Design of Multi-Utility Zero Slip Gripper Device using Worm Arrangement

Deepak S. Jogade[1]
ME (Mech-Design), N B Navale Sinhagad College of Engineering, Solapur University,
Kegaon, Solapur, Maharashtra
India.

Abhay.M.Kalje[2]
Associate Professor, Departement of Mechanical Engineering, N.B. Navale Sinhagad College of Engineering,
Kegaon, Solapur, Maharashtra
India.

Abstract:- Material handling is the primary activity of every manufacturing organization. It has been estimated that at least 15 to 25% of the cost of the product is attributable to material handling activities. Unlike many other operations, material handling adds to the cost of the product and not to its value. It is therefore important first to eliminate or at least minimize the need for material handling and second to minimize the cost of handling. In case of machine tools like lathe or vertical machining centres it is desired to handle heavy jobs, which is conventionally done manually using chain blocks. This method is time consuming, unsafe and takes a lot of labour time adding to unproductive time of machine. Thus there is a need of a modified work handling device in the form of jaw capable to handle heavy pipes as well as plates with equal efficiency. This paper describes an efficient mechanism for clamping & de-clamping of work piece with zero slip.

Keywords:- *Gripper, Zero slip, Worm, Self-locking.*

I. INTRODUCTION

This template, modified in MS Word 2007 and saved as aMaterial handling systems are classified as per the type of handling equipment being used, material handled, the method and the functions performed.

A. Equipment-oriented systems, on the basis of equipment type being used

- Overhead Systems
- Conveyor Systems
- Tractor Transfer Systems
- Fork-lift Truck and Pallet Truck Systems
- Industrial Truck Systems
- Underground Systems

B. Material-oriented systems, on the basis of equipment type being used

- Unit Handling Systems
- Bulk Handling Systems
- Liquid Handling Systems

C. Method-oriented systems, on the basis of equipment type of being used

- Manual Systems
- Automated or Mechanical Systems

II. PROBLEM DEFINITION

The clamping in the case of twin jaw gripper that is presently used is a function of the pull force applied to the pull tie rod attached to one of the jaw arms. But sometimes the tie rod pull force may reduce and become insufficient to grip the object in the jaw owing to the slack in the pull chain attached to the tie rod, this may lead to slipping of the gripped object further leading to accident that may lead damage to work-piece / property or human life.

III. PROBLEM STATEMENT AT SPONSOR END

M/s Anil Industries 35/6 MIDC ROAD, Morwadi, Pimpri, Pune -18 It is a Small scale manufacturing industry which supplies parts to Chemical industry, Material handling equipment manufacturing industry. A vertical machining centre require to handle heavy job up to 90-100 kg maximum, presently the loading of work-pieces is done manually using chain blocks , which requires two or more labour to handle the system. This method is time consuming, unsafe .there was a need of a modified work handling device in the form of jaw capable to handle pipes as well as plates with equal efficiency.

IV. LITERATURE REVIEW

Wiktor W Panjuchin has done Self locking worm system with parallel axes and linear contact which gives High efficiency drive to provide instantaneous self locking.(1) Earl H. Sigman& Timothy E. Abblett done tong type lifter by use of gear and linkage mechanism. Here in this article it is shown that aluminium or steel ingots can be grabbed from their side, and safely and effectively lifted, without the necessity of employing non-positive acting side clamping mechanisms that require substantially greater levels of inward clamping force than those required with the mechanism of the present invention.(2) Madhusmita Senapati has considered gripper as a class of unknown nonlinear discrete-time system. The gripper mechanism is implemented for unscrewing a square headed screw on the wall-tiles of a fusion reactor vessel. Various stages of this handling task are explained in detail with theoretical modelling. (3) O.Dennis Mullen has done Improving a Gripper End Effect. In this paper he has discusses the improvements made to an existing four-bar linkage gripping end effector to adapt it for use in a current projects(4)

V. CONSTRUCTION

- *The setup comprises of the following parts*

A. Motor : The PMDC geared motor is with 5 watt power 92 rpm as output and with a integral 9 teeth 2 module pinion on the output shaft of the motor.

B. Spur Driven Gear: The spur driven gear is the driven gear mounted on the nut held in ball bearing 6005zz .The spur gear is 2 module 44 teeth.

C. Screw: The screw is 24 mm diameter 8 mm pitch, It is constrained to slide only to and fro in the input load arm lever by means of slot provided on screw.

D. Input load arm lever : This arrangement is a lever 25x6 mm cross section and it is held on the input worm shaft in the boss.

E. Input worm shaft : It is a high grade steel part held in ball bearing s 6004 zz and 6003 zz held in bearing housing mounted on base frame.

F. Input RH worm: Input right hand worm is a right hand trapezoidal thread screw with 10 mm pitch and 2 degree lead angle . It is mounted at and skew angle of 3 degree to the output worm to effect the self lockingaction. Input right hand worm is made of 20 MnCr1 material.

G. Output Left hand worm: Output left hand worm is a left hand trapezoidal thread screw with 10 mm pitch and 5 degree angle. It is mounted on the output worm shaft. Input right hand worm is made of 20 MnCr1 materials.

H. Output worm shaft : It is a high grade steel part held in ball bearing s 6004 zz and 6003 zz held in bearing housing mounted on fixed movable jaw, where as the output worm shaft carries the movable top jaw.

I. Bottom fix jaw: Thebottom fix jaw is welded to the base frame. It also carries the bearing housing for output worm shaft .Material of the fixed jaw is structural steel.

J. Top input Jaw: The top input jaw is movable element that effects the clamping action. The top jaw is made of structural steel which is welded to the output worm shaft.

K. Electrical control circuit: The control circuit consists of 2-pole 2-way switch that controls the direction of motor thereby facilitating the raising or lowering of the load where as the push button is used to control the position of load.

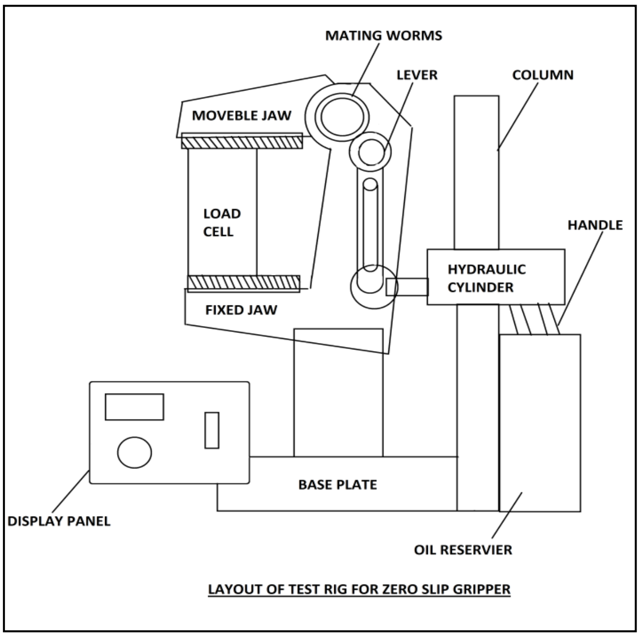


Fig 1:- Layout of test Rig for Zero Slip Gripper

VI. DESIGN OF PARTS

A. Design of Rh Input Worm Shaft

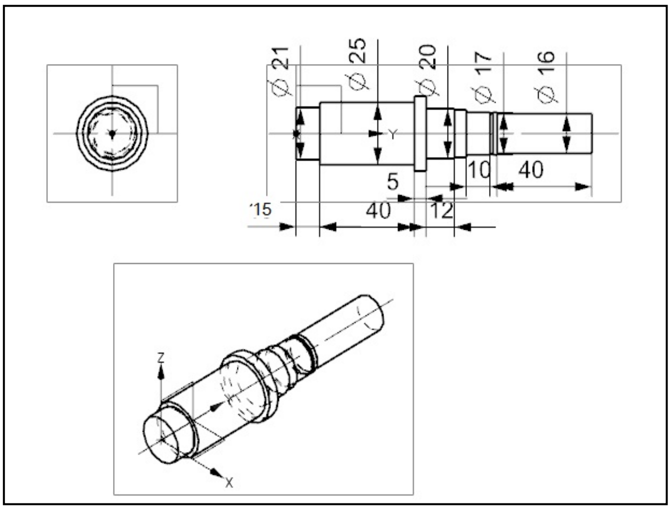


Fig 2:- Dimensions of RH input worm shaft

MATERIAL- EN 24,
ULTIMATE TENSILE STRENGTH-800 N/mm2 ,
YEILD STRENGTH -680 N/mm2,
fs max = uts/fos = 800/2 = 400 N/mm2

- *Check for Torsional Shear Failure of Shaft*

Torque is applied at the LEVER mounting point on the shaft which 16mm in diameter

Td = Π/16 x fs act x d3

fs act = 16 x Td = Π x 16 3 = 3.02 N/mm2
Π x d 3 16 x 2444

⇒ WORM SHAFT is safe under torsional load

- *Analysis of Rh Input Worm Shaft*

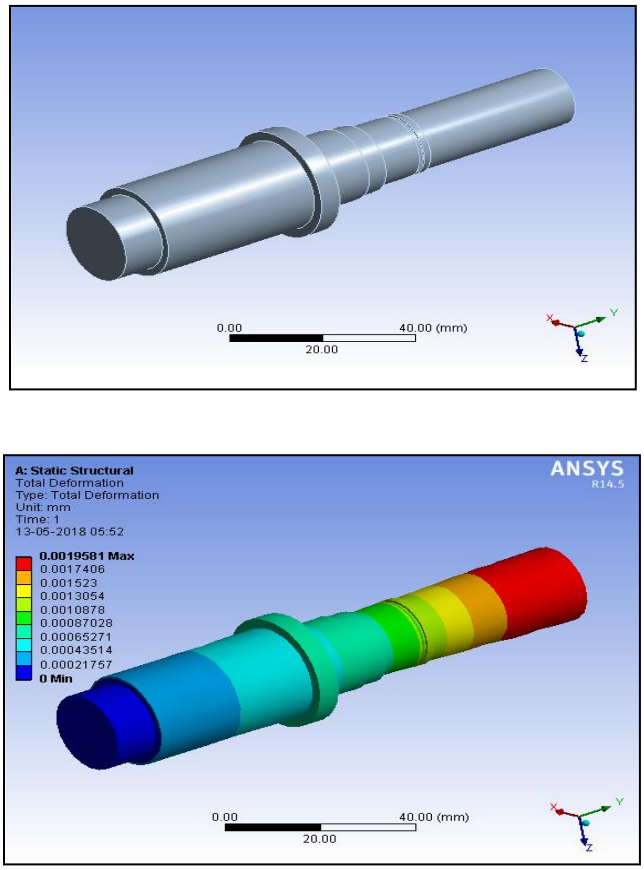


Fig 3:- Analysis of Rh Input Worm Shaft

Similarly for LH OUTPUT WORM SHAFT
fs act = 3.03 N/mm2,
WORM SHAFT is safe under torsional load

B. Design of Lh Output Worm

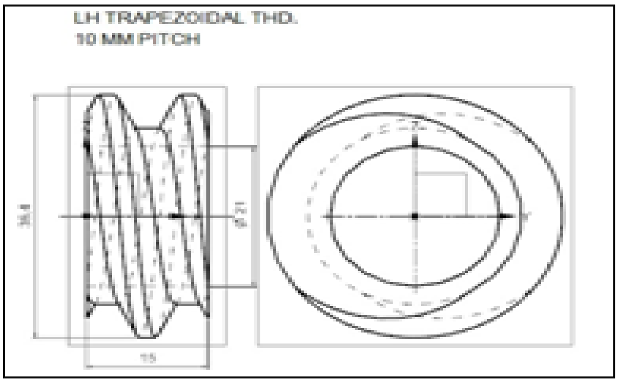


Fig 4:- Dimensions Of LH output worm

MATERIAL- 20 MnCr1,
ULTIMATE TENSILE STRENGTH-1000 N/mm2 ,
YEILD STRENGTH -800 N/mm2
fs allowable = 0.18 X 1000=180 N/mm2,
T design = 2 Nm

- *Check for Torsional Shear Failure of Shaft.*

Td = Π/16 x fs act x(D4- d4) /D

⇒fs act = 16 x Td = 16 x2 .44 x 10 3 x 36.4
Πx (36.64- 214) Π x (D4- d4) /D

⇒fs act = 0.289N/mm2 ,As fs act <fs all

⇒OUTPUT LHworm is safe under torsional load.

- *Analysis of Lh Output Worm*

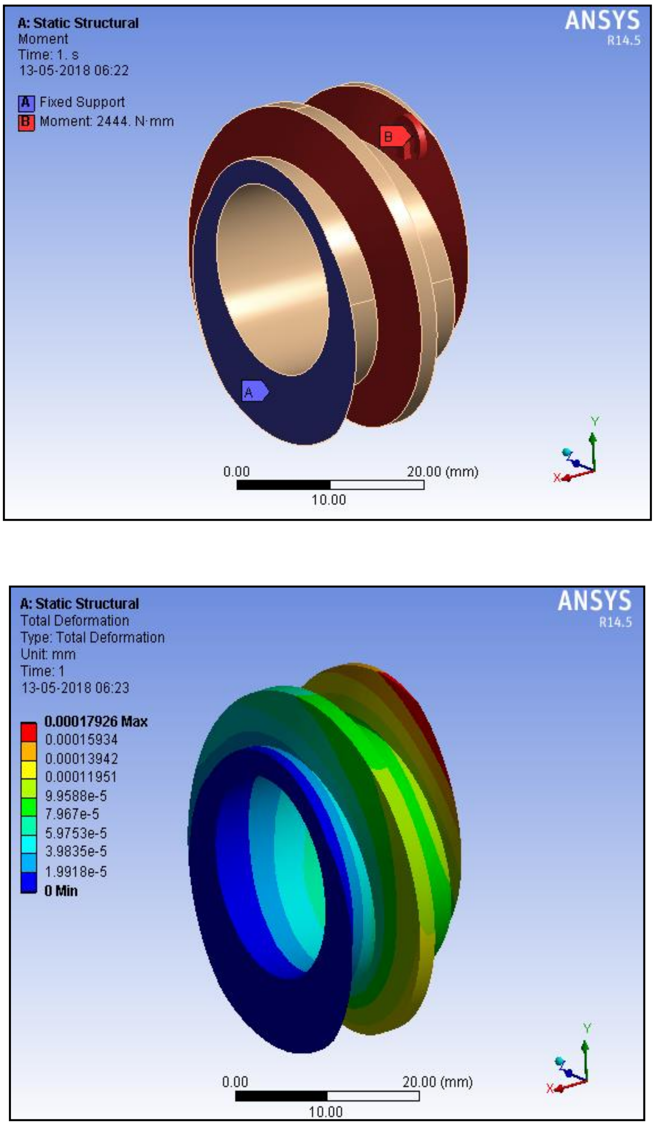


Fig 5:- Analysis of Lh Output Worm

➢ *Design of Bottom Fixed Jaw*

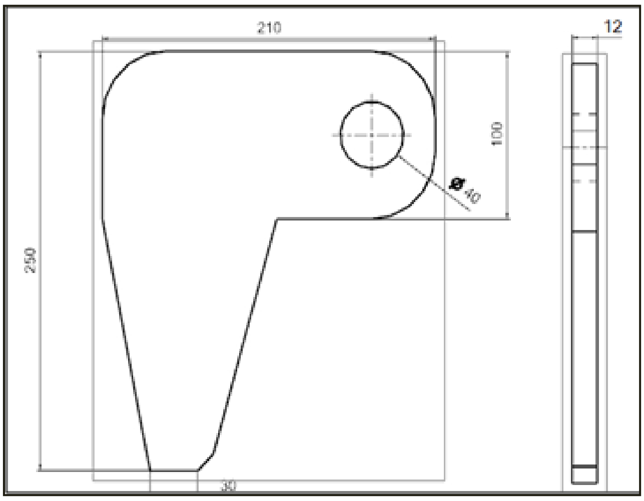


Fig 6:- Dimensions of fixed jaw

MATERIAL- EN9,
ULTIMATE TENSILE STRENGTH-650 N/mm2 ,
YEILD STRENGTH - 480 N/mm2,
Allowable stress = UTS /Factor of safety
= 650 /3 =216.7 N/mm2
The linkage has an MINIMUM section of (30 x 12) mm at the load application end
Let; t= thickness of link, B= width of link
Bending moment;

Section modules; Z= 1/6 t b2

$$Fb = m/z = \frac{PL}{1/6\ t\ B^2} = \frac{6PL}{tB^2}$$

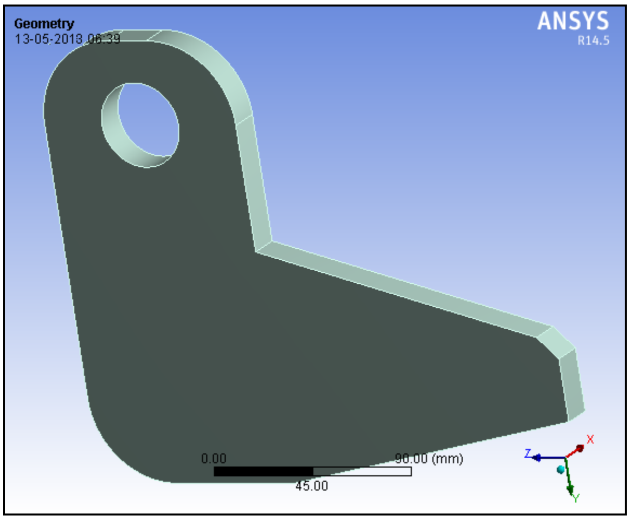
Maximum effort applied by mechanism = 88 N

$$\Rightarrow fb = \frac{6 \times 88 \times 200}{12 \times 30^2} = 9.8\ N/mm^2$$

Asfbact<fball

Thus selecting an (30x12) cross-section for the link for load arm lever is safe.

C. Analysis of Bottom Jaw Arm



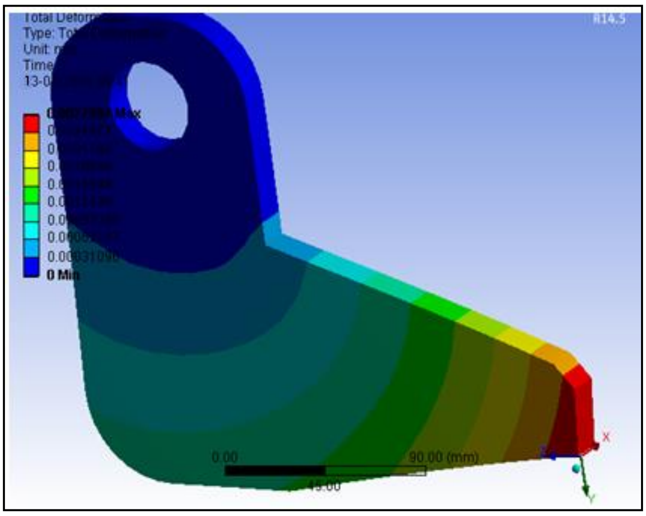


Fig 7:- Analysis Of Bottom Jaw Arm

Similarly selecting an (50x12) cross-section for the link for movable jaw is safe.

REFERENCES

[1] 1. Wiktor W Panjuchin Self locking Dual worm gear & tools to produce it US Patent 55,22,278 June 1996 Self locking worm system with parallel axes and linear contact is proposed

[2] 2. V.B.Bhandari, "Design Of machine elements", Tata McGraw Hill, 2005

[3] 3. O.Dennis Mullen Improving a Gripper End Effect Pacific Northwest National Laboratory Journal 9, 2003 modeling of gripper mechanism and end effectors

[4] 4. Alex Kapelevich and Elias Taye Applications for Self-Locking Gears Spline & Gear Dec 2008 Variety of self locking solutions with their specific applications are