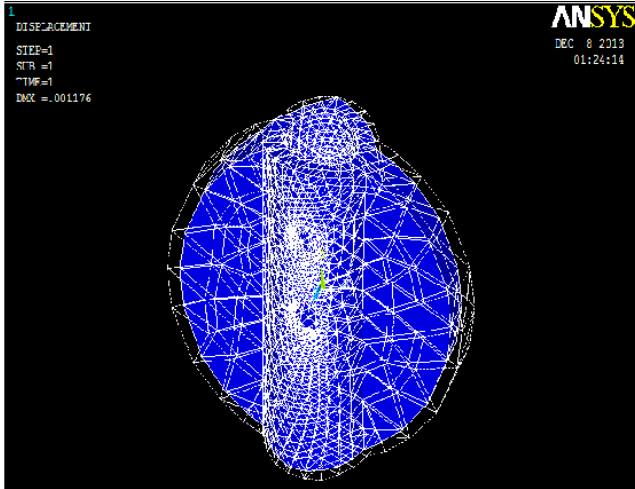


Figure 3: Disc was subjected to 100 N/m² pressure and the maximum deflection was 0.001176m.

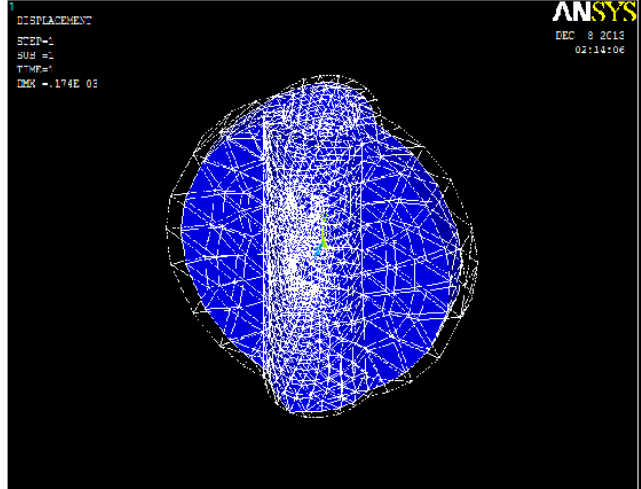


Figure 6: Disc was subjected to 100 N/m² pressure and the maximum deflection was 0.174x10⁻³m.

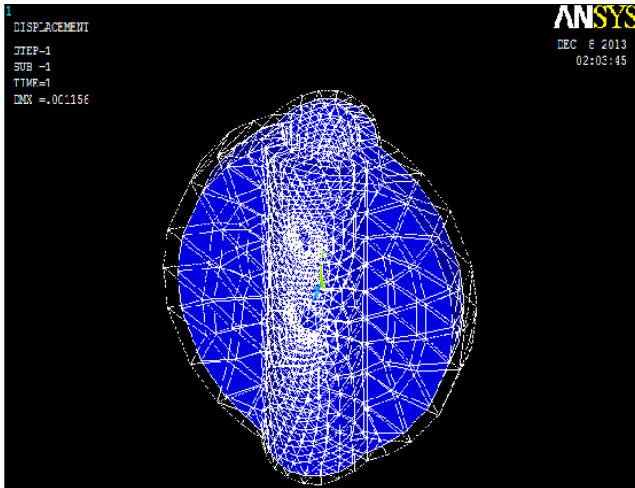


Figure 4: Disc was subjected to 250 N/m² pressure and the maximum deflection was 0.001156m.

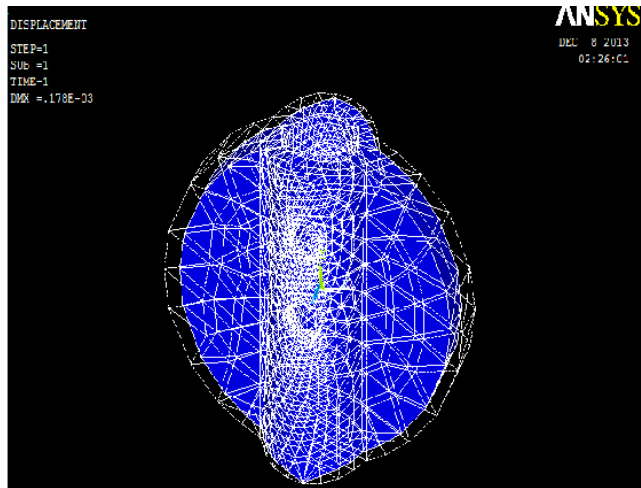


Figure 7: Disc was subjected to 250 N/m² pressure and the maximum deflection was 0.178x10⁻³m.

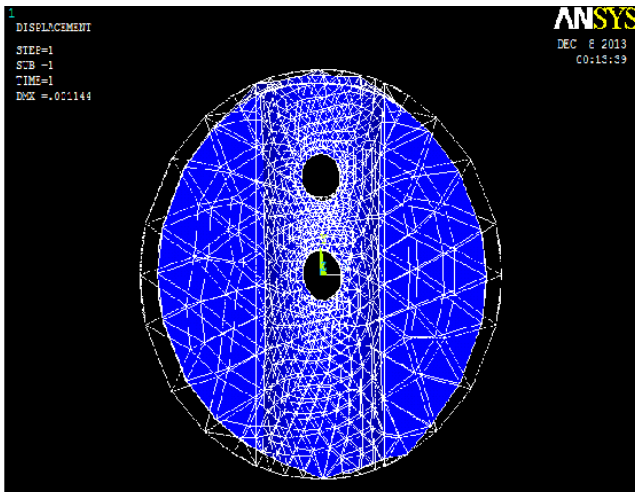


Figure 5: Disc was subjected to 500 N/m² pressure and the maximum deflection was 0.00114m

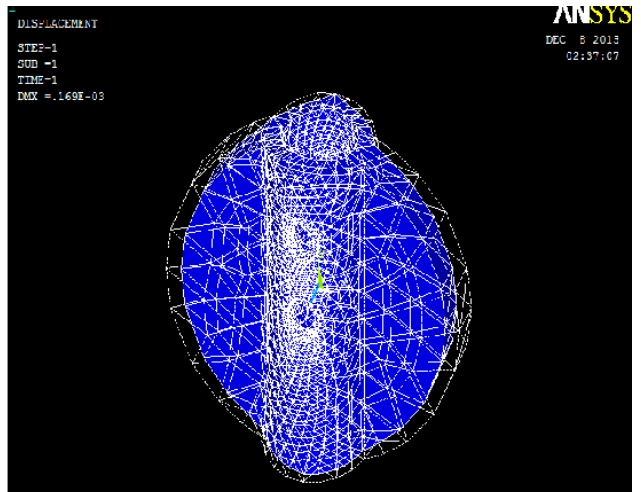


Figure 8: Disc was subjected to 500 N/m² pressure and the maximum deflection was 0.169x10⁻³m.

RESULT AND DISCUSSION

The table 1 shows the details about the maximum deflection of butterfly valve disc for applying different pressure values and using Aluminium (1100) as a material. In aluminium (1100) the maximum deflection of the entire pressure category in my all analysis is almost same, so the value is 0.001176m or 1.176mm.

Table 1: Maximum deflection of butterfly valve disc for applying different pressure values and using Aluminium (1100) as a material.

S.No	Pressure in N/m ²	Deflection in Meter	
		In Meter	In Millimeter
1	100	0.001176	1.176
2	250	0.001156	1.156
3	500	0.001140	1.140

The table 2 shows the details about the maximum deflection of butterfly valve disc for applying different pressure values and using Al-CNT-4% as a material. In the Al-CNT-4% material the maximum deflection of the entire pressure category in my all analysis is almost same, so the value is 0.174x10⁻³m or 0.174mm.

Table 2: Maximum deflection of butterfly valve disc for applying different pressure values and using Al-CNT-4% as a material.

S.No	Pressure in N/m ²	Deflection in Meter	
		In Meter	In Millimeter
1	100	0.174x10 ⁻³	0.174
2	250	0.178x10 ⁻³	0.178
3	500	0.169x10 ⁻³	0.169

The Figure 9 shows the comparative chart of pressure versus deflection for aluminium and Al-CNT4%. According to the table and chart the Al-CNT4% has less deflection compare to aluminium (1100). So Al-CNT4% is mechanically very stable compare to aluminium (1100).

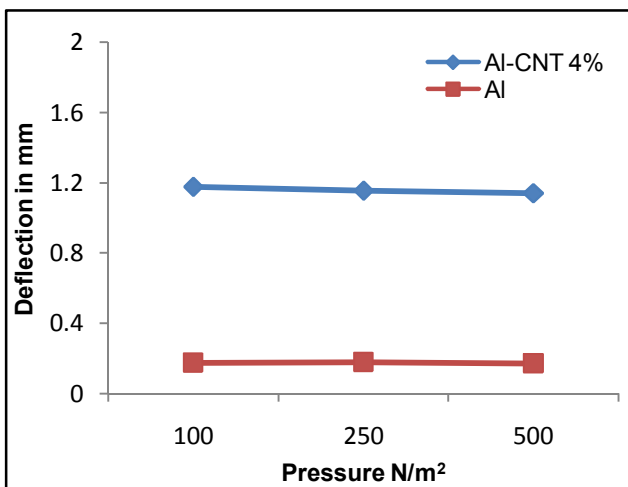


Figure 9: Comparative chart of pressure versus deflection for aluminium (1100) and Al-CNT4%.

In aluminium (1100) the maximum deflection of the entire pressure category in my all analysis is almost

same, so the value is 1.176mm. In Al-CNT4% composite analysis also the maximum deflection of the entire pressure category is almost same, so the value is 0.178 mm. The amount of decrease in maximum deflection is 0.998mm and the percentage of decrease is 84.86%.

CONCLUSION

The result of the present study reveals that the amount of deflection in Al-CNT4% composite is around 7 times lesser than aluminium (1100). So taking deflection in to consideration that Al-CNT4% is more stable than that of aluminium (1100) for the application of butterfly valve disc. Furthermore, study needs further research for standardization and for its application.

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