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STRESS ANALYSIS OF RATCHET PAWL DESIGN IN HOIST USING FINITE ELEMENT ANALYSIS

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ABSTRACT:
The ratchet and pawl mechanism plays a crucial role in providing one way transmission and safety against heavy loading conditions. At the mechanical hoists ratchet when locked, allows only one way motion explicitly lifting of masses and restricts its falling probability even if the tensions on counter sides are removed.
The paper considers ratchet of a 1.5 ton capacity of hoist. The mechanism constraints are outlined and the modeling is exercised. The finite element analysis is carried to study an assortment of stresses in ratchet wheel. The nalysis results are concluded in detail.

KEYWORDS:

ANSYS, Pawl, PTC Creo, Ratchet wheel, Safety mechanisms

INTRODUCTION

A ratchet mechanism is based on a wheel that has teeth cut out of it and a pawl that follows as the wheel turns. Studying the diagram you will see that as the ratchet wheel turns and the pawl falls into the 'dip' between the teeth. The ratchet wheel can only turn in one direction - in this case anticlockwise. In engineering, machines that alternately turn and stop often employ ratchet mechanisms – in particular, free-play ratchet mechanisms. They are used, for instance, in hoists, transport mechanisms, supply mechanisms for metal-cutting machines, hydrodynamic transmissions, starting systems for internal combustion engines and gas turbines, bicycle and helicopter transmissions, pulsed mechanical transmissions, and continuous mechanical transmissions.

Such mechanisms operate at speeds between $\omega_{min} = 1$ rad/s and $\omega_{max} = 400$ rad/s. The design of a free-play mechanism with frictional locking is shown in Fig.1.

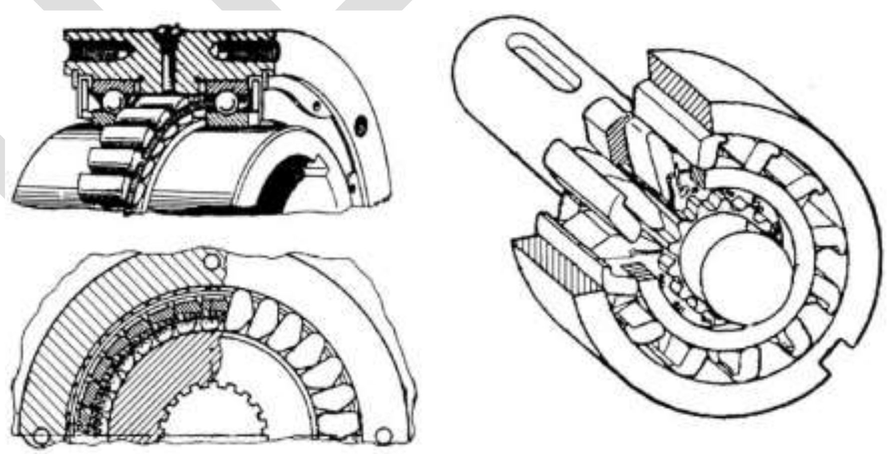


Fig.1.Frictional free-play mechanism

II. RATCHETS AND RATCHETS GEARING

A *ratchet* is a form of gear in which the teeth are cut for one-way operation or to transmit intermittent motion. The ratchet wheel is used widely in machinery and many mechanisms. Ratchet-wheel teeth can be either on the perimeter of a disk or on the inner edge of a ring.

The *pawl*, which engages the ratchet teeth, is a beam member pivoted at one end, the other end being shaped to fit the ratchet-tooth flank.

Ratchet Gear Design. In the design of ratchet gearing, the teeth must be designed so that the pawl will remain in engagement under ratchet-wheel loading. In ratchet gear systems, the pawl will either push the ratchet wheel or the ratchet wheel will push on the pawl and/or the pawl will pull the ratchet wheel or the ratchet wheel will pull on the pawl. See Figs. 8.1a and b for the four variations of ratchet and pawl action. In the figure, *F* indicates the origin and direction of the force and *R* indicates the reaction direction.

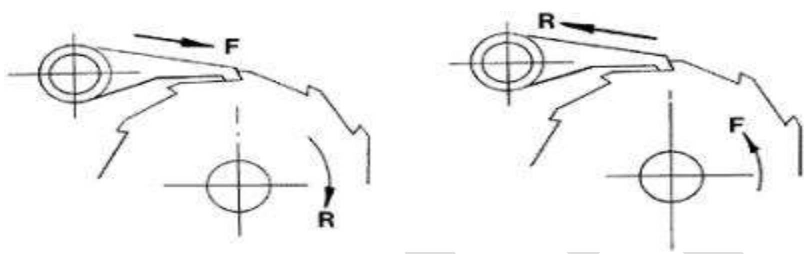


Figure 2: Variation of ratchet and pawl action (F = force; *R* = reaction).

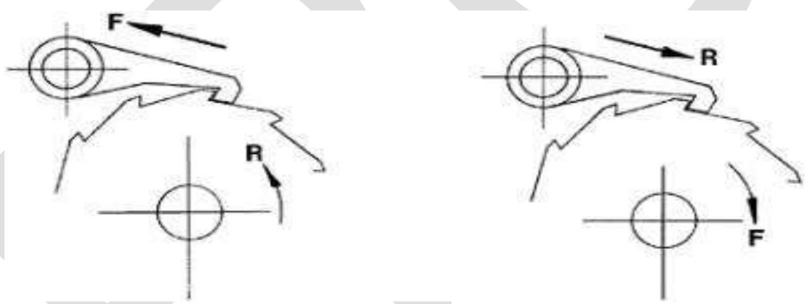


Figure 3: Variation of ratchet and pawl action (*F* = force; *R* = reaction).

Tooth geometry for case I in Fig. 8.1a is shown in Fig. 8.2. A line perpendicular to the face of the ratchet-wheel tooth must pass between the centers of the ratchet wheel.

II. PROPERTIES OF MATERIALS

- **Part Name : Ratchet Pawl**
- **Material Name: C20 (Steel Forging)**

1) Tensile Strength : 425 MPa
2) Poisson Ratio: 0.27 – 0.30
3) Modulus of elasticity (E) : 190 - 210 GPa
4) Specific Heat Capacity: 0.46
5) Density : 7.85 g/cm^3
6) Thermal conductivity : 58.6 W/m.k
7) Bulk modulus : 140 MPa
8) Yield strength : 360 MPa
9) Hardness :156 HB
10) Shear modulus :80 MPa

- **Part Name : Ratchet wheel**

- **Material Name: EN9 (Normalize)**

  1) Tensile Strength : 700 MPa
  2) Yield Strength : 355 MPa
  3) Elongation % : 13%
  4) Modulus of elasticity (E) : 206 x 10^3 N/mm^2
  5) Density : 7800 kg/m
  6) Hardness : 201 to 255 HB

III. RAPR MECHANISM DESCRIPTION

The RaPR mechanism described in this work was designed with the following design criteria as constraints: the ratchet wheel should advance one and only one tooth per actuation pulse; the ratchet wheel driver and restraint mechanism will be in a planar arrangement; the ratchet mechanism should operate on as little space of the ratchet wheel as possible; stand-alone spring elements and complicated assemblies should be minimized or eliminated; moving parts should be balanced about their pivot points; the aspect ratio of parts will be 10:1 or less; the device must be able to be actuated by a stator electromagnet; the driver mechanism will act as the rotor to the electromagnet stator by completing a magnetic circuit; the ratchet wheel will have 36 teeth; no lubricants will be considered for friction reduction; the ratchet mechanism will be designed such that it can be fabricated using micro wire EDM.

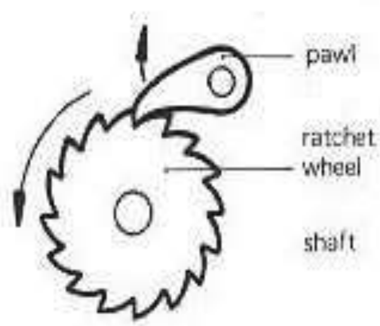


Fig.4.Ratchet pawl mechanism

IV.MODELLING WITH CREO

Following is the modeling of the existing model:

(a) **(b)**

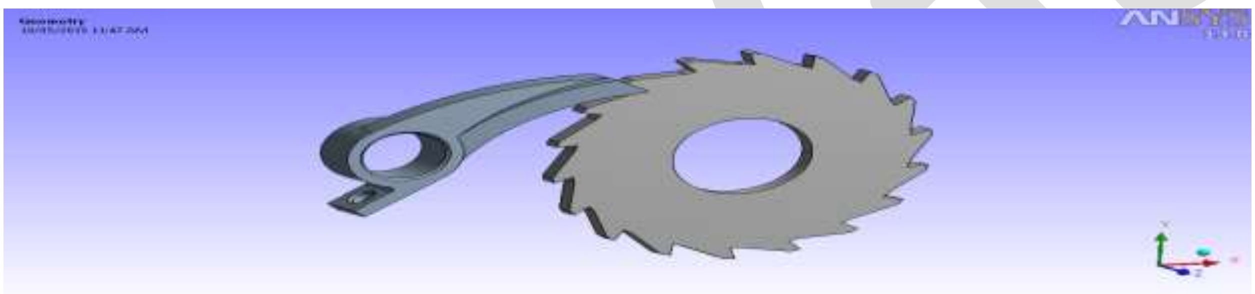
Fig.5.Ratchet wheel

(b) **(d)**

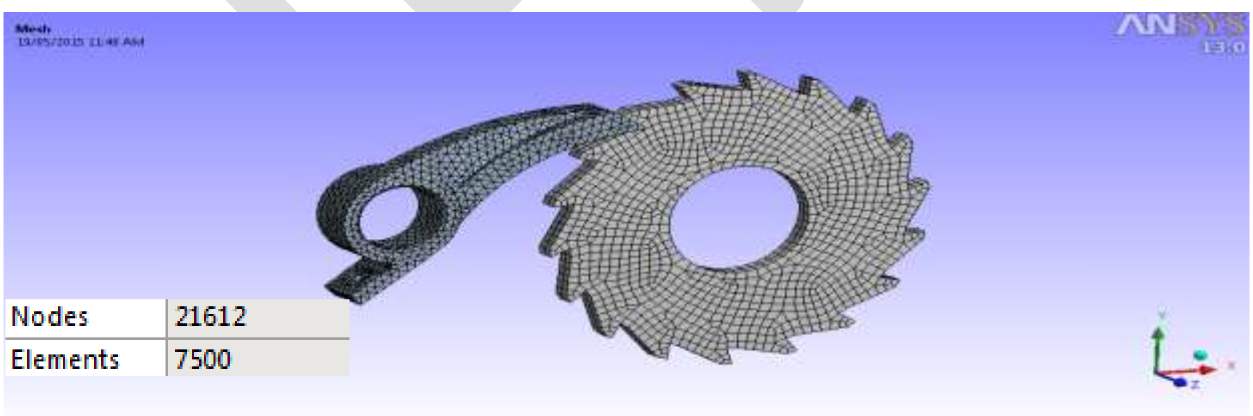
Fig.6.Pawl

FINITE ELEMENT ANALYSIS OF THE ABOVE PARTS OF EXISTING MODEL THROUGH ANSYS

Geometry



Meshing



BOUNDARY CONDITION

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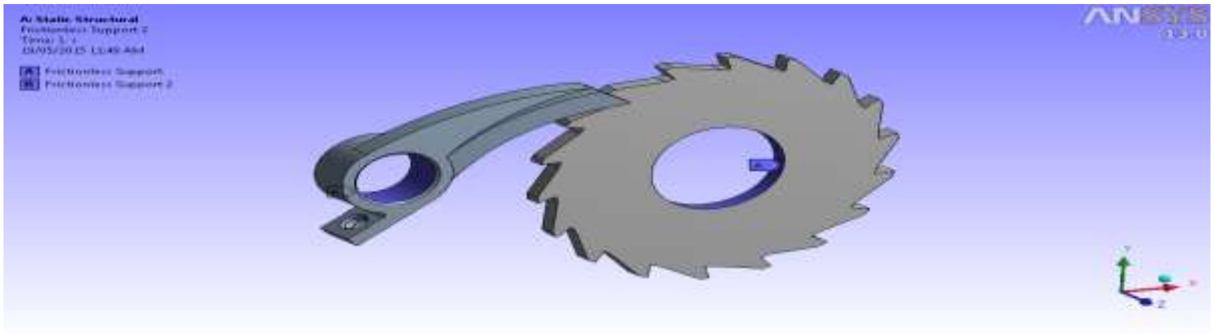
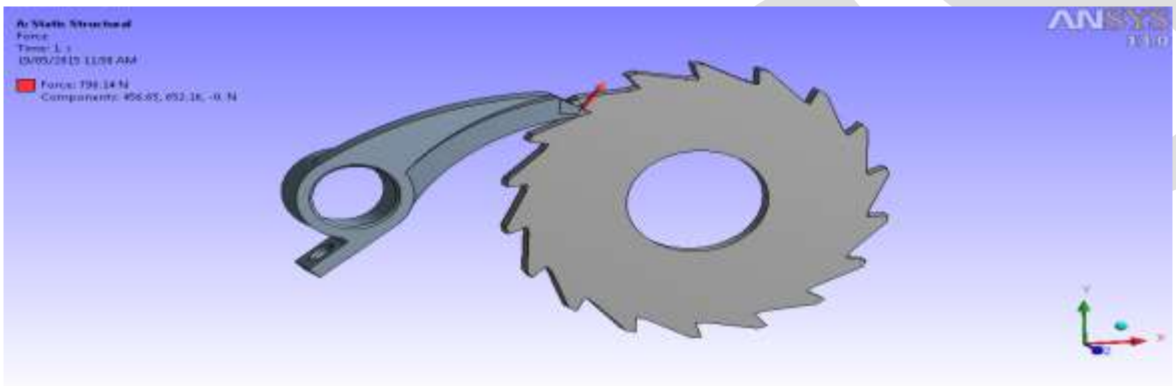
Frictonless Support

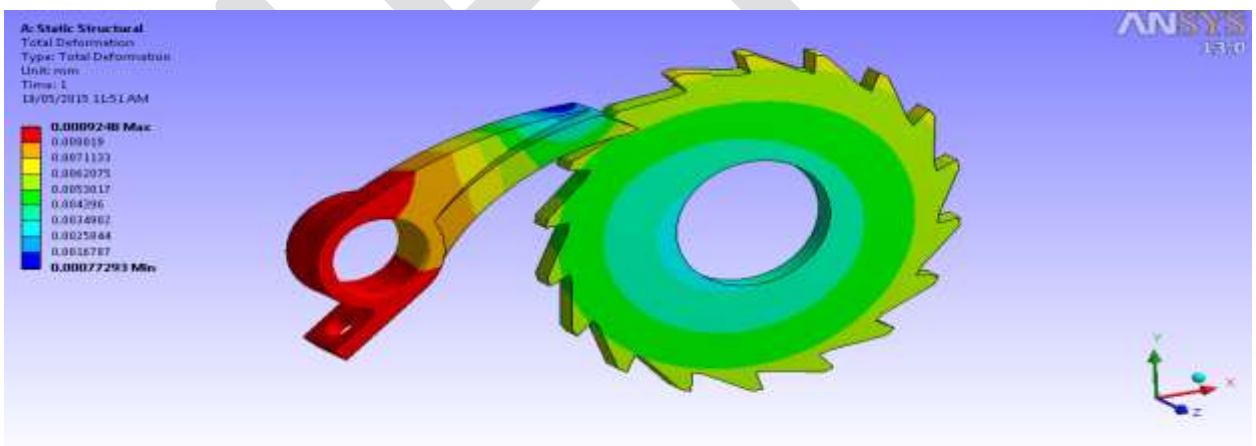


Force

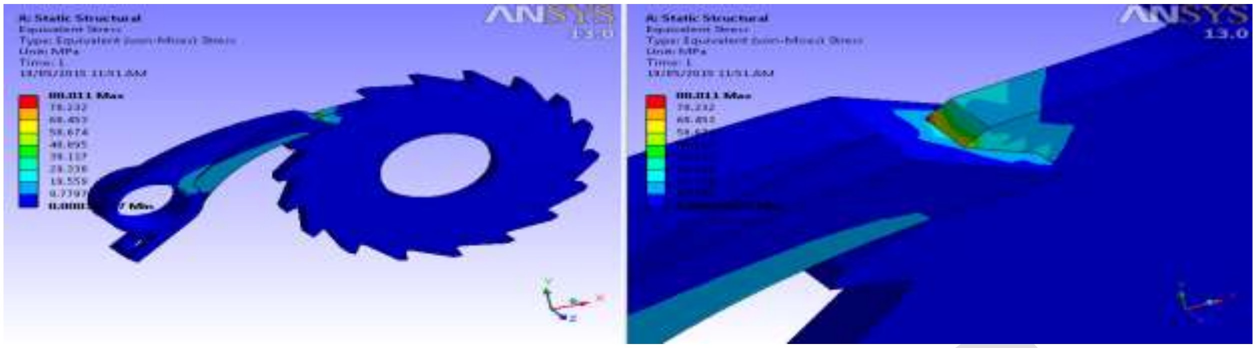


RESULTS

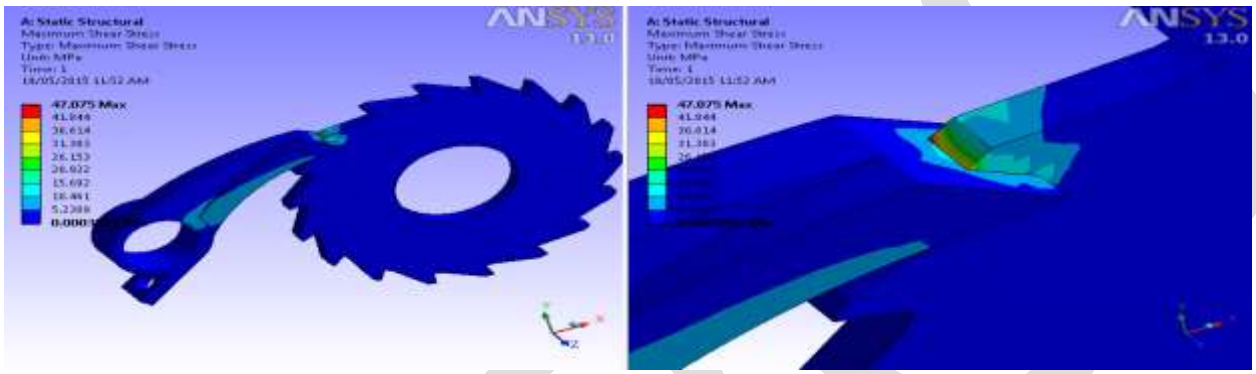
Total Deformation



Von-Mises Stress



Max Shear Stress



CONCLUSION

The RaPR mechanism design was able to adequately fulfil the design specifications.. The ANSYS results shown that maximum shear stress and principle stresses are nominal stresses on ratchet mechanism

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