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Design and Contact Stress Analysis for Fixture Design of Pressure Valve Plate

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ABSTRACT
The fixture designing and manufacturing is considered as complex process that demands the knowledge of different areas, such as geometry, tolerances, dimensions, procedures and manufacturing processes. Milling fixtures must be sturdy, with relatively large locating and supporting areas and strong clamp. Work piece deformation is unavoidable due to its elastic/plastic nature, and the external forces impacted by the clamping actuation and machining operations. Deformation has to be limited to an acceptable magnitude in order to achieve the tolerance specifications.The forces for which the fixtures are analysed are external loads. The external loads comprise of cutting forces, the weight of the part and fixture and inertia forces. With modern analytical and computational techniques it is often possible to estimate the stresses to which a component is subjected in service. This in itself is not sufficient for the reliable prediction of component performance. Indeed, in many cases where unexpected failure has occurred, this has been due to the presence of residual stresses which have combined with the service stresses to seriously shorten component life. The stresses at the contact point are computed by means of the theory of Hertz. This theory provides mathematical expressions of stresses and deformations

KEYWORDS: *Hertzian contact theory, Fixtures, Contact stresses, Locators*

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I. PROBLEM DEFINITION & OBJECTIVE

- This project involves study of contact stresses acting on a valve plate and fixture during machining and the approach used is Hertzian contact theory. The contact stresses will be predicted theoretically with this approach. These results will be validated by comparison with the analysis results (Contact stress analysis) using software packages (Ansys, hypermesh)
- Fixture design to achieve higher accuracy of valve plate and minimise errors due to previous process
- The contact pressure acting on the valve plate and therefore on fixture has been found which are due to cutting operation, spindle torque & self-weight. Hence the Objective of the project includes;
- Static analysis of fixture for reaction loads and pretension loads & identification of stress zones and deflection plots of fixture holding valve plate
- Contact stress estimation through Ansys between fixture and valve plate and its theoretical validation

II. FIXTURE FOR REFERENCE MILLING AND DRILLING

Number of different fixtures was used to carry out the sequence of operations to achieve valve plate as per the requirement of EATON Pvt Ltd. The different operations (OP) carried out on valve plate are the following:
OP20-Reference milling and drilling (1st setup)
OP30-Main milling (2nd setup)
OP40-Milling of ports (3rd setup)
OP50-Finish machining setup
OP60-Break sharp edges to 0.25mm
OP70-Deburring
OP80-Marking for traceability
OP90-Inspection
OP100-Anodizing
OP110-Assembly
OP120-Pressure testing

The above following operations were carried out using different fixtures for different operations; the time required for each operation depends upon the setup time, loading of material, machining time, skill of labour, finishing operations and unloading of the part. Large number of operations on different faces of the component demands specific types of fixtures which can provide ease while machining. Pressure valve plate was machined using fixture as shown in fig.1, this fixture contained two points for holding which is provided with help of screw and boss of valve plate is supported by fixture plate and clamped with help of bolt and nut, the operation OP20 carried out using this fixture was reference milling and drilling.

2.1. Elimination of fixture for OP20

Due to non-uniform and complex geometry of valve plate it is difficult to find the point of locating and holding the valve plate, and also the means by which the valve plate is supported or being hold, in the above case screw was provided for positioning the part and the operator was allowed to adjust the part. Due to manual adjustment and improper positioning, the valve plate while machining used to slide and move from its actual position which affected machining operation. As this operation was initially done taking in account the drawing provided by the customer (EATON) but the final drawing of the valve plate does not include such a requirement. The unnecessary operation of reference milling and drilling was then eliminated as shown in fig 2.

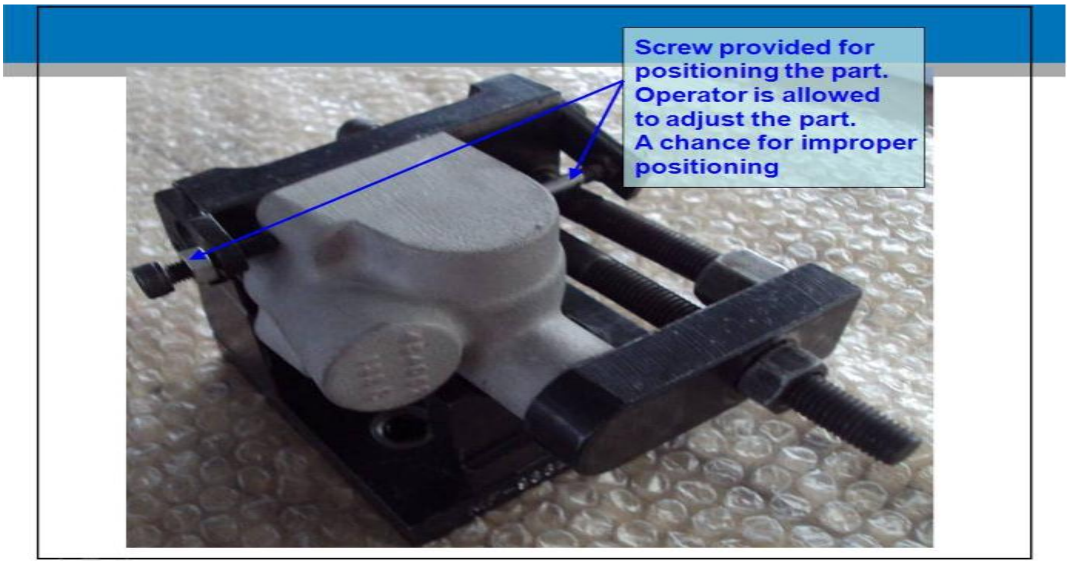

Fig 1: Fixture for reference milling and drilling

[1] In the existing fixture the locating points are not taken as per drawing while designing the fixture
[2] The target points given in the drawing are not considered for location
[3] And the supporting / resting face is not considered as per drawing

Fig 2: Eliminated operation 20 and fixture setup

2.2. Fixture for milling 2nd setup

Fixture for holding valve plate casting while carrying out OP30 (milling) , the valve plate is held and supported with the help of the nut and bolt at one end and is rested at the other end as shown in fig.3. In the existing fixture, the valve plate is supported with nut and bolt on the cylindrical surface due to which the valve plate tilts while carrying out the machining operation and tends to cause error in the dimensions of valve plate, which increases the rejection rate, machining cost and machining time. The bolt provided for supporting the valve plate was adjustable and mainly depends upon the operator's skill while fixing the valve plate in fixture. The placing of valve plate too tightly by nut and bolt adjustment causes deviation while machining which again leads to error.

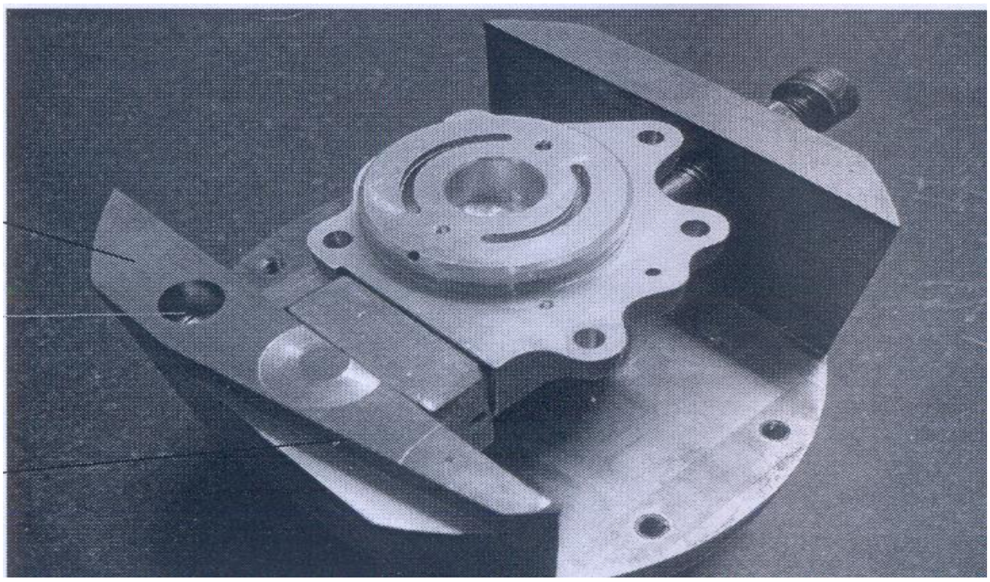

Fig 3: Fixture for milling 2nd setup

III. DETAILED DRAWING AND SPECIFICATIONS OF NEW FIXTURE AND ITS PARTS

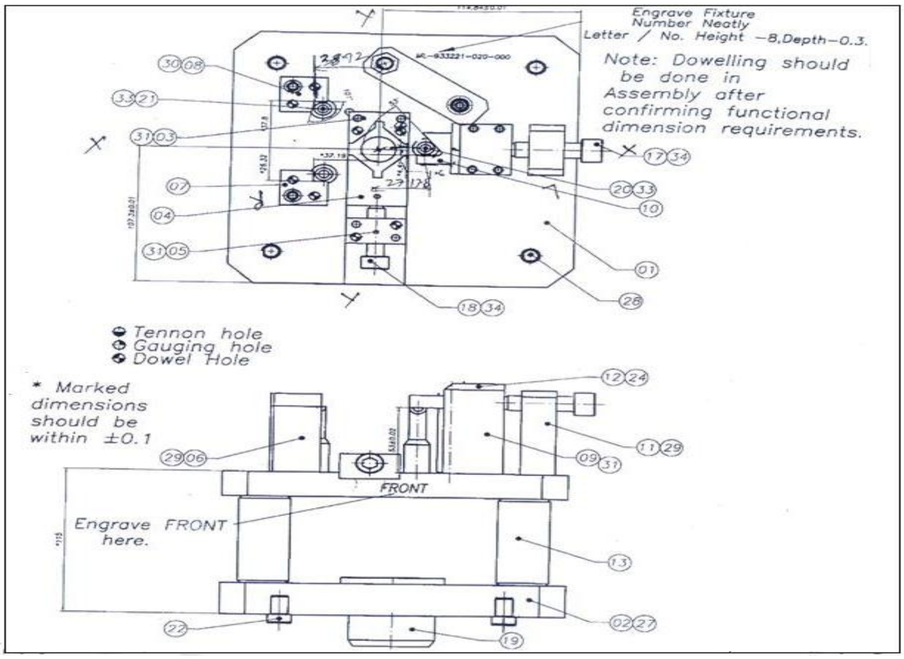

Fig 4: Detailed drawing of fixture assembly

IV. REDUCTION IN NUMBER OF SETUPS AND CONSTRUCTION OF NEW FIXTURE

Fixture for reference milling and drilling (OP20) is eliminated as the final geometry of the valve plate does not demand such a requirement, thus reducing the 1^{st} setup which saved machining cost and time, which also ensure on time delivery and customer satisfaction. OP20 is replaced by 2^{nd} machining setup with new fixture and sequence of operations. The revised sequence of operation is given below:

OP20-Milling (1st setup)
OP30-Milling of ports (2nd setup)
OP40-Finish machining setup
OP50-Break sharp edges to 0.25mm
OP60-Deburring
OP70-Marking for traceability
OP80-Inspection
OP90-Anodizing
OP100-Assembly
OP110-Pressure testing

Therefore a corrective action is taken and a new fixture is designed as shown in fig.5 with the help of following considerations:

1. The new fixture made as per the conceptual design with the help of tool design
2. Target points and resting/supporting points considered as per the part drawing
3. Manual adjustment by operator not permitted
4. Two fixed locators and one adjustable locator provided
5. CNC program changed to suit the new process

Fig 5: New fixture for OP20

The new fixture is implemented and the casting was properly placed and located in this fixture, the results found were better than previous results and there were less rejections. The new fixture not only improved the quality but also eliminated operation 20 which is not required on the final part. This had directly saved the set up time of 45 min and machining cycle time of 37 min/part also the skill operator for setting the part on the fixture is not required. Fig.6 shows new fixture design holding pressure valve plate. Target points at which component (valve plate casting) comes in contact with fixture is shown in fig 7.

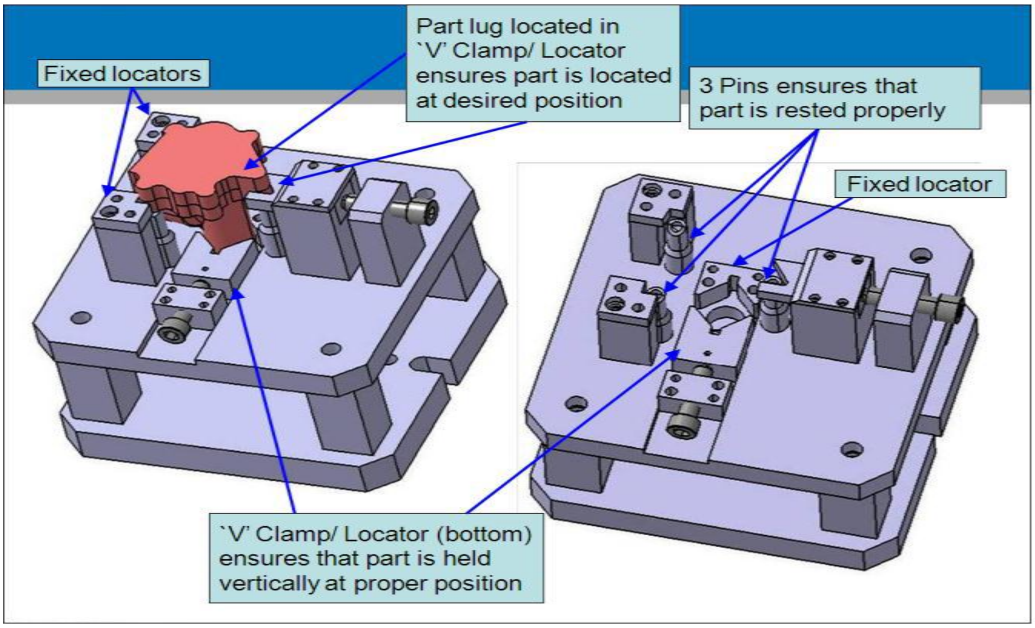

Fig.6: Fixture for holding valve plate

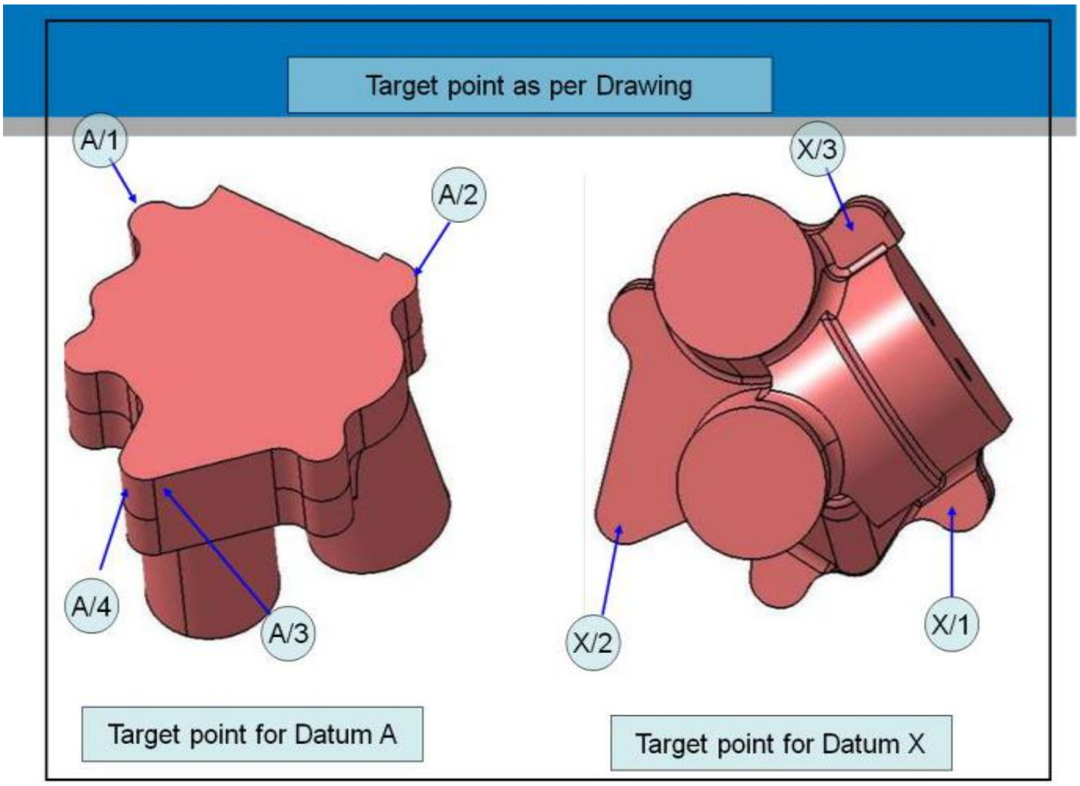

Fig.7: Casting of valve plate

V. INVESTIGATION AND ANALYSIS OF VALVE PLATE

The outlet port of valve plate after completing the machining operation was found with an error due to eccentricity leading to low wall thickness of 0.0625inch to 0.0630inch as shown in fig 8, whereas the required wall thickness is 0.075inch

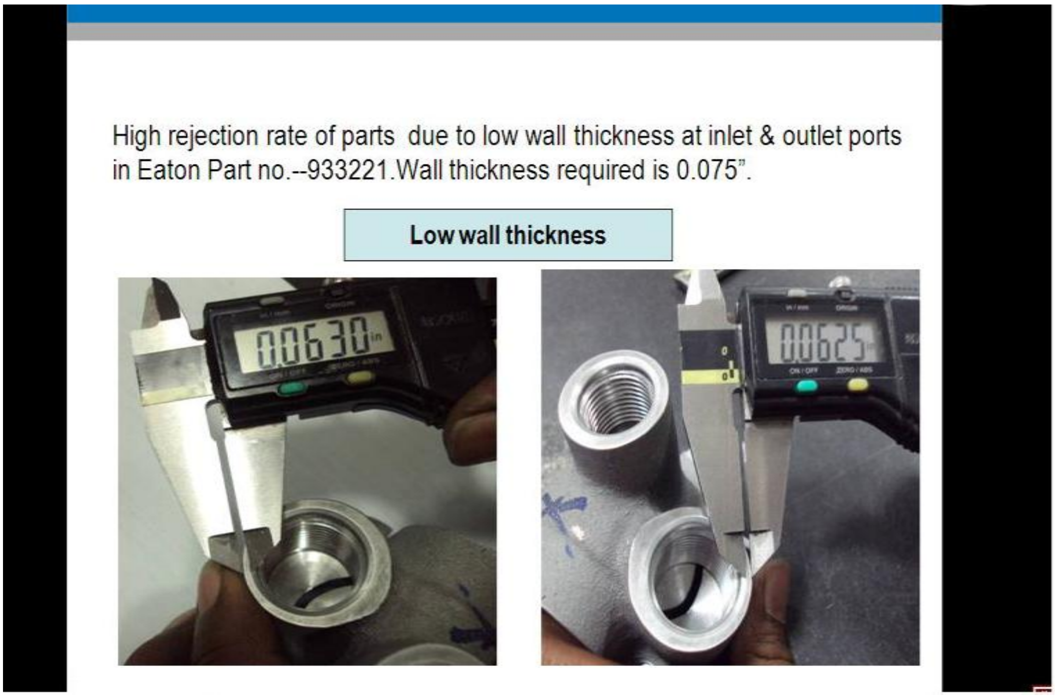

Fig.8: Valve plate outlet port

Initially the casting is investigated and there are no error in the casting as per the drawing, but the port angle of 12 degree is observed as 11 degree, which contributes to the deviation of low w/t ratio though the casting is correct as per its drawing also the other dimensions were found correct.

VI. CAUSE AND EFFECT

The deviation in angle of the outlet port contributes to low wall thickness which means the tooling provided is not correct, some of the observations regarding the tooling as shown in fig 2.9 are:

[1] The fixture is not positioning the part at required position while carrying out the operation
[2] The locating pin provided on the fixture was undersize by 0.3mm
[3] The position of pin was offset by 0.15mm

Fig.9 Valve plate with improved valve thickness

With reference to fig.9 it can be seen that wall thickness has increased from a range of 0.625-0.630 to 0.920-0.935 due to which the rejection rate has been minimized. Table 9.3 is the comparison of theoretical results obtained by Hertz theory and Ansys result. Whereas fig.10 refers to Meshed Model of Fixture and Pressure Valve Plate assembly obtained using Hyper mesh.

VII. VALIDATION OF RESULTS WITH THEORETICAL CALCULATION

Sl.no	Contact details	Theoretical results	Ansys results	Percentage difference
1.	Maximum contact pressure	201 Mpa	197.6 Mpa	1.7%

Table.1: Comparison of Contact results

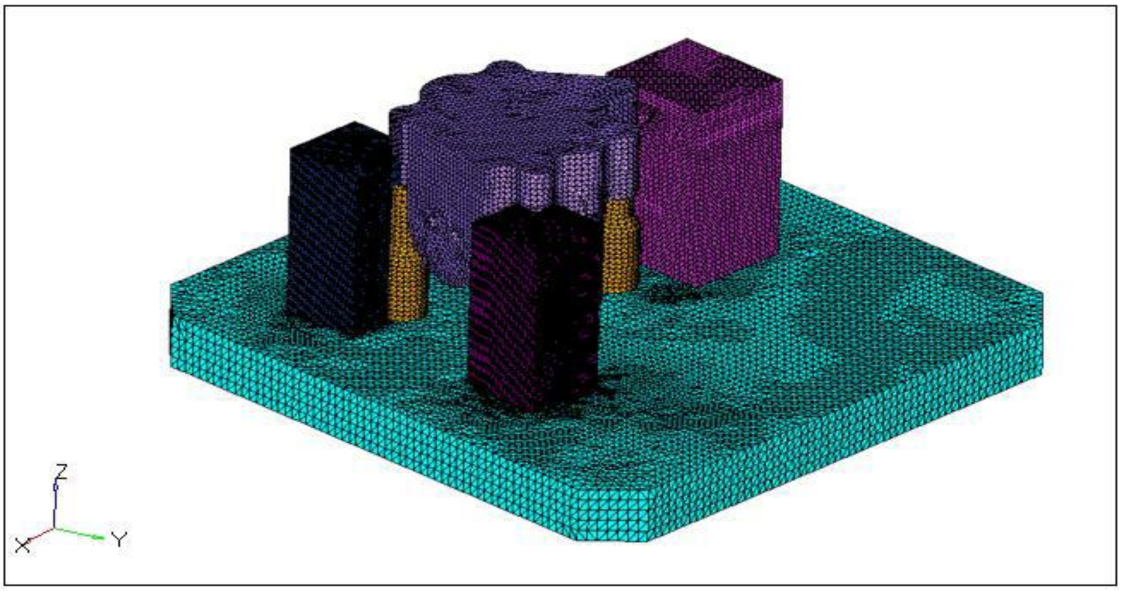

Fig.10: Meshed Model of valve plate and fixture assembly

VIII. CONCLUSIONS

[1] The changes made in fixture design eliminated the error of low wall thickness while manufacturing the valve plate.
[2] Fixture design has helped to reduce the number of setups and thus reducing the machining cost and time.
[3] The new fixture not only improved the quality but also eliminated OP20 which is not required on the final part.
[4] The Catia V5 and Hypermesh software has shown good agreement in this work giving good meshed model for analysis and its results.
[5] The Stresses and deformation of fixture assembly are well below the allowable limits; hence failure due to static loads is not possible.
[6] The FEA model can be used to simulate contact stresses between fixture and valve plate accurately.
[7] The FEA results are then compared with theoretical analysis(Hertz theory), and the percentage difference between Finite element analysis results and theoretical analysis results is 1.7%, which is within the limits.

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REFERENCES

[1] "Design of machine tools" by S.K Basu and D K. Pal
[2] "Fundamentals of Machining and Machine tools" by R.K Singal, Mridul Singal and Rishi singal Aug 2000
[3] H. Hertz, "Über die Berührung fester elastischer Körper," Gesammelte Werke (P. Lenard,ed.), Bd. 1, (J.A. Barth, Leipzig, 1895) pp. 155-173. Originally published in Journal f. d. reine u. angewandte Mathematik 92,156-171 (1881).
[4] http://www. Eaton hyd aerospace/valve plate/summary.pdf
[5] www.Eaton.com

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