Static Analysis and Structural Optimization OF Trunnion Mounted Ball Valve by Varying Shell Thickness and Fillet Radius

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Abstract—Valve is a mechanical device which regulates either the flow or pressure of the fluid. Among the different types of valves, high pressure ball valve finds use in certain application like industrial hydraulics and marine hydraulics. The present study involves designing the high-pressure valve of nominal diameter 25mm. This project consists of design & analysis of trunnion mounted ball valve. The project work consists of verification of design of ball component of ball valve. In this project static analysis of ball component is carried out. The stress values are calculated from stress calculations manually first. Then to determine the stresses in software a 3D CAD model created in CATIA V5 software. Again, static analysis will be performed by Varying Shell Thickness and Fillet Radius of ball. The result from static analysis is compared with the experimental results. According to the result comparison if required the design changes suggested to the manufacturer.

Keywords*- Trunnion mounted ball valve, CATIA V5, Shell Thickness, Fillet Radius of ball.*

I. INTRODUCTION

A trunnion mounted valve implies that the ball is compelled by direction and is just permitted to turn. The course follow up on the trunnions which may fundamental to the ball, or might be discrete relying upon the valve structure. The key component is that the ball doesn't move as it does in a drifting valve to press the ball into the downstream seat. Rather, the line pressure powers the upstream seat onto the ball to make it seal. As the territory on which the weight demonstrations are a lot of lower, the measure of power applied ready is significantly less, prompting lower rubbing esteems and littler actuators or rigging boxes. In this task the investigation center is around the structure check of ball, body and stem by diagnostic strategy and approval of it with test results. Additionally, this paper will check the standard act of plan of ball part of valve.

The trunnion ball valve is a type of quarter-turn valve which utilizes an empty, punctured and fixed/bolstered ball to control course through it. A trunnion mounted valve implies that the ball is obliged by orientation and is just permitted to pivot, most of the water driven burden is upheld by the System requirements, bringing about low bearing weight and no pole weakness. The line pressure drives the upstream seat against the fixed ball so the line pressure powers the upstream seat onto the ball making it seal. The mechanical tying down of the ball retains the push from the line pressure, forestalling abundance grating between the ball and seats, so even at full evaluated working weight working force stays low. This is especially favorable when the ball valve is incited on the grounds that it decreases the size of the actuator and subsequently the general expenses of the valve activation bundle. Points of interest of trunnion ball configuration is the lower working force, simplicity of activity, limited seat wear (Stem/ball disengagement forestalls side stacking and wear of downstream seats improving execution and administration life), predominant fixing execution at both high and low weight (a different spring system and upstream line pressure is utilized as the fixing against the fixed ball for low weight and high-pressure applications). The trunnion is accessible for all sizes and for all weight classes however they are not appropriate for choking purposes.

Fig 1 Ball valve

II. LITERATURE REVIEW

Akshay B Ravande et al[1], Ball valves are normally used in funneling framework to control the stream. They are likewise utilized for on/off or choking tasks. Valves are indicated by estimations of their stream coefficient (CV). CV for fluid is only volume of the water at 680F in US gallons every moment that goes through the valve at pressure drop of 1PSI. In the current work, volumetric stream control of water through valve is finished by making distinctive opening of ball ie. 10% to 100% and CV esteems with regarding edges are determined numerically. For computing the CV, right off the bat model of ball valve is set up by utilizing device SOLIDWORKS 2014 and furthermore recreations are completed in SOLIDWORKS

FLOW SIMULATION. From results got from numerical examination, it was discovered that stream rates with various opening points are relative and by decline in pressure drop CV esteems for valve are expanded. In spite of the fact that the ball valve Cv esteem isn't engaged previously, with ongoing patterns in funneling plan progressions its being basic to center these qualities.

S. Bagherifard et al[2], deal with the failure of a sub-ocean ball valve, utilized in an oil-channeling line, is broke down. The valve was of a similar sort and material previously utilized for the development of valves that were worked in administration with no issue. The valve fizzled in the principal pressure cycles during the primer research facility tests, in spite of the fact that the applied weight was not exactly the structure esteem. Metallographic and microstructural investigation of the break surfaces performed by methods for optical and examining electron magnifying instrument (SEM), lingering pressure and hardness estimation, elastic, sturdiness and Charpy tests, were executed so as to recognize the reasons for the failure.

Xue-Guan SONG et al[3], the mechanical and concoction properties of CF8M were concentrated through analyses. An utilization of CF8M in valve body was examined by utilizing limited component method(FEM) to assess the basic wellbeing. An improvement containing a few factors dependent on the reaction surface method(RSM) was led to locate the ideal component of the valve. The outcomes show that utilizing this procedure can spare valve mass just as the computational cost viably. Ball valve has been utilized broadly in different businesses. It is opened by turning a handle connected to a ball inside the valve. The ball has a gap or port through the center, so when the port is in accordance with the two finishes of the valve, the stream will happen. At the point when the valve is shut, the opening is opposite to the closures of the valve, and the stream is blocked. The ball valves are sturdy and as a rule work to accomplish impeccable shut-off considerably following quite a while of neglect.

Peng Liu et al [4], a subsea entryway valve is a critical piece of a subsea Xmas tree framework. An advancement strategy for subsea door valve is proposed dependent on consolidated examination of liquid attributes and affectability. Liquid qualities are examined by means of Computational Fluid Dynamics (CFD) technique to reenact the stream field inside a door valve. So as to check that the CFD examination technique is appropriate to this paper, a subjective analysis has been led. The kind of door valve is favored by consolidating with speed way lines, pressure field dissemination, and entryway twisting shapes. The quantity of affectability examination tests for key plan boundaries of the entryway is decreased by symmetrical exploratory structure. The components influencing the pinnacle stream speed inside the valve and the most extreme twisting of the entryway are resolved. The range strategy is utilized to investigate and assess the factor affectability, and the blend of the base pinnacle stream speed and the decreased most extreme entryway misshapening is gotten. Trial results show that the favored consolidated structure can lessen the pinnacle stream speed in pipes by around 8.0%, with a most extreme door disfigurement decrease of roughly half. This strategy can give another method of improving the stream attributes and structure of valve entryways.

Daniel Moses[5] this paper portrays the disappointment examination of a 1/4 in. metal ball valve that worked broadly in a somewhat opened state. The valve gave indications of extraordinary disintegration and erosion harm and was in the end supplanted because of spillage from the valve body. The disappointment instruments watched are an aftereffect of ill-advised valve choice as well as operational mistake. Synopsis of disappointment causes: The valve was left somewhat open for delayed choking applications. This brought about broad liquid and cavitation disintegration. Rough particles (sand) got installed in the seals. These particles scratched grooves into the ball surface and forestalled appropriate fixing. Saltwater debilitated the metal segments through a de-alloying erosion process. Consumption was additionally sped up by cavitation. Ball valves are not expected for ceaseless choking activities in brutal conditions. Utilization of a globe type valve is suggested for controlling liquid stream rate in this application.

III. Problem Statement

In present research existing pressure valve containing extreme condition flow in which ball valve are subjected to high stress so, to reduce stress at edge cross section fillet radius and shell thickness is to be varied to obtain optimum results.

IV. OBJECTIVES

- Modelling of actual trunnion mounted ball valve in CATIA V5R20 software.
- Analysing for stresses and deformation ball of trunnion mounted ball valve.
- In order to accomplish the objective of weight reduction over existing design, finite element analysis method is used.
- Static analysis will be performed byVarying Shell Thickness and Fillet Radius of ball.
- To calculating the equivalent stress, total deformation and then the weight of optimized trunnion mounted ball valve.
- To perform experimental testing of new, optimize trunnion mounted ball valve model on UTM.
- Experimental testing will be correlated with the founded results.

V. METHODOLOGY

The approach to our design problem is elaborated through the flow-chart given below

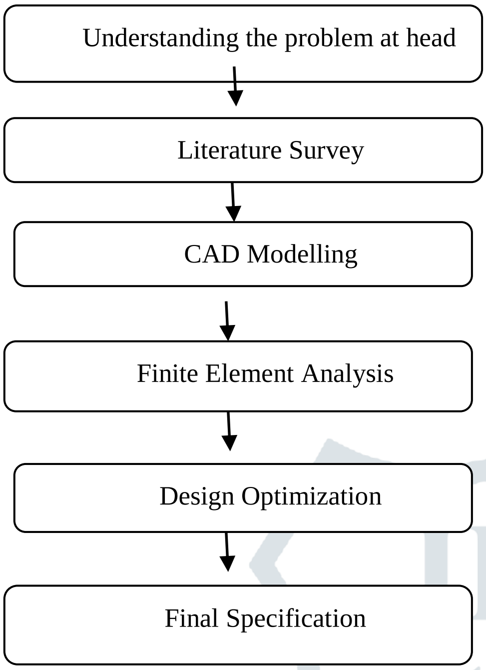


Fig..2 Flowchart for the Methodology

VI. CAD MODEL

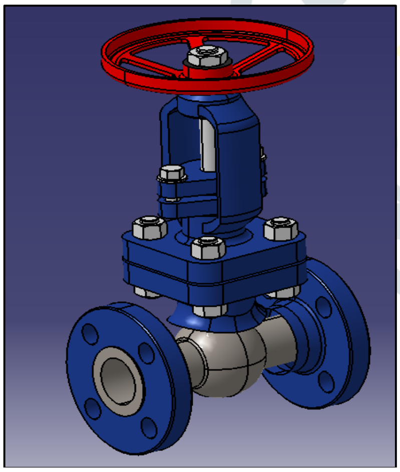


Fig. 3: CATIA model of ball valve

In pressure valve only ball valve is only considered for project to study changeset in radius of ball.

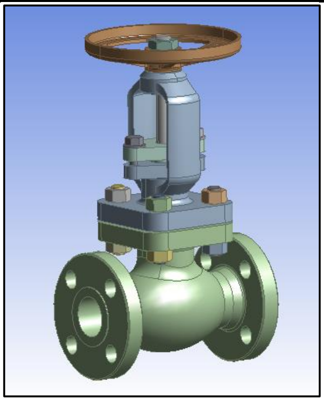


Fig. 4: CATIA model of ball valve

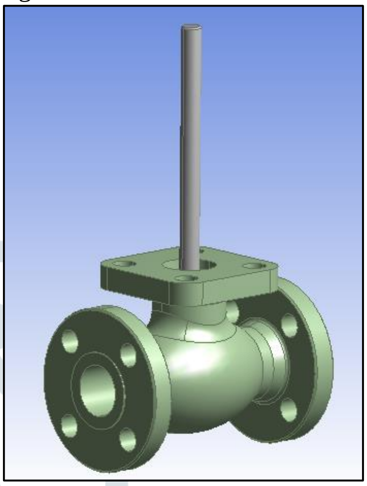


Table. Material properties

Properties of Outline Row 3: Structural Steel

	A	B	C
1	Property	Value	Unit
2	Material Field Variables	Table	
3	Density	7850	kg m^-3
4	Isotropic Secant Coefficient of Thermal Expansion		
6	Isotropic Elasticity		
7	Derive from	Young's Modulus and Pois...	
8	Young's Modulus	2E+11	Pa
9	Poisson's Ratio	0.3	
10	Bulk Modulus	1.6667E+11	Pa
11	Shear Modulus	7.6923E+10	Pa

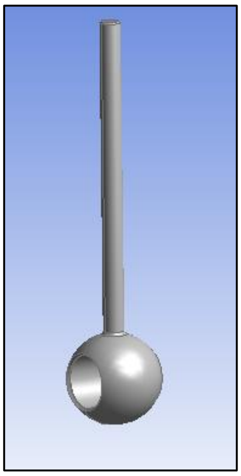
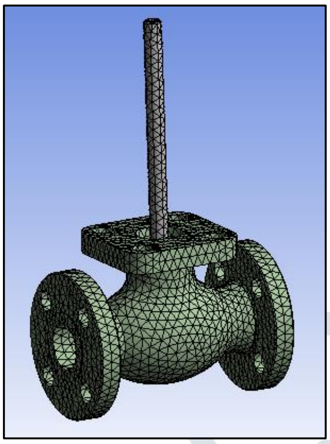


Fig. 5: CATIA model of ball valve inner part

VII. MESH

ANSYS Meshing is a general-purpose, intelligent, automated high-performance product. It produces the most appropriate mesh for accurate, efficient multiphasic solutions. A mesh well suited for a specific analysis can be generated with a single mouse click for all parts in a model. Full controls over the options used to generate the mesh are available for the expert user who wants to fine-tune it. The power of parallel processing is automatically used to reduce the time you have to wait for mesh generation.



Statistics	
Nodes	35175
Elements	20639

Fig. Details of meshing of ball valve

VIII. BOUNDARY CONDITION

A boundary condition for the model is the setting of a known value for a displacement or an associated load. For a particular node you can set either the load or the displacement but not both. In boundary condition internal pressure of 16 MPa on inner surface of inner wall and fixed support at outer surface.

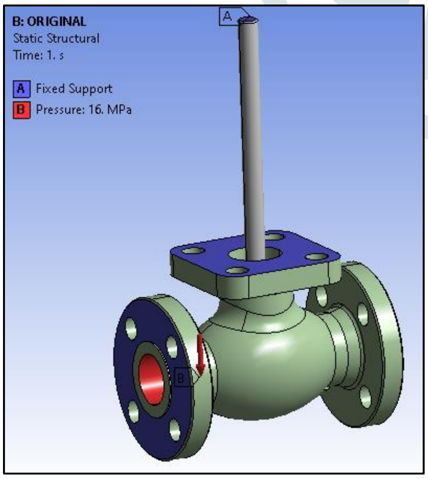


Fig. Details of boundary condition of ball valve

The total deformation & directional deformation are general terms in finite element methods irrespective of software being used. Directional deformation can be put as the displacement of the system in a particular axis or user defined direction. Total deformation is the vectors sum all directional displacements of the systems.

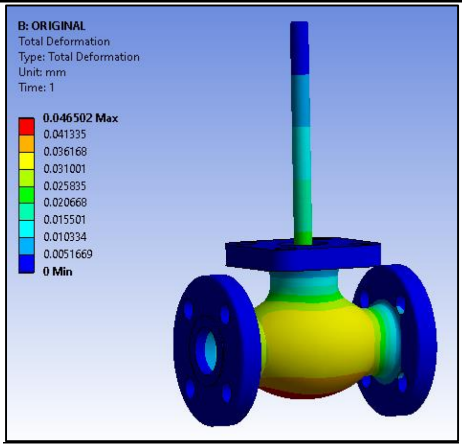


Fig.No.8 Deformation results for ball valve

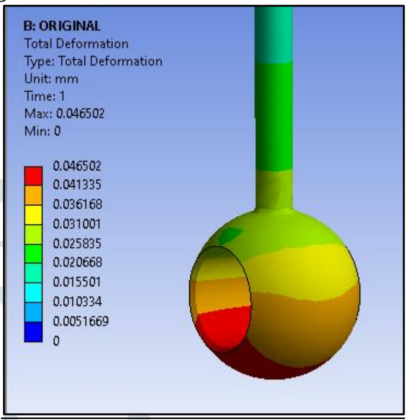


Fig.No.9 Deformation results for ball valve inner part

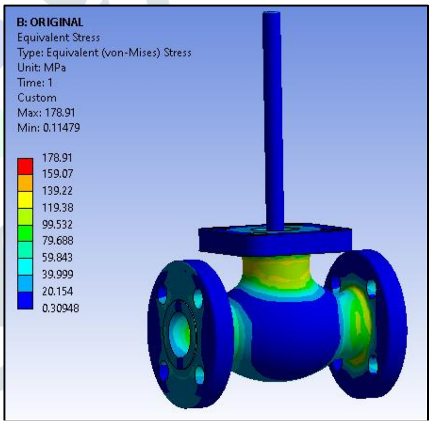


Fig. 10: Von misses stress results for ball valve

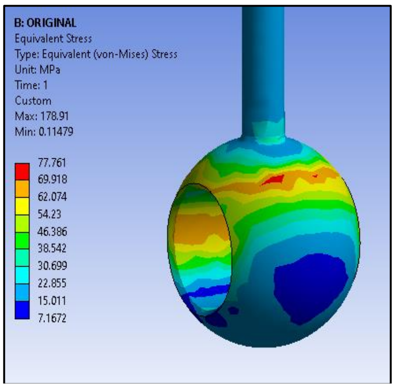


Fig 11: Von misses stress results for ball valve inner part

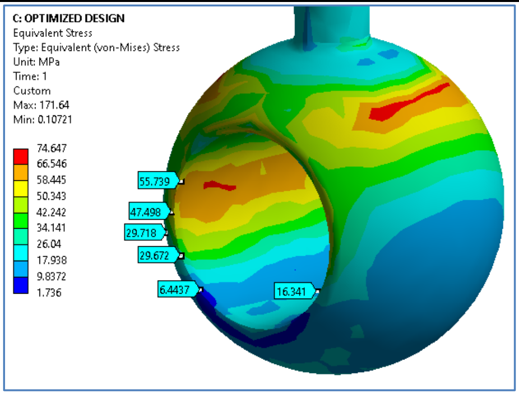


Fig.15 Equivalent stress

Reduction in stress is observed compared to existing design with varying shell and fillet thickness of 3 mm is provided.

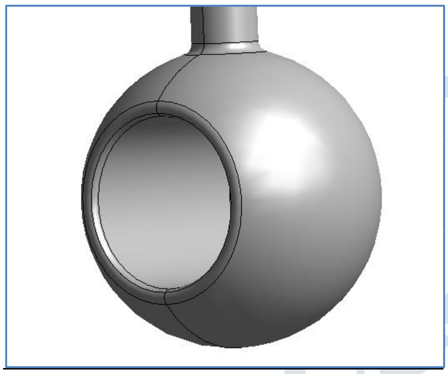


Fig.12 Optimized cad model for ball valve

ANALYSIS OF OPTIMIZED MODEL

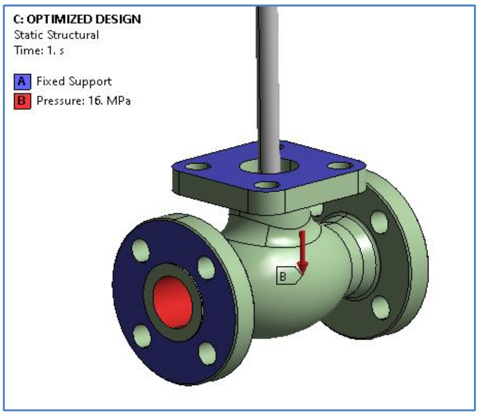


Fig.13 Boundary condition

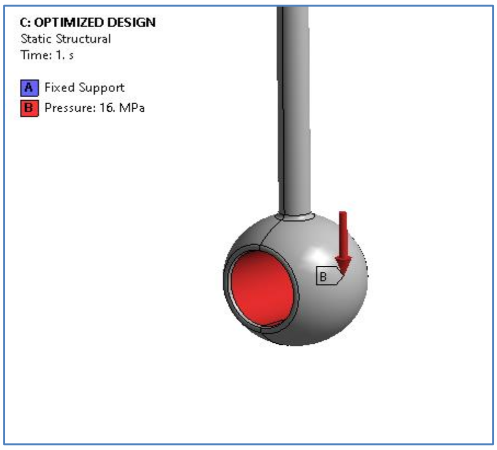


Fig.14 Boundary condition

EXPERIMENTAL FEA

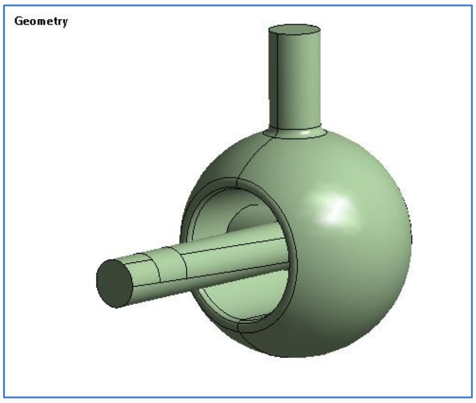


Fig.18 Cad model

To obtain pressure distribution of 16 MPa inside in experimental
To generate pressure of 16 mpa, a rods are welded with equation
Force- pressure x surface area
Surface area of inner surface ball – 8466 mm^2
Force- 16 x 8466
Force – 135.46 kN

Fig.19 Material properties

Properties of Outline Row 3: Structural Steel

	A	B	C
1	Property	Value	Unit
2	Material Field Variables	Table	
3	Density	7850	kg m^-3
4	Isotropic Secant Coefficient of Thermal Expansion		
6	Isotropic Elasticity		
7	Derive from	Young's Modulus and Pois...	
8	Young's Modulus	2E+11	Pa
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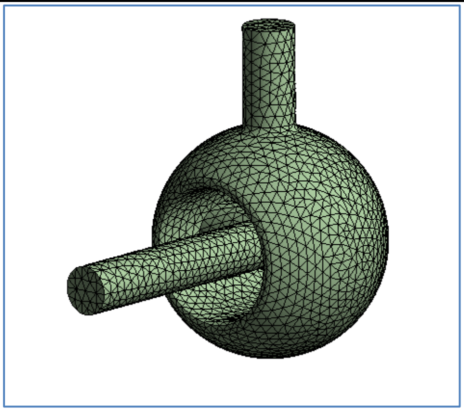

Statistics	
Nodes	48322
Elements	31924

Fig.20 Details of meshing

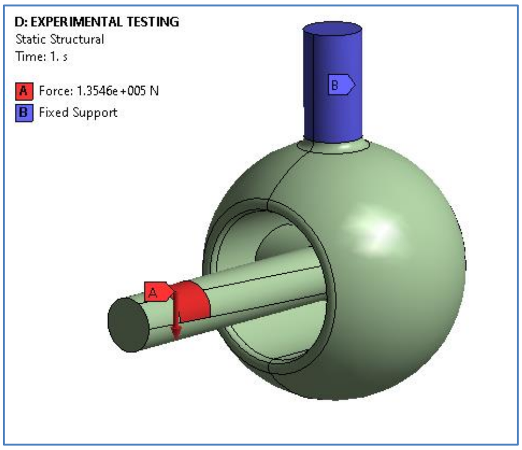

Fig.21 Boundary condition

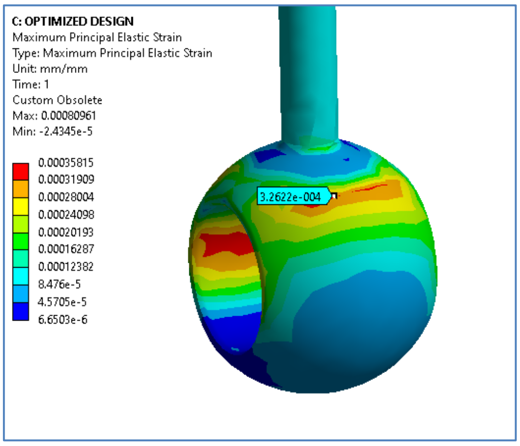

Fig.22 Maximum principal elastic strain

Strain is observed around 326 microns.

EXPERIMENTAL SETUP

A universal testing machine (UTM), also known as a universal tester, materials testing machine or materials test frame, is used to test the tensile strength and compressive strength of materials. An earlier name for a tensile testing machine is a tensometer. The "universal" part of the name reflects that it can perform many standard tensile and compression tests on materials, components, and structures (in other words, that it is versatile). The set-up and usage are detailed in a test method, often published by a standards organization. This specifies the sample preparation, fixturing, gauge length (the length which is under study or observation), analysis, etc.The specimen is placed in the machine between the grips and an extensometer if required can automatically record the change in gauge length during the test. If an extensometer is not fitted, the machine itself can record the displacement between its cross heads on which the specimen is held. However, this method not only records the change in length of the specimen but also all other extending / elastic components of the testing machine and its drive systems including any slipping of the specimen in the grips. Once the machine is started it begins to apply an increasing load on specimen. Throughout the tests the control system and its associated software record the load and extension or compression of the specimen.

Specification of UTM

1	Max Capacity	400KN
2	Measuring range	0-400KN
3	Least Count	0.04KN
4	Clearance for Tensile Test	50-700 mm
5	Clearance for Compression Test	0- 700 mm
6	Clearance Between column	500 mm
7	Ram stroke	200 mm
8	Power supply	3 Phase , 440Volts , 50 cycle. A.C
9	Overall dimension of machine (L*W*H)	2100*800*2060
10	Weight	2300Kg

Fig.16 Experimental testing

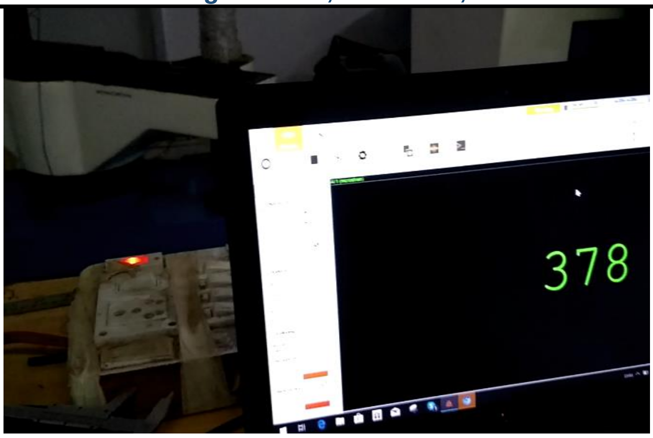

Fig.17 Experimental result

IX. CONCLUSION

- In present investigation static structural analysis of existing pressure valve with ball valve in investigated to determine stress and deformation.
- In next semester shell thickness and fillet radius is to applied with proper design to reduce the exterior stresses at edges with existing maximum stress around 77 MPa.
- By modifying the existing design stress are reduced as well as during experimental testing FEA and experimental strain are 326 and 378 microns respectively.

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