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DESIGN AND STRUCTURAL BEHAVIOR ANALYSIS OF DEDICATED HOOK FOR CRANK SHAFT HANDLING MACHINE

Amol Patil[*1], Prof. Vikram Avhad[2] & Prof. Anantharma3

[*1]PG Student, M.E., Department of Mechanical Engineering, Dhole Patil College of Engg., Pune, India

[2&3]Professor, M.E., Department of Mechanical Engineering, Dhole Patil College of Engg, Pune-, India

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ABSTRACT

Crank shaft machining on two end faces by dedicated tooling solution is designed with conceptual model and full proof assembly structure. Work gives conceptual model and mechanical design of special application fixture hook made for crane which is to be used overhead material handling application in component machining automation. Crank shaft is to be machined for drilling operation executes in line on end faces of the component so this hook gives perfect fixturing with full proof poka yoke to move on overhead sliding panel provided in shop floor. design and product development considered with the manufacturability and practical feasibility. Structural weldment is the out coming function for this work of innovation .boundary conditions are examined and applied for analysis on actual behavior of the structure in working conditions. Loads are calculating by considering input parameters. Structural behavior analysis done in CAE tool to prove its workability.

KEYWORDS: Lifting, crankcase crankshaft.,

I. INTRODUCTION

Casted crank shaft is to be machined on its both ends for drilling operation to be carried out at height of 2.2 m above ground level. Dedicated Hook will hold the workpiece from powerised conveyor and pick and place operation will be perform. But the operation will not end till drilling and tapping get finished, In assembly line it is required to drill this crank shaft before shaft ending plate is assembled with it. For this process it is required to increase production rate so that to cover 12 components in every hour.

Existing system gives the process is carried out manually with average 7 components processed in one hour.
Input: Details of Object for making customized hook handler are as given below.

Crank shaft for 6 cylinder engine
Weight: 32 kg.
Drilling operation to be perform on both end faces side,
No of holes and size: m10 x 6, M12 x4 on both sides

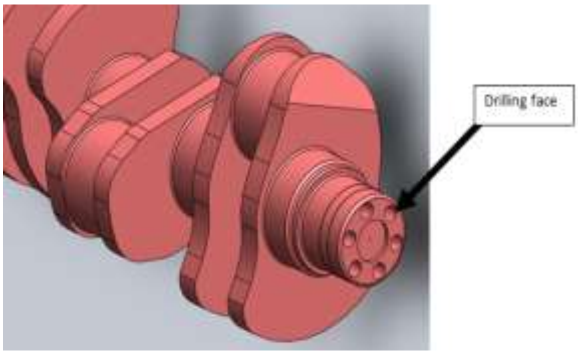

Fig:1 Side view of crank shaft

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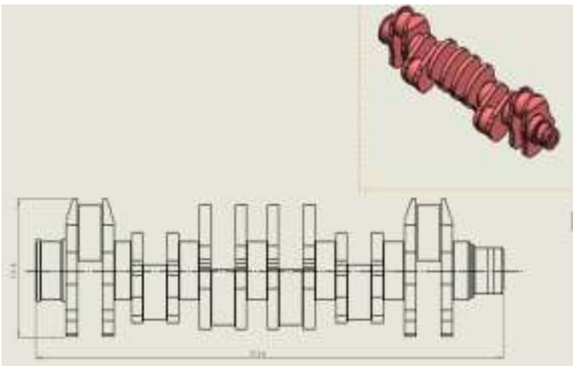

Fig : 2 Component view (crank shaft for 6 cylinder engine)

II. LITERATURE REVIEW

1. Thae company Schlumpf shaft handling machines are intended only as safety devices to eliminate the manual handling of heavy expanding shafts. Shaft handling machines add a step in the production process, so by their very nature they are often more time consuming to use compared to extracting a shaft by hand (if and when manual handling is even possible). When thinking about purchasing a shaft handling machine, safety should be the primary consideration. It may take some time for the operators to become accustomed to the proper and best use of a shaft handling machine. Visual aids to determine the shaft center and roll position are helpful. [1]

2. The invention relates to a lifting device, operable from the drivers seat, for the frames of agricultural machines whose working tools can be manually engaged and disengaged during operation. In hitherto-known machines such as hoeing' machines in which the frame complete with hoes is 'very heavy, engagement and disengagement from the drivers seat has been extremely difficult. There has also been a need for means to increase the load, even during operation, without having to release a detent on the hand lever. [2]
   The lifting device pursuant to the invention eliminates these disadvantages. The lifting is effected by a cranked shaft actuated by the manual lever at the drivers seat by means of an automatically acting ratchet and lifter combination, where such cranked shaft may alternatively be replaced by a unilaterally supported crank.
   The essence of the invention consists in that this manually operated lift and ratchet combination acts entirely automatically; the method of the invention is characterized in that a cranked shaft bears a rotatably mounted hand lever provided with a spring pawl that, in known manner, [2]

3. **Crank Shaft Grinding On Machine**
   Four indexing locations on the head stock with the air operated index pins make it faster to dial in the crankshaft properly. Easily adjusted outboard counterweights never need to be supplemented by inboard weights. The CG360's are built very heavy with widely spaced ways to assure positive alignment of the wheel head to the table. Moreover, the controls are easier to use. Precision Incremental In-Feed Lever is much easier to use than a hand wheel to achieve the precise desired journal size. One full stroke of this lever moves the wheel head precisely .0004", and it can be used in steps to move the wheel head .0001", .0002", or .0003". The superior accuracy of this machine allows double plunge grinding precisely to the same size leaving no lap line. CG360 provides longer machine life, longer grinding wheel life and greater safety for the operator and machine. [3]

4. **General Lifter For Crank Shaft**
   Right Roll Handling Equipment:

   Easy Lift Roll Manipulators & Transporters Capacities to 1500 lb/680 kg

   Paper Roll Handling Lifts And Grippers Straddle Leg models are available with several different clamps for specific ranges of roll diameters. The I.D. between the straddle legs is built to the customers' specification, [4]

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Working layout

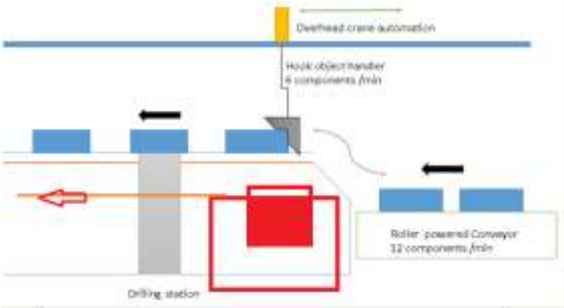

Fig: 3 working layout

Red colored parts are showing for existing system
Rest of the system is to be considering for new concept of hook design.

Objective
To Design customized fixturing hook for heavy crank shaft for 6 cylinder engine to make feasible pulling, pushing and tooling with overhead crane.

To validate working behavior of structural hook for crank shaft for 6 cylinders by examining boundary conditions.

Scope Of Work
1. Concept design of structural tooling cage shaped hook,
2. Define technology for manufacturing preferring element,
3. Boundary conditions calculations
4. Material selection,
5. Installation feasibility,
6. Cycle time calculation,
7. Torque calculations,

Material Selection
Material options we have Stainless steel
1) Structural carbon steel/ mild steel

Stainless steel grade

Type 304 – This is the most common grade of steel; the classic 18/8 (18% chromium, 8% nickel) stainless steel.

SAE designation	UNS designation	% Cr	% Ni	% C	% Mn	% Si	% P	% S	% N
304	S30400	18–20	8–10.50	0.08	2	0.75	0.045	0.03	0.1
304L	S30403	18–20	8–12	0.03	2	0.75	0.045	0.03	0.1

Of the two types, 304 is the most widely used alloy steel, followed by 304L. 304L is typically used for welding applications to resist the intergranular corrosion. The main difference is in the carbon content, which is less in 304L than 304. These two grades are frequently declared dual certified as 304/304L. This means that the carbon content, is more in both grades, In addition to this, the dual certified material meets the mechanical properties, which are required to be higher in 304. Hence, this dual certification means the material is in full compliance with both specifications, providing the higher strength requirements for one grade along with the better intergranular corrosion resistance of the other.

Structural carbon steel/ mild steel
Mild steel also known as low carbon steel; typically the AISI grades 1005 through 1025, widely used for structural applications.

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Carbon steel, or plain-*carbon steel*, is a metal alloy. It is a combination of iron and *carbon*. To improve the properties other elements are present in quantities too small. These other elements present in plain-*carbon steel* are Mg (1.65%), Si (0.60%), and Cu (0.60%). Typically carbon steels are highly stiff and strong. They also exhibit properties of ferromagnetism (i.e. they are magnetic). Hence they are widely used in motors and electrical appliances. Welding of carbon steels with a metal having carbon content greater than 0.3 % requires special precautions that be taken. However, welding carbon steel has very less problems than welding stainless steels. The carbon steels is having poor corrosion resistance (i.e. they rust) and so they should not be used in a corrosive environment without using some form of protective coating.

Selection : From above features as the drilling process is to be handled with holding the component.

It is needed to consider coolant and drilling bar cleaning chemical and water usage on this fixture hook. Hence Steel AISI304 is selected which holds the good property of corrosive resistant.
Transfer conveyor to be used on floor

Fig: 4 Actual working layout

III. DESIGN AND IMPLEMENTATION

Present practices:

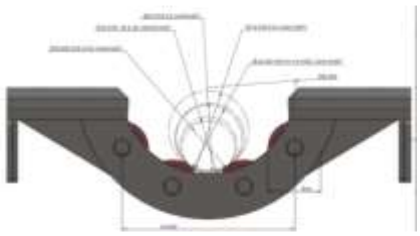

Fig: 5 Shaft rotary mount

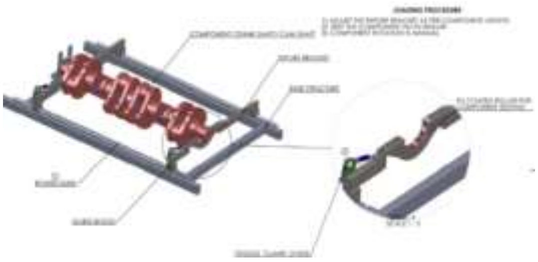

Fig: 6 existing drilling platform for same component.

Operation type : manual.
Production rate: 7-8 components /hour

Expecting rate in new design: 12-15 components/hour. Including load unload time.

Development Of Component
Two L brackets holding the component and lifting to place on platform for starting machining operations **,**

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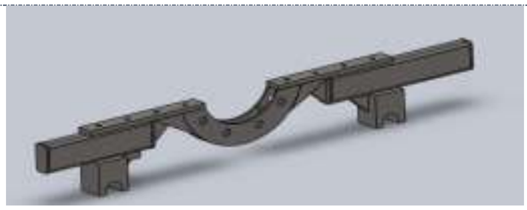


Fig:7 Botoom bracket holder

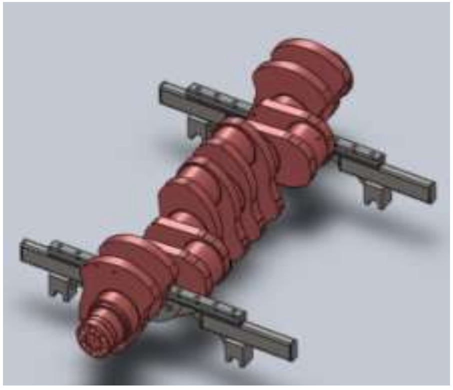


fig: 8 Mounting

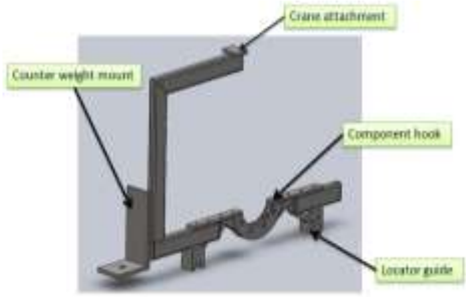


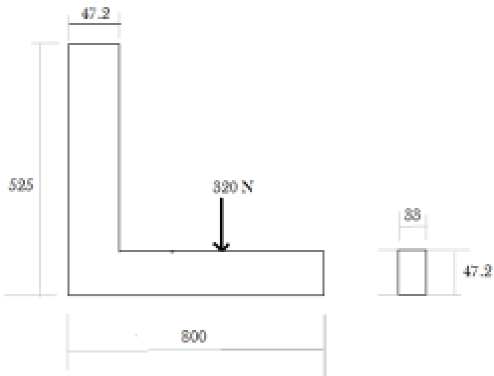
Fig: 9 Holding L btacket

Complete dedicated hook for crank shaft drilling automation

Two units will be there for handling the component .

- Counter weight proposed for making balancing while crane lifting by this hook
- Half circular mount to make easiness in rotating /indexing in tool cabinet.

Case 1 : By considering load due to Component weight only
The load of the crank shaft is acting on flange of the bracket as shown in fig



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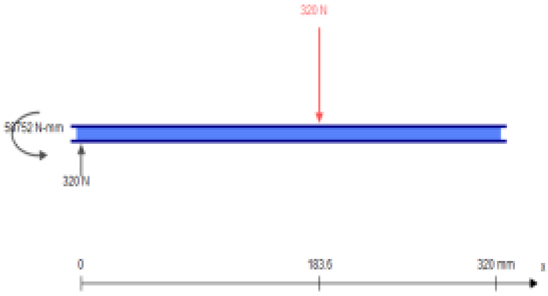
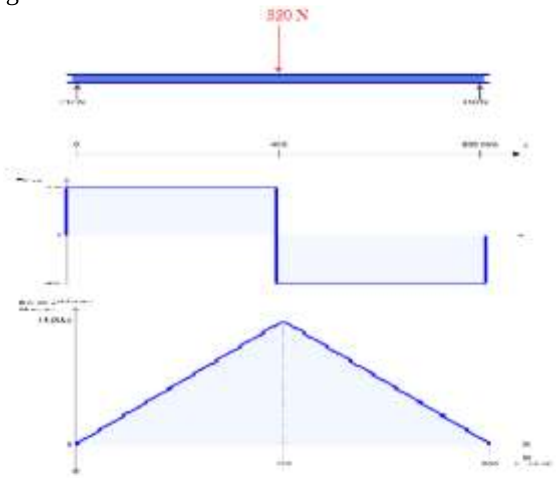
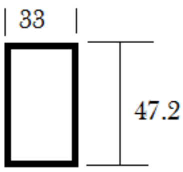
The FBD of the flange can be shown as in fig



The SFD and BMD of the flange are shown below



The maximum bending moment is 64000 N-mm.
The cross section of the flange is rectangular



Moment of inertia,

$$I = \frac{bd^3}{12} = \frac{33 \ x \ 47.2^3}{12}$$

I = 289173.63 mm^4

Also, y = 23.6 mm and
M = 64000 Nmm
We have from Flexure formula,

$$\frac{M}{I} = \frac{\sigma}{y}$$

Hence,

$$\frac{64000}{289173} = \frac{\sigma}{23.6}$$

$$\sigma = 5.22 \ N/mm^2$$

Hence the maximum bending stress due to component load only in the flange of the L shaped (90^0) crane hook is 5 N/mm^2.

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Deflection of the flange

$$\delta_{max} = \frac{WL^3}{48EI}$$

Where, E = Modulus of Elasticity = 200GPa
Hence

$$\delta_{max} = 0.06\, mm$$

Case 2:In this condition assembly get loaded on tool section and get mounted properly on drilling bed platform.

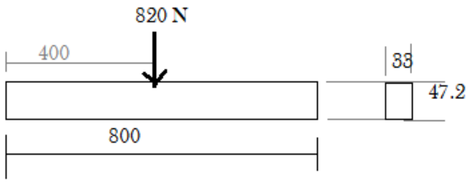
By considering load due to Cutting (drilling) force and Component weight

Let the drilling force acting equals to 500 N

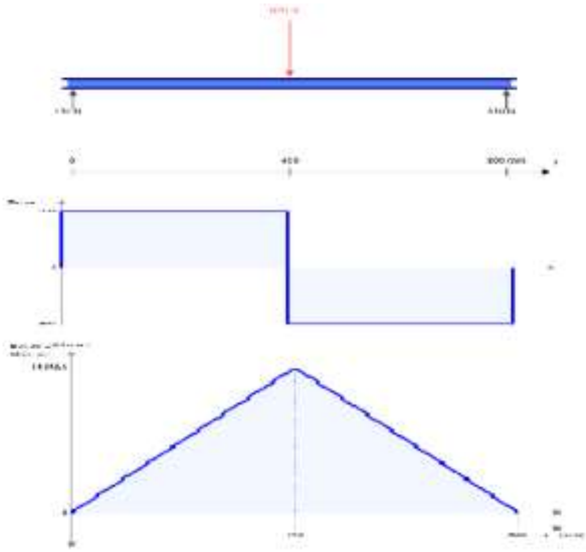
Hence total load acting on the component will be drilling force + load of component.

Hence total load, F = 500 + 320 = 800 N

As the bracket is supported at both ends, the flange of the bracket will act like simply supporteded Structure. The free body diagrame of the flange is as shown in fig.



The SFD and BMD of the flange due to loading are as shown in figure.



From Bending moment diagram, the maximum bending moment is
M = 164000 N-mm
Moment of inertia,

$$I = \frac{bd^3}{12} = \frac{33\,x\,47.2^3}{12}$$

I = 289173.63 mm^4

Also, y = 23.6 mm and

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We have from Flexure formula,

$$\frac{M}{I} = \frac{\sigma}{y}$$

Hence,

$$\frac{164000}{289173} = \frac{\sigma}{23.6}$$

Hence maximum bending stress

$$\sigma = 13.38 \text{ N/mm}^2$$

Deflection of the component

$$\delta_{max} = \frac{WL^3}{48EI}$$

Where, E = Modulus of Elasticity = 200GPa
Hence

$$\delta_{max} = 0.15\ mm$$

IV. CAE VALIDATION

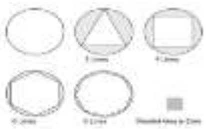
Lets consider L bracket loded with component and lifting by hook on upward

Meshing

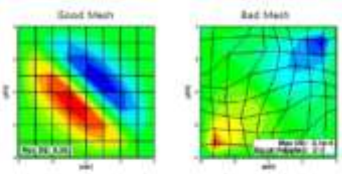
The model is made in ANSYS workbench used for the Stress analysis. The Finite Element Method (FEM) has developed into a key, indispensable technology in the modelling and simulation of advanced engineering systems in various fields like housing, transportation, manufacturing, and communications and so on The fine meshing is carried out. The meshed model created is shown in following figure.

Finite element analysis is the process of dividing or discretizing our geometry into finite nodes and elements and solving it for stress and strains and the particular process of discretization is known as meshing. Meshing is the way of communicating our geometry to the FEA solver. In meshing we will divide our geometry into any one of the following shapes of elements like triangles, quadrilaterals, tetrahedron, quadrilateral pyramid, triangular prism, and hexahedron. and the selection of particular shape of the element depends on the type of analysis and the shape of the geometry. [5]

Elements on the mesh of the geometry will only capture the structural response of the system so it is mandatory to understand the impact of element type and mesh quality before solving a problem. Even the density of the mesh can affect the output so it is best to have a more elements. If we want to analyse a circle, then the geometry of the circle have to be captured as much as possible the image below shows that how the mesh have to be done for circular geometry



Also it is important to have fine structural mesh than coarse unstructured mesh, only at some critical points it is good to have coarse mesh to get accurate result. The image below shows the result variation for good structured mesh and unstructured mesh and also notes that the experimental results correlates more with the structural mesh.



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Processing with Component

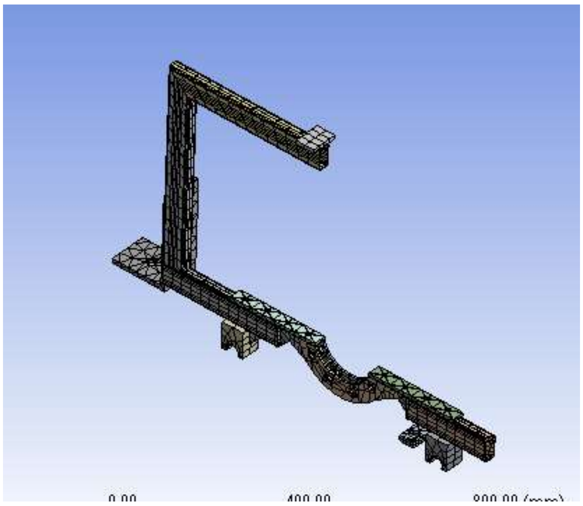

Fig: 10 Meshing model

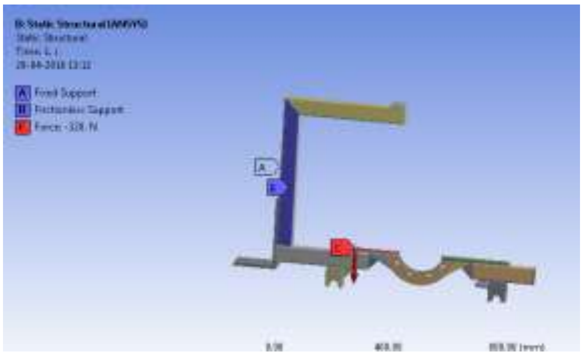

Fig: 11 applied boundary conditions

Conditions are examined from the industrial regular practices.

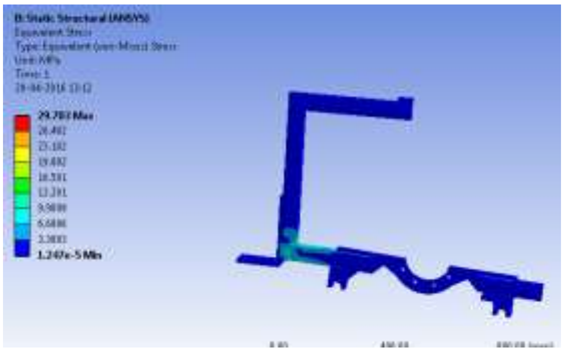

fig : 12 von misses stress

von misses stress = average 16.5 mpa

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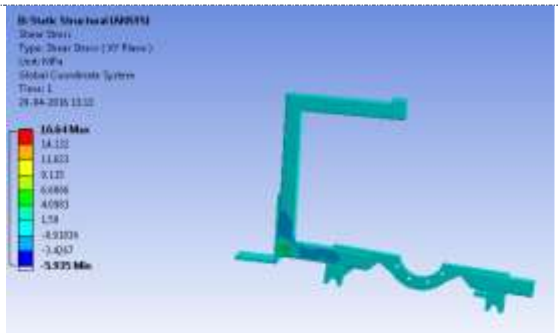

Fig: 13 Shear stress

Shear stress =16.64 mpa

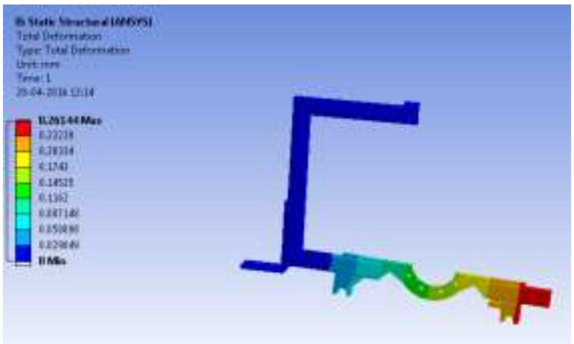

Fig: 14 Deformation under lifting condition.

0.2 mm only ie negligible.
Let's have a look on component loading and drilling forces exerted on it,
Since for drilling of m16 hole 460 to 500 N force imported on body, hence with component loaded model we can check another conditions of static behavior.

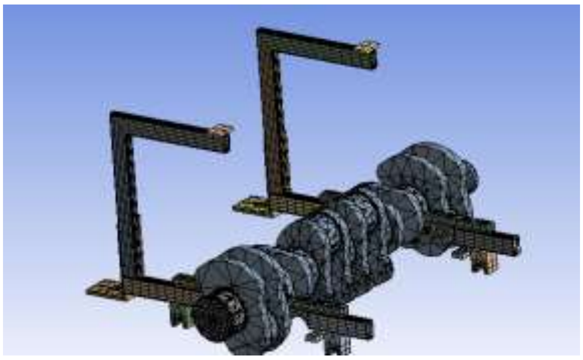

Fig:15 Meshed model

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Fig: 16 Loading conditions applied

Conditions are examined from the industrial regular practices.

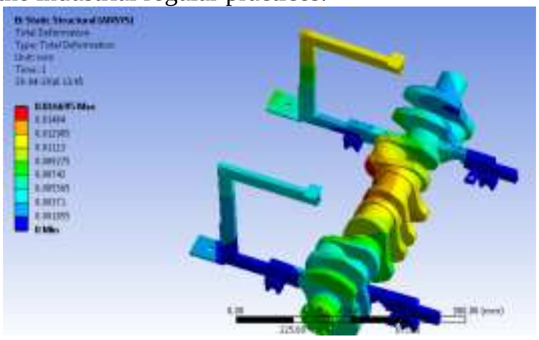
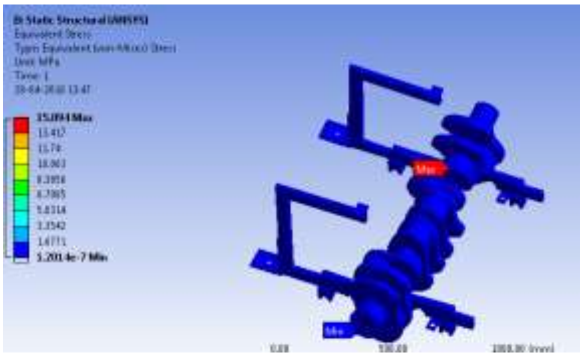


Fig: 17 Total Deformation

Tot. Deformation = 0.01 mm
Deformation gives any buckling strategies under the stress and can be controlled by stiffening components if those are higher or positive, but here found deformation is negligible.
Equivalent stress range under 15.09 mpa



Stress = 15.09 mpa
Stresses found more safer side as if compared with 200 mpa yield strength .

Future scope

poka yoke system need to be developed here because of open lifting and operating conditions no fastening and clamping found here that's the reason accidental chances are more. Finally product will work for the operations to be performed on this .

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V. RESULTS AND CONCLUSION

Condition 1: component loading/lifting

Parameters	Design	CAE validation
V M stresses	5.22 mpa	16.5 mpa
Deformation	0.06 mm	0.26 mm

Copndition2: actual machining operation

Parameters	Design	CAE validation
V M stresses	13.3 mpa	15.09 mpa
Deformation	0.15 mm	0.01 mm

VI. CONCLUSION

From above results it can be concluded that mechanical parameters are safe in working also feasibility of concept is possible and can be implemented, old system was comparatively bulky and complicated for manual use.

Important conclusion obtained on it is in standardized process gaining to develop a new assembly line with higher side production with these design changes in the machine setup.

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