Static Analysis of Pokayoke for Stud and Push Rod Holes Present on Cylinder Head

Upendra Sharan Gupta*1, Sanjay Nainani*2, Raman Hora*3, Parivesh Saxena*4, Shubham Patel*5, Shubham Rathoure*6

#1 *Reader Dept. of Mech. Engineering, SVITS, Indore, India*

#2, 3, 4, 5, 6 *UG Scholar Dept. of Mech. Engineering, SVITS, Indore, India*

Abstract — *The design ensures that the stud and pushrod holes on the cylinder head are present, are properly aligned as well as checks whether these holes are of proper diameter or not before it undergoes further process. The design decreases human work, increases efficiency and precision thus decreases the probability it will cause problem while engine assembly. The design was tested on some cylinder head and the probability of error came to an almost zero. Analysis of this machine fetched the result that even in case of failure i.e. the holes on face of head are not perfect there will be no major damages on any part.*

Keywords — *pokayoke, cylinder head, cylinder block, failure analysis, static analysis.*

I. INTRODUCTION

Cylinder Head

In an internal combustion engine, the cylinder head sits above the cylinders on top of the cylinder block. It closes in the top of the cylinder, forming the combustion chamber. This joint is sealed by a head gasket. In most engines, the head also provides space for the passages that feed air and fuel to the cylinder, and that allow the exhaust to escape. The head can also be a place to mount the valves, spark plugs, and fuel injectors. [1]

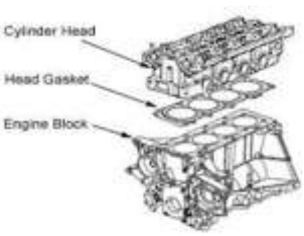

Fig 1.1 View of Engine comprising of Head, Gasket and Block

Poka-Yoke

Poka-yoke is a Japanese term that means "mistake-proofing" or "inadvertent error prevention". The key word in the second translation, often omitted, is "inadvertent". There is no Poka Yoke solution that protects against an operator's sabotage, but sabotage is a rare behavior among people. A poka-yoke is any mechanism in a lean manufacturing process that helps an equipment operator avoid (yokeru) mistakes (poka). Its purpose is to eliminate product defects by preventing, correcting, or drawing attention to human errors as they occur. The concept was formalized, and the term adopted, by Shigeo Shingo as part of the Toyota Production System.

II. METHODOLOGY

The design includes cylinder head and sectioned cylinder block with protrusions in form of studs. After the designs a scrape cylinder block was taken and sectioned accordingly. Then studs of correct measurement were taken and welded in position of studs so as to get a correct position of where the studs are on the head. This block was then connected with a pneumatic cylinder for up and down motion of the block.[12] After the manufacturing the machine was tested on some heads and the probability of error decreased to an almost zero. The analysis was done in HyperWorks. The analysis was done in case of failure for different value of loads which would act upon the pins if the holes on the face of cylinder head are not perfect because of manufacturing defects and the pins hit the face of the head.

Fig. 1 Final Assembly of Poka-Yoke

III. STATIC ANALYSIS USING FINITE ELEMENT METHOD

The finite element method is a numerical method for solving problems of engineering and mathematical physics. Typical problem areas of interest in engineering and mathematical physics that are solvable by use of the finite element method include structural analysis, heat transfer, fluid flow, mass transport and electromagnetic potential.

Analysis was done in Optistruct solver of HyperWorks 13.0. Firstly modelling was done in CreO 2.0 and then imported to HyperWorks. After meshing of the component different loads were applied to check the displacement and the elemental stress values.

3.1 Loading and Boundary Conditions

Component is modelled in CreO 2.0. The sectioned block has following dimensions, thickness = 20mm, length of studs = 100mm, stroke of pneumatic cylinder = 250mm, bore of pneumatic cylinder = 75mm, diameter of stud holes = 12mm and no. of studs = 17.

Load is varied as 300N, 500N, 850N, 1000N, 1250NN and 1500N.

The material properties are:

Material	Cast Iron
Modulus of Elasticity	$1.20*10^5$ N/mm^2
Poisson's Ratio	0.28
Density	$7.2*10^{-9}$ tonne/mm^3
Yield Strength	85 N/mm^2

Table 3.1 Material Properties of Cast Iron

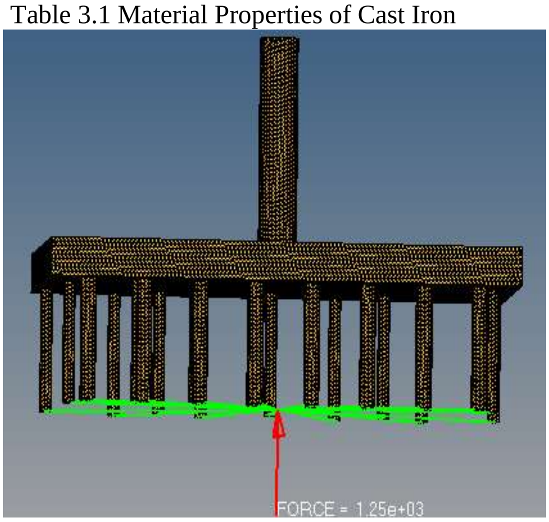

Fig 3.1 HyperWorks Model of Sectioned Block with Studs and Pneumatic Cylinder

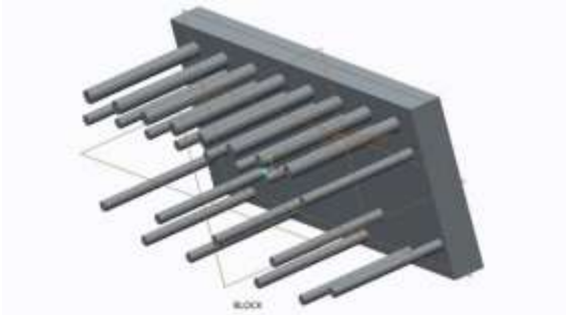

Fig 3.2 Creo drawing of Cylinder Block with Protrusions in form of Studs

Force (N)	Displacement (mm)	Elemental Stress (N/mm^2)
300	$2.27*10^{-2}$	1.41
500	$3.79*10^{-2}$	2.36
850	$6.44*10^{-2}$	4.01
1000	$7.585*10^{-2}$	4.727
1250	$9.481*10^{-2}$	5.909
1500	$10.38*10^{-2}$	7.09

Table 3.2 HyperWorks value of Load Distribution

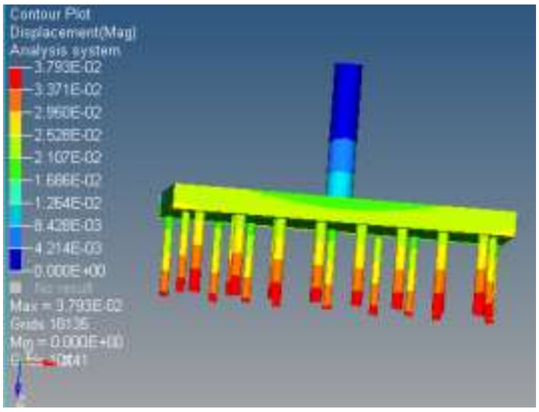

Fig 3.3 Displacement at 500N

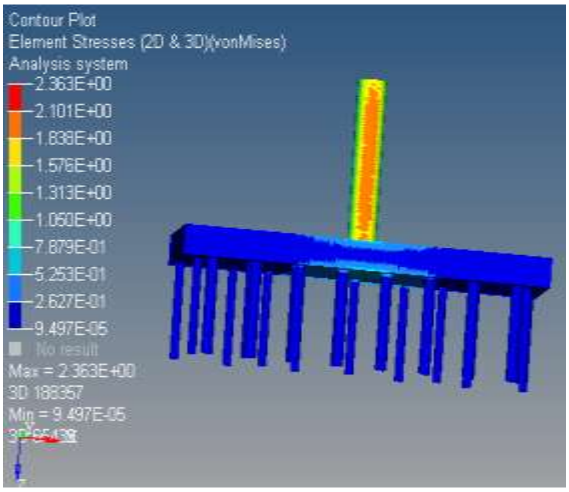

Fig 3.4 Elemental Stress at 500N

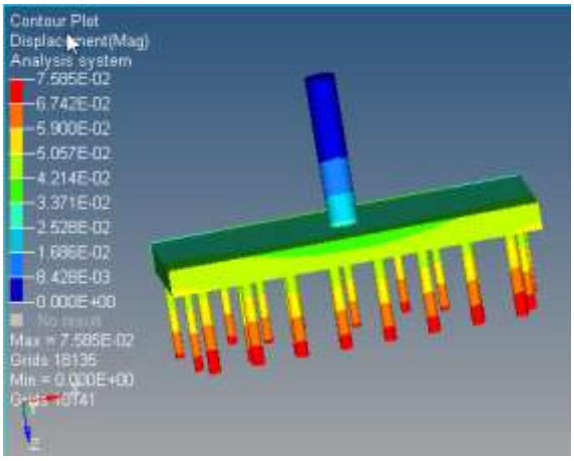

Fig 3.5 Displacement at 1000N

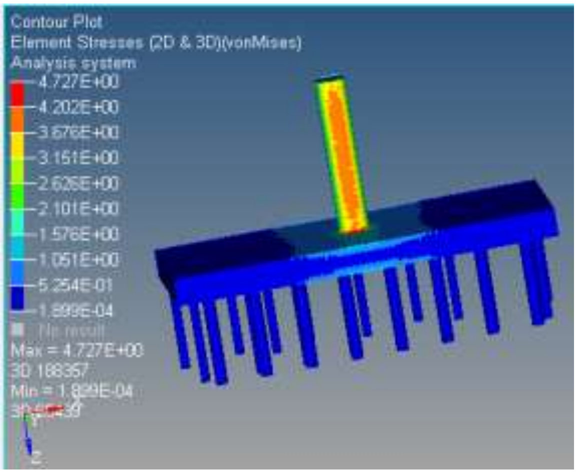

Fig 3.6 Elemental Stress at 1000N

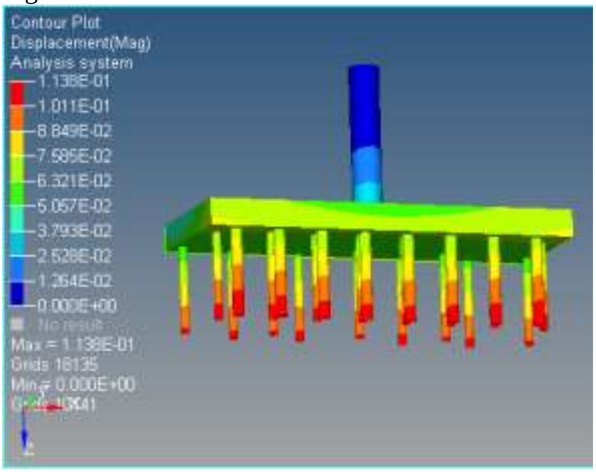

Fig 3.7 Displacement at 1500N

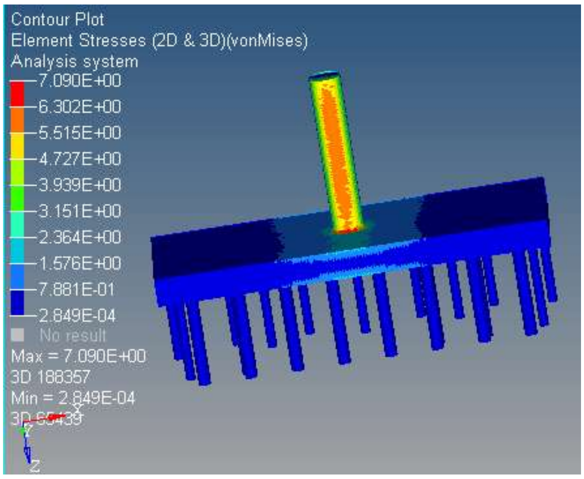

Fig 3.8 Elemental Stress at 1500N

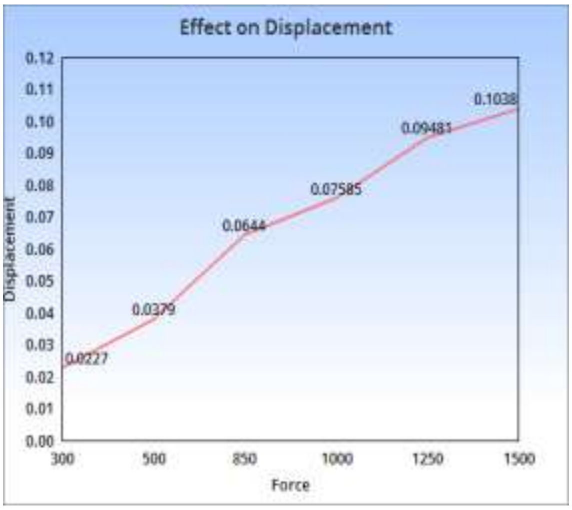

Fig 3.5 Load vs Displacement

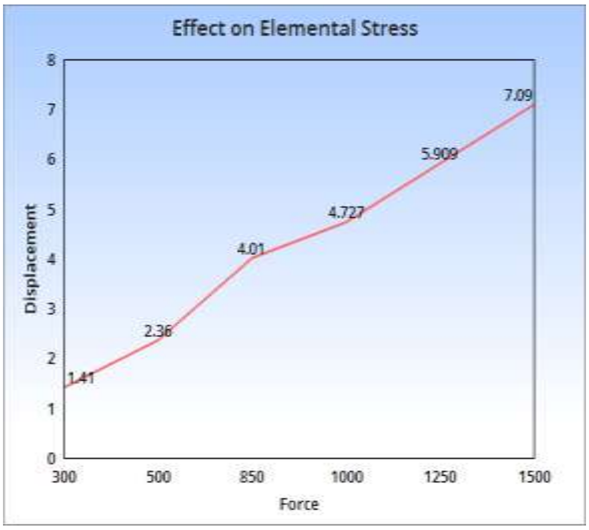

Fig 3.6 Load vs Eleemntal Stress

IV. Conclusion

The design checks the alignment, or presence and dimensions of stud and push rod holes. Analysis work was necessary for this machine as in case of failure no part should be damaged. For a maximum load of 1500N it is found that elemental stress is 7.09 N/mm^2 while for cast iron the yield strength is 85 N/mm^2. The value of stress generated is very less hence there will be no damages. For the varying values of load from 300N to 1500N the displacement was very less and the stress was under boundary conditions. Hence the design will not damage the cylinder head in case of manufacturing defects.

REFERENCES

[1] https://en.wikipedia.org/wiki/Cylinder_head

[2] Misiurek, Bartosz (2016). Standardized Work with TWI: Eliminating Human Errors in Production and Service Processes. New York: Productivity Press. ISBN 9781498737548.

[3] Robinson, Harry (1997). "Using Poka-Yoke Techniques for Early Defect Detection". Retrieved May 4, 2009.

[4] Shingo, Shigeo; Dillon, Andrew (1989). A study of the Toyota production system from an industrial engineering viewpoint. Portland, OR: Productivity Press. ISBN 0-915299-17-8. OCLC 19740349.

[5] John R. Grout, Brian T. Downs. "A Brief Tutorial on Mistake-proofing, Poka-Yoke, and ZQC". MistakeProofing.com. Retrieved May 4, 2009.

[6] H Robinson. "Using Poka-Yoke techniques for early defect detection". Retrieved June 18, 2012.

[7] "The Sayings of Shigeo Shingo: Key Strategies for Plant Improvement". QualityCoach.Net. Retrieved August 20, 2012.

[8] "Poka Yoke or Mistake Proofing :: Overview". The Quality Portal. Retrieved May 5, 2009.

[9] Nikkan Kogyo Shimbun (1988). Poka-yoke: improving product quality by preventing defects. Productivity Press. p. 111. ISBN 978-0-915299-31-7.

[10] Ivan Fantin (2014). Applied Problem Solving. Method, Applications, Root Causes, Countermeasures, Poka-Yoke and A3. How to make things happen to solve problems. Milan, Italy: Createspace, an Amazon company. ISBN 978-1499122282

[11] http://www.autoserviceprofessional.com/article/92024/Engine-studs-Understanding-the-advantages-of-using-studs-vs-bolts-and-tips-on-achieving-proper-c?Page=3

[12] http://www.ijettjournal.org/archive/ijett-v41p248