

Remanufacturing by Design Modification Of Rocker Arm

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ABSTRACT: Material recovery from End-of-Life (EOL) products is a key issue in sustainable product development and research to explore this aspect is gaining importance today. Among the various material recovery processes, remanufacturing is gaining importance as one of the profitable alternatives. Remanufacturing is the process, wherein an EOL product is collected from a customer and a series of remanufacturing operations carried out so as to achieve the product having quality “as good as” that of a new product. With a motto to introduce concept of remanufacturing in a component manufacturing industry an attempt has been made to modify a component design such that the product is transformed into assembly of parts and thus facilitating remanufacturing. Rocker arm is converted into an assembly of components by isolation the wear affected region to make it a separate component.

I. INTRODUCTION

Design modification in remanufacturing is done in order to create the link between design and remanufacturing by design in the context of remanufacturing, product design detailing for remanufacturing and practices of design for remanufacturing. Comprehend the related manufacturing processes and linking it with product design for successful remanufacturing. The design for remanufacturing leads to the increased innovation and environment friendly development and economically beneficial and finally Designing product with enhanced product life cycle and more suitable for multi life cycle. Generally product design doesn't take into account the need for remanufacturing at a later stage. This leads to difficulty while disassembly of the product while remanufacturing at a later stage of the products life cycle. So we intend to introduce design modification of the component to facilitate remanufacturing.

II. EXPERIMENTAL PROCEDURE

Rocker arm wear occurs on the finger region. In most cases the remaining part of the rocker arm remains unaffected since it acts just as a connecting part that transfers motion from the camshaft to the valve. But when rocker arm wear occurs, the entire rocker arm is disposed where only the finger region is worn out while the other regions are still in good condition. Hence useful material is wasted which is not a sustainable practice.

It is important that separation of wear region from secure region is done by modifying the design by means of temporary joint to facilitate replacement of finger region alone in case of failure due to wear.

The model is developed using a software package (NX CAD) and joint is analysed for its strength to withstand actual working conditions using an analysis package (NX NASTRAN).

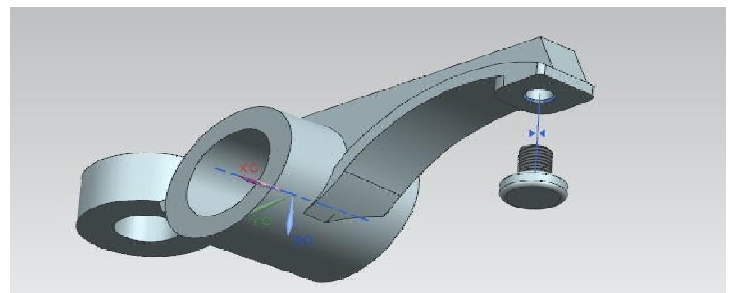
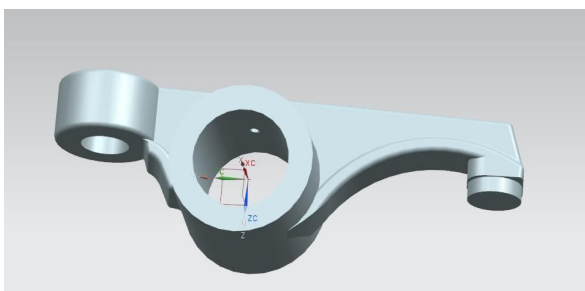


Fig 1: 3-D view of the rocker arm

In the modified design of the rocker arm to facilitate remanufacturing the finger part where the wear occurs is made into a separate part and assembled by temporary fastener into the rocker arm. Thus localization of wear affected region in turn helps in remanufacturing. Thus the unaffected base part of rocker arm can be used again in remanufacturing Thus meeting the customer requirement while also ensuring the sustainability of the product.

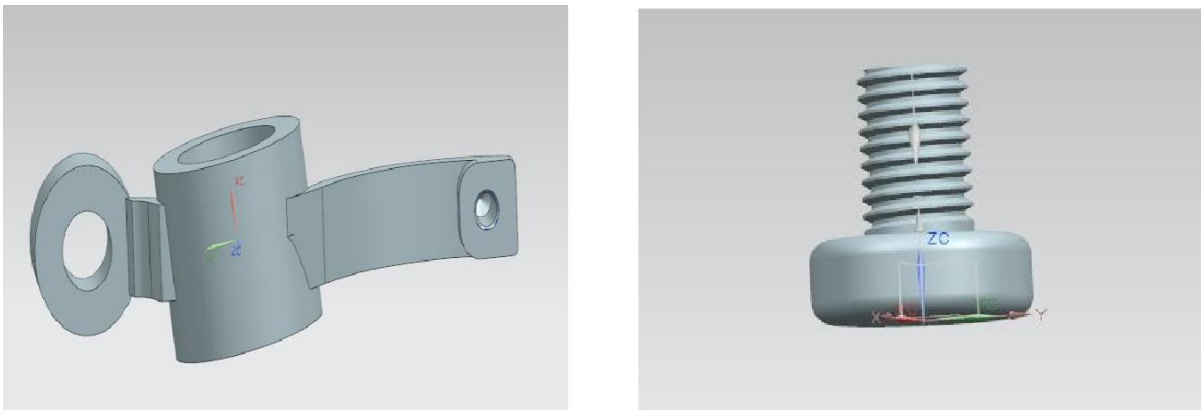


Fig 2: The modified base of the rocker arm with isolated finger region

III. CALCULATION

The calculation is done in order to determine the load acting on the rocker arm. This load is applied in the analysis software to simulate the rocker arm and to determine its ability to withstand that load

Let,

m_v = Mass of the valve, d_v = Diameter of the valve head, h = Lift of the valve,

a = Acceleration of the valve, P_c = Cylinder pressure or back pressure,

P_s = Maximum suction pressure, d_1 = Diameter of fulcrum pin,

D_1 = Diameter of boss, l = Length of arm, Θ = Angle between two arms

We have,

$$m_v = 0.09 \text{ kg}, d_v = 40 \text{ mm}, H = 13 \text{ mm}, r = 13/2 = 6.5 \text{ mm}, P_c = 0.4 \text{ N/mm}^2, P_s = 0.02 \text{ N/mm}^2$$

$$d_1 = 8 \text{ mm}, D_1 = 40 \text{ mm}, \text{Speed of engine} = 3000 \text{ RPM}, \text{Angle of action of cam} = 110^\circ$$

Calculating Forces Acting:

- We know that gas load on the valve, $P_1 = \frac{1}{4}(d_v)^2 P_c$

$$= \frac{1}{4} \times (40)^2 \times 0.4$$

$$P_1 = 502.4 \text{ N}$$

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Weight of associated parts with the valve = $m \cdot g$

$$= 0.09 \times 9.8 \quad w = 0.882 \text{ N}$$

Total load on the valve, $P = P1 + w$

$$= 502.4 + 0.882$$

$$P = 503.282 \text{ N}$$

The force due to valve acceleration (Fa) may be obtained as discussed below: The speed of camshaft = $N/2 = 3000/2 = 1500$ r.p.m

Angle turned by the camshaft per Second = $(1500/60) \times 360$

$$= 9000 \text{ deg/s}$$

Time taken for the valve to open and close, $t = \text{Angle of action of cam}$

Angle turned by camshaft = $110/9000$

$$t = 0.012 \text{ s}$$

We know that maximum acceleration of valve, $a = r \omega^2$

$$= (2/t)^2 \cdot r$$

$$= (2/0.012)^2 \times 0.0065$$

$$a = 1780.2 \text{ m/s}^2$$

Force due to valve acceleration, considering the weight of the valve,

$$Fa = m \cdot a$$

$$= 0.09 \times 1780.2$$

$$Fa = 160.21 \text{ N}$$

Total force acting on the rocker arm Fe

$$Fe = P + Fa$$

$$= 503.282 + 160.21$$

$$Fe = 663.49 \text{ N}$$

Since the length of the two arms of the rocker is not equal, therefore, the load at the two ends of the arm is not equal.

By moment formula

F1 – force acting on the finger side of the rocker arm

F2 –force acting on the cam side of the rocker arm

L1 -distance between the finger end and the boss

L2 –distance between the cam end and the boss

$$F1 * L1 = F2 * L2$$

$$663.49 * 60 = F2 * 45$$

$$F2 = 995.235 \text{ N}$$

These values of the forces F1 and F 2 are used in the analysis software to calculate the effect of these forces.

IV. ANALYSIS

The analysis part consists of applying the load acting on the rocker arm both the actual one and the modified design. The stresses acting on both the rocker arms are determined and compared. If the stress and deflection values do not vary much it can be concluded that the design modification is possible. The rocker arm part from the NX-CAD Software is imported into NX-NASTRAN and meshing is done with element size as 1.25mm. The material used is AISI-1080HR steel.

For the purpose of analysis the rocker arm is assumed to be fixed for both translation and rotation at the boss. After the application of the boundary condition the load (which is determined by calculation) is applied on the rocker arm which is visible

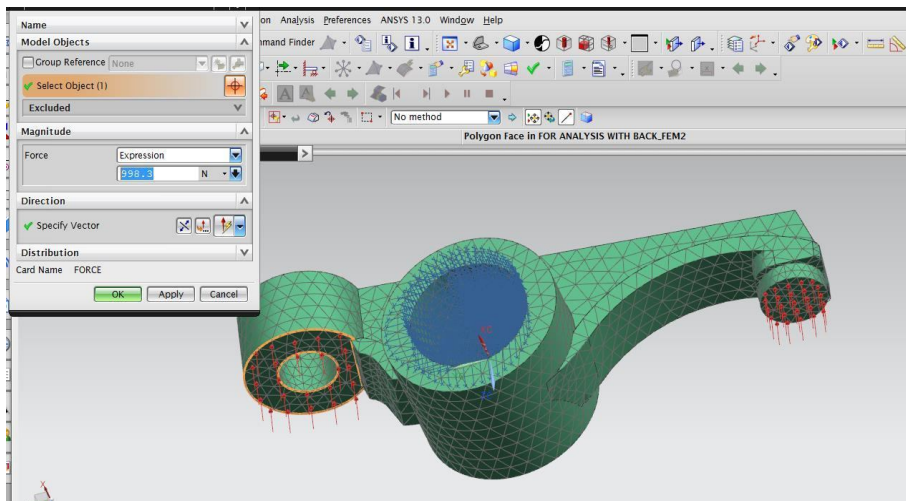


Fig 3: Application of load on the rocker arm

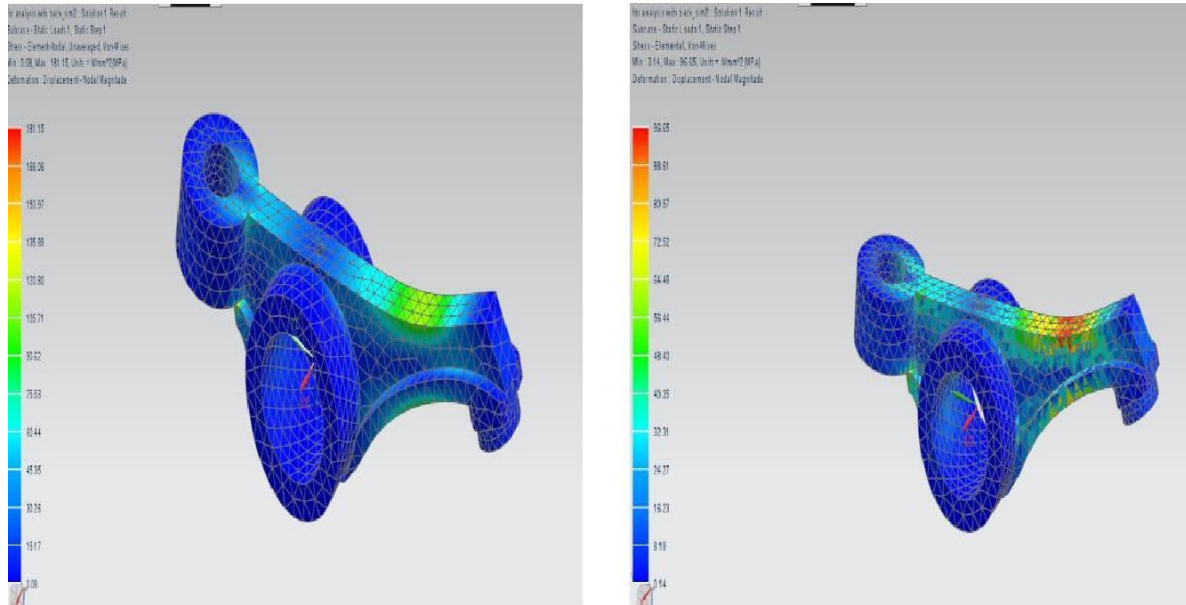


Fig 4: Nodal and elemental stresses of the rocker arm

After the application of the loads the file is solved using NX-Nastran solver and the stresses are determined. A similar procedure is adapted for the design modified rocker arm. The rocker arm which is an assembly of two components is imported. The meshing operation has to be performed for each component separately. A mesh of size 1.25mm is created for the base part. A separate mesh for the finger part of the rocker arm of size 0.25mm created which can also be seen

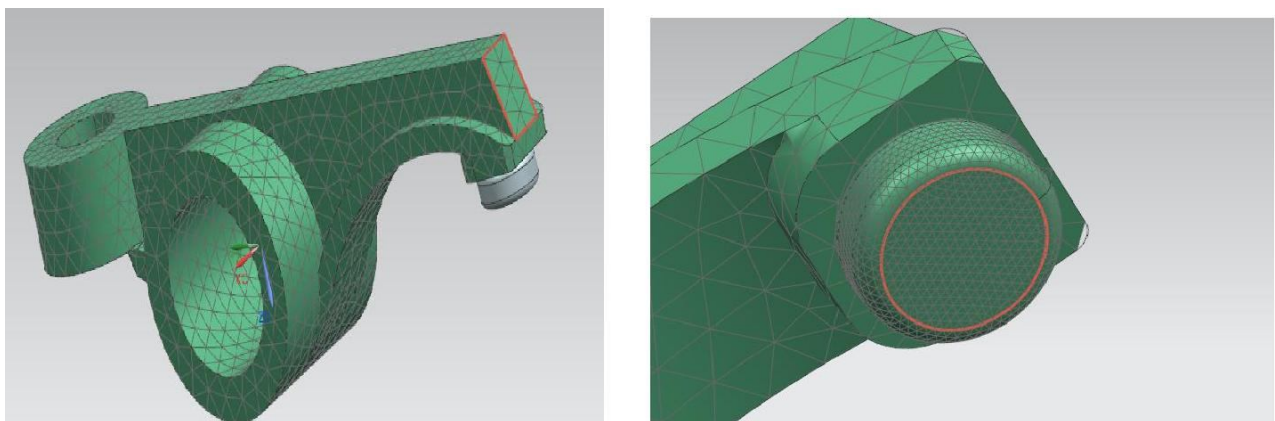


Fig 5: Separate Meshing of each component of the Design modified rocker arm

In order to simulate the screw type fastened joint a 1-D collector element of bolt and nut type connection is defined between the two components. This will approximate the type of connection between the two components.

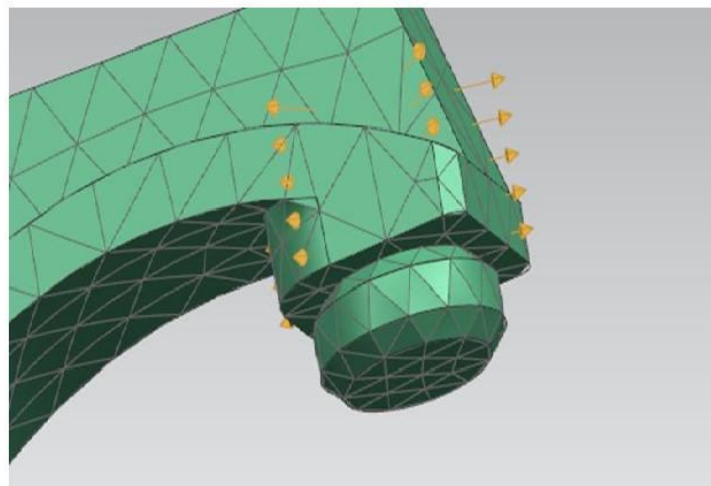
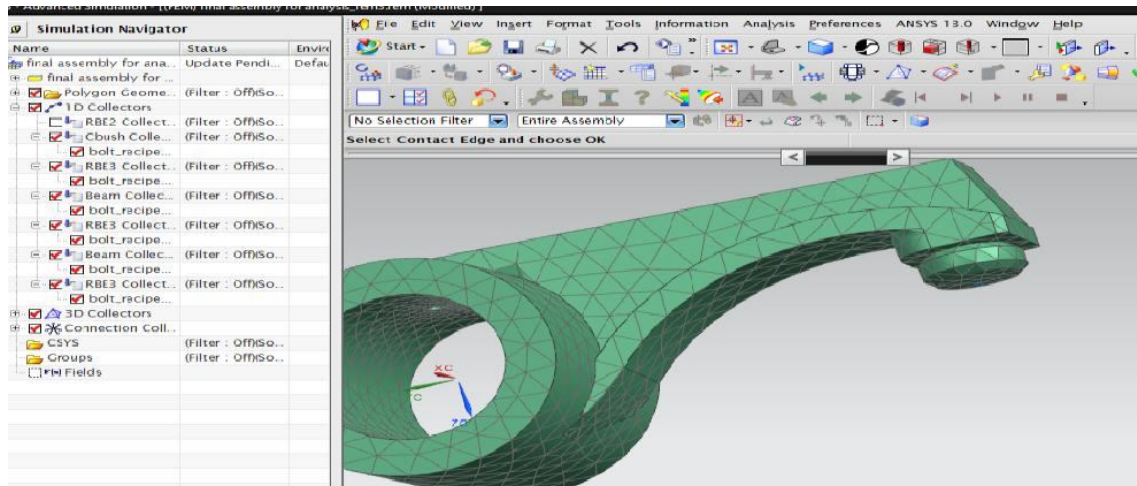


Fig 6: bolt and nut type 1-D collector

After the creation of the 1-D elements surface to surface contact between the components with a coefficient of friction of about 0.8 is applied to simulate screwed fasteners. The same loads are applied as in case of the first rocker arm and the final component before solving.

By solving the above file the element and nodal stresses of the modified rocker arm is determined as indicated by.

The results of both the analysis are compared. The maximum elemental (nodal) stress in the original rocker arm is 181.15 N/mm^2 whereas in the modified rocker arm is 181.57 N/mm^2 .

The maximum elemental stress in the original rocker arm is 96.65 N/mm^2 whereas in the modified rocker arm is 97.14 N/mm^2 .

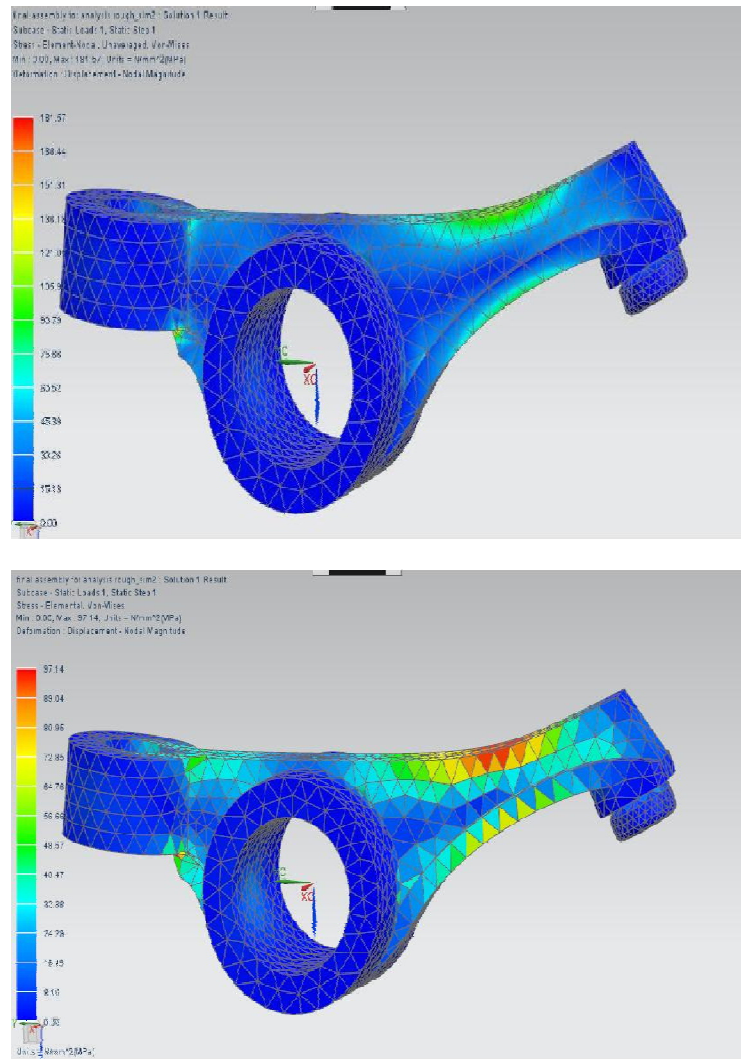


Fig 8.7: Nodal and elemental stresses of the modified rocker arm

It can be observed that the stress values differs through only a small value it can be suggested that the assembly will withstand the load in a similar manner to the original rocker arm. This implies that the design modification is feasible

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