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Finite Element Analysis of Seat Replacement Fixture for 12”- 600# Gate Valve

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Abstract: Gate valve is an element that controls system streamline by opening and closing fluid flow, fluctuating the amount of fluid flow and regulatory direction of fluid. The appellation of the gate is obtained by the presence of the slab gate in the streamline. Gate valves are used for controlling flow of fluid. Because of their ability to cut through liquids, gate valves are used in the industry. Valve seat is one of the main parts of the gate valve. It is used to avoid leakage of fluid, pair of valve seat gets worn after some duration so that working of valve gets affected. There is need for replacement of valve seat after some duration for good working condition of gate valve. The objective of this paper to perform a stress analysis of seat replacement fixture of gate valve. A model of each element of seat replacement fixture is developed in solid works software, and analyzed in ANSYS 11. Stress analysis is done by FEM using ANSYS 11.

Keywords: Gate Valves, Seat, Flow, Lifting

Introduction: A gate valve offers the linear flow of harmful liquids and gasses which are widely used in chemical and petroleum industries. Gate valves are sometimes used for regulating flow, but many times have been designed to be fully opened or fully closed. When fully open gate valve no obstruction in the flow very low friction loss, and fully closed gate valve there are many obstructions in the flow high friction loss. A gate valve is operated by performing when handle wheel be rotated anticlockwise direction, gate will be move in upward direction and valve will open. And handle wheel be rotated clockwise direction, gate will be move downward direction and valve will closed and flow stopped. [11]

Roles of Gate valve are as follows, [6]

- Start and stop flow.
- Increase and decrease of flow.
- Governing the way of flow.
- Control a flow and pressure of whole process.
- Release pipe classification of a certain pressure.

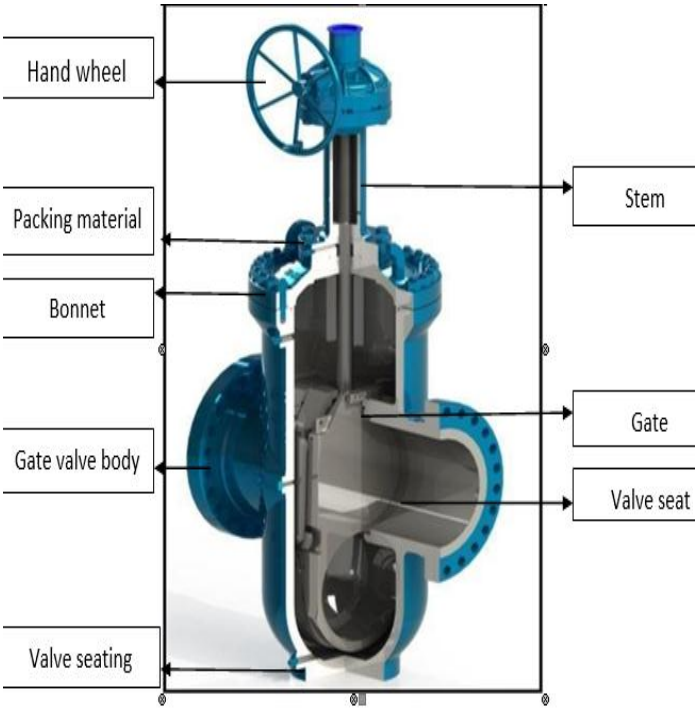

Fig. 1- Gate Valve. [12]

Application of the fixture:

Application of the fixture under consideration is the field of oil and gas. Oil and gas industry deals with the corrosive environment that corrodes the parts and components that are used for various applications. So, there is a need to enhance the product quality that reduces the repairing / replacing cost and unnecessary waste of time. The project is based on seat replacement fixture, designed and developed for spring loaded gate valves, where there is a

need to replace the seat when it gets corroded, previously to replace these seats we need to completely disassemble the valve from the pipeline that is quite costly and time consuming. [4] To overcome these problems, we have designed a seat fixture such that it replaces the seat inline i.e. without disassembling the valve from the pipe line. Various mechanical linkages are used that provide easy in-line seat replacement.

Findings from Literature Review:

Some authors worked on design and development of critical components of gate valve while some authors have done 3D modeling using CATIA and finite element analysis (FEA) of critical parts of gate valve. Some authors have developed new workbench development method. Some authors studied on cavitation coefficient finding.

Some authors studied gate valve working and have done weight optimization of gate valve body and also cost optimization. But no-one has worked on gate valve seat replacement.

Research Issues:

1) Seat is one of the main parts of the gate valves. It is used to avoid leakage of fluid.

2) Valve seat gets worn after some time duration so that working of valve gets affected. There is need for replacement of the valve seat after some time for good working condition of gate valve.

The foregoing objects of the present invention are accomplished and the problems and Shortcomings associated with the prior art, techniques and approaches are overcome by the present invention.

The present invention provides a tool/device that is used for in line maintenance of spring loaded seat slab gate valve. This device is used to remove the seats from the valve in service and replace with new seats. After mounting new seats in seat pocket using this device; the seat position is held by two seat holding pins and holding pins are withdrawn after the gate is inserted into the body.

Problem Definition and Methodology:

A. Problem Definition:

Currently the worn out seat of spring loaded gate valve is replaced from the valve by completely disassembling the valve from the pipeline that takes too much of effort and time. To avoid this we need to design and develop inline seat replacing fixture without disassembling the valve that will reduce the human effort and time.

B. Methodology:

- Study of current situation in replacement of valve seat in valve.
- To study different methods for solving in seat replacement.
- Design of seat replacement fixture.
- Modeling of seat replacement fixture.
- Structural analysis and finalize the design of fixture.
- Manufacturing of seat replacement fixture.
- Testing of seat replacement fixture.
- Implementation of seat replacement fixture.

Study Parameters for Design Parts of Seat Replacement Fixture:

The studying performed 12" 600# pressure slab gate valve. Studying all dimensions of valve body and seat properly, to design the parts of seat replacement fixture. As we know that simulation is a very useful technique as we can get a design that is cost effective and less in weight. Initially we designed a model that meets all our functional requirements thereafter we focused on optimizing the design and check for safety. [2]

We design 5 different models with different thicknesses by using trial and error method.

There were two options either to make a prototype model and validate the design or to first simulate the model using software. As the later one is cost effective so we decided to first validate the model using ANSYS software and then manufacture the best suitable model.

Given:

Total height of valve body = 1073 mm.

Total width of valve body = 838 mm.

Distance between two seats from valve body = 165 mm.

Diameter of seat = 370 mm.

Weight of seat = 5.70 kg.

Force Calculation:

Spring force calculation of valve seat

Given:

1 spring carrying = 33 kg. load

Number of springs in seat = 64

Total load = 33*64

= 2112 kg.

Total load carrying valve seat = 2112 kg.

Introduction to Solid Works:

Solid Works is a solid modeling computer-aided design and computer aided-engineering computer program that runs on Microsoft Windows. Solid Works is published by Dassault system. Solid Works supports multiple stages of product development, including conceptualization, design (CAD), engineering (CAE) and manufacturing (CAM). Solid works enables the certain of 3D parts from 3D sketches, sheet metal, composites, molded, forged or tooling parts.[9]

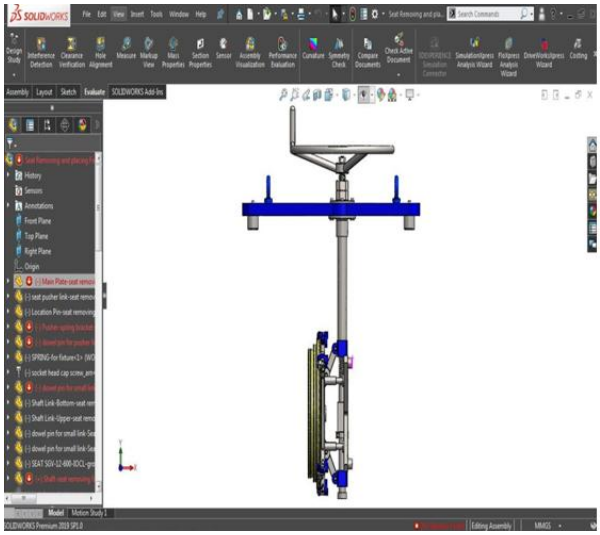

Fig 2 Solid Modeling of fixture

The software provides advanced technologies for mechanical surfacing and BIW. It provides tools to complete product definition, including functional tolerances as well as kinematics definition. Solid Works provides a wide range of applications for tooling design, for both generic tooling and mold and die. In the case of Aerospace engineering an additional module named the aerospace sheet metal design offers the user combine the capabilities of generative sheet metal design and surface design.

Modeling of seat replacement fixture component:

The various components of seat replacement fixture are as follows –

- Seat guide plate
- Shaft guide plate.
- Top plate.
- Stem.
- Seat puller.
- Tube.
- Seat puller bracket.

Material Selection:

While selecting the material for the fixture our main focus was on cost reduction and light weight. There were various options available like AISI 1018, AISI4130, mild steel etc. but we know that application of the fixture is not so intensive and also the load acting on it will be static load, therefore we went for AISI 1018 material as it is easily available, cheap in cost, good machinability and also good weldability when compared to mild steel, on the other side mechanical strength of AISI 4130 is good as compared to AISI 1018 but the cost was one and a half times more for AISI 4130 material therefore here also we decided to go with the AISI 1018 material. Finally we selected AISI 1018 material for our consideration and further analysis were performed on the same material to decide dimensional parameters and weight reduction techniques

Static structural analysis:

Structural analysis is the determination of the effects of loads on physical structures and their components. Structures subject to this type of analysis include all that must withstand loads, such as buildings, bridges, vehicles, furniture, attire, soil strata, prostheses and biological tissue. Structural analysis employs the fields of applied mechanics, science and applied mathematics to compute a structure's deformations, internal forces, stresses, support reactions, accelerations, and stability. [8] The results of the analysis are used to verify a structure's fitness for use, often precluding physical tests. Structural analysis is thus a key part of the engineering design of structures.

Analysis steps: -

Step 1: Pre-processing

Pre-processing is divided into various steps -

Firstly, the model that was designed in Solid works software is saved in IGES format. Then this file is imported to ANSYS workbench and opened in design modular. There after we defined names to the respective parts.

The next part is to assign the material properties that were done in engineering data; we have all the required mechanical properties for the material that is assigned for the respective parameters. Then the file was opened in mechanical window where all the remaining activities are performed, that starts with meshing the file. Meshing means discretization of the parts in which all the parts are divided into small elements and calculations are performed on this element. The accuracy of the results depends on the quality of the mesh hence it is very much important to have an optimized mesh to get a correct result. Therefore to generate a good quality mesh we used various meshing techniques like, and then checked the mesh quality in mesh matrices.

The next step is to apply the boundary condition to the fixture. Deciding a correct boundary condition is also an important part from engineering point of view as different boundary conditions may exist for the same problem, so we have to design for the worst condition. For our case variable force will be acting on the seat due as the spring force is not constant it varies as per spring constant and the number of spring used in the seat. The maximum spring force required as per design calculation is around 2000 Kg, therefore from safety point of view we have assumed the reaction force acting on the spring as 2500 Kg, and this force will act on the area where the fixture will rest on the seat, the direction of the force will be parallel to the flow bore. The opposite side of the fixture that will rest on the seat of the other side is defined as fix support. So, these are the two boundary conditions assigned to the fixture. Then we need to decide the parameter that need to be validated. In our case we need to verify the stress generated in the parts and the total deformation caused due to the applied boundary conditions. For this we have selected the stress and total deformation values as our required results.

Step 2: Processing

The next step is to solve the above assigned problem. This step is performed by the computer processor, the time required to solve the problem depends on your CPU memory and number of elements generated while meshing. The calculation is performed for each and every element using the partial differential equation that is pre-defined into the software and the results are generated.

Step 3: Post processing

After solving the model, the generated results that are stress and total deformation values are displayed on the screen that is analyzed to validate the results.

NOTE – All these three steps are performed for all the five iterations and the results are compared to get an optimized solution.

The first two steps i.e. pre-processing and processing is same for all the case but the third step i.e. post processing that displays the results will show the different values for stress and deformation that will used for result comparison.

Calculation for Factor of Safety:

Syt = 265 Mpa.(Material yield strength)

Sw = 144 Mpa. (Working stress)

Factor of safety = 1.84

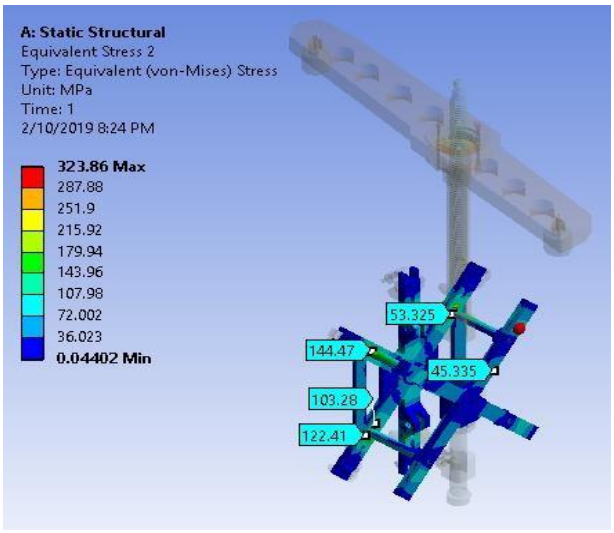

Fig. 3- Stress value of selected fixture model.

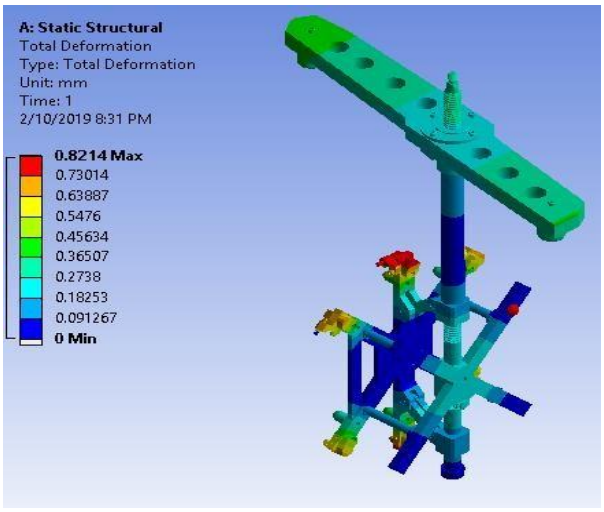

Fig. 4- Deformation value of selected fixture model.

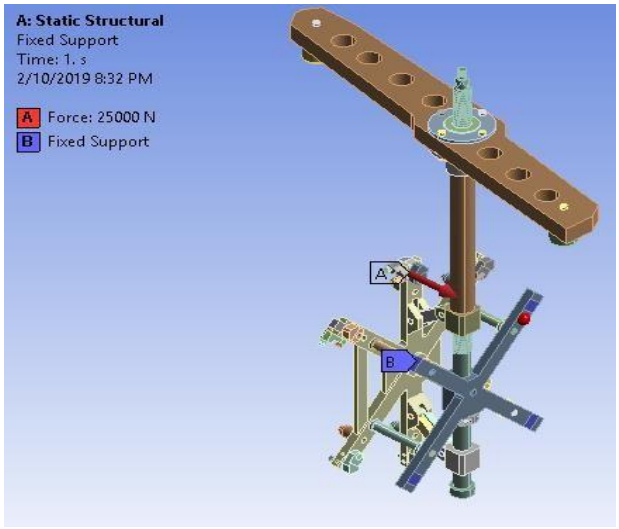

Fig. 5- Force apply fixture model.

Results:

Test results for all the iteration are the compiled and evaluated for the better and safe design. All the results are shown in table given below –

ITERATION NUMBER	STRESS VALUES (MPA)	DEFORMATION VALUE (mm)
1	266	0.8268
2	514	5.6885
3	280	1.269
4	144	0.8214
5	266	0.3806

Table 1

From the above table we can see that the stress value for iteration number 4 is less than the others at the same time the deformation value for iteration number 5 is less i.e. 0.3806mm but the deformation value for model 4 with less stress value is 0.8214 that has negligible difference when compared from iteration no. 4. Hence, we decided to finalize the iteration number 4.

Conclusion:

The previous method of seat replacement which we need two or three workers to disassemble the complete valve from pipeline that is more time consuming (8-12) hours. New seat replacement ````fixture design it has become easy and less time consuming (2-4) hours. A single worker with the help of crane, to replace the seat in-line without completely disassembling the valve from pipeline.

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References:

[1] I.R. Chinyaev, A.V. Fominykh, E.A. Pochivalov, Method for Determining of the Valve Cavitation Characteristics, International Conference on Industrial Engineering, ICIE 2016, Procedia Engineering 150 (2016) 260 — 265

[2] M.M. Zakirnichnaya, I.M. Kulsharipov, Wedge Gate Valves Selected during Technological Pipeline Systems Designing Service Life Assessment, International Conference on Industrial Engineering, ICIE 2017, Procedia Engineering 206 (2017) 1831—1838

[3] Luis Alberto Breda Mascarenhas, Jefferson de Oliveira Gomes, Andrey Teixeira Portelaa, Cristiano Vasconcellos Ferreirac, Reducing the development life cycle of automotive valves and seat valves using a new workbench for high temperature wear testing, The 22nd CIRP conference on Life Cycle Engineering, Procedia CIRP 29 (2015) 833 — 838

[4] Pujari A.A, Joshi G. S., Analysis and design optimization of 8- 600# gate valve body using FEA and stress analysis, International Journal of Research in Engineering and Technology, ISSN: 2319-1163 | ISSN: 2321-7308

[5] M.M. Tverskoy, V.N. Andrianov, A.V. Sokolov ;Creating New Generation of Actuators for Shut-off and Control Ball Valves with Double-Gate, International Conference on Industrial Engineering, ICIE 2017, Procedia Engineering 206 (2017) 1303—1308

[6] Satish M. Silaskar, Dr. Vilas B. Shinde, Weight Optimization of Valve for Cost Effectiveness: Using Value Analysis, 2nd International Conference on Materials Manufacturing and Design Engineering, Procedia Manufacturing 20 (2018) 329—337

[7] K.H.Jatkar and Sunil S. Dhanwe, Finite Element Analysis of Gate Valve, Asian Review of Mechanical Engineering, ISSN 2249 - 6289 Vol. 2 No. 1, 2013, pp.44-49

[8] Shashank S. Jadhav, Design of M-Type Gate Valve, International Journal of Science and Research (IJSR), Volume 3 Issue 11, November 2014 ISSN (Online): 2319-7064

[9] Mr. Satish M. Silaskar, Prof. (Dr.) Vilas B. Shinde, Investigation of Valve by Value Engineering for Sustainability, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 13, Issue 1 Ver. IV(Jan. - Feb. 2016), PP 118-123

[10] Mr. Nikhil Yashwant Katkar Prof. R. S. Kulkarni, Prof. Pratik Ashok Patil, Mr. Sourabh Eknath Katkar, A Review on Design and Analysis of Gate valve using Various Computer Aided Techniques, IJIRST —International Journal for Innovative Research in Science & Technology| Volume 3 | Issue 10 | March 2017 ISSN (online): 2349-6010

[11] https://en.wikipedia.org/wiki/Gate_valve

[12] http://gpi.co.in/

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