Development of a Gear Hobbing Fixture to Reduce Ineffective Work and Increase the Productivity using Ergonomics

Mr. Sumeet Shinde*, Mr. Priyanshu Tanna, Mr. AdityaWalunj, Mr. Akshay Ozarde

Department of Mechanical Engineering, Marathwada Mitra Mandal's College of Engineering (Pune University), Pune, India

*Corresponding Author: sumeetshinde109@gmail.com

Abstract--The present work deals with the development of a gear hobbing fixture for manufacturing of gear drive of fuel pump hobbed on Lambert 82 machine. The primary objective is to reduce the time & improve the current working method of manual clamping by using screw clamp. This is achieved by replacing the existing method with a hydraulically actuated clamping and de-clamping mechanism activated by a switch, thus using ergonomic principle of reducing the manual efforts required. In addition to this the other important criteria to be considered are cutting forces and shear experienced, along with total runout, positive location, repeatability, production rate and reliability .

Keywords – fixture, productivity, ineffective work, clamping mechanism, disc springs, hydraulic and pneumatics, switch, ergonomics, BRIEF survey

INTRODUCTION

Gear Hobbing is a widely applied manufacturing process for the construction of any external tooth form developed uniformly about a rotating centre. It is an advance process compared to turning and milling [6]. The fixture used for hobbing process should be designed such that the gear blank is clamped accurately about the machining axis and restrain any undesirable movement throughout the machining. Fixtures consisting of clamps and locators should also ensure a good quality performance beside positioning and holding. Michael Yu Wang [7] stated that fixture layout is the fundamental task of fixture design, to determine the number, type and location of the basic fixturing elements of locators, supports, and clamps, as opposed to the detailed design of the fixture assembly.
Ineffective work can be defined as any efforts put into any process which does not contribute to the productivity, profit or significant returns, and results in wastage of time and energy. Human factors and ergonomics (HF&E), also known as comfort design, functional design, and systems, is the practice of designing products, systems, or processes to take proper account of the interaction between them and the people who use them. In this project we are dealing with the physical ergonomics, which is concerned with human anatomy, and some of the anthropometric, physiological and bio mechanical characteristics as they relate to physical activity.

PROBLEM FORMULATION

Fixtures are very vital parts of conventional as well as modern manufacturing processes since it directly affects the productivity and quality. The total machining time for a workpiece includes work-handling, the methods of locating and clamping and the total machining time should be as minimum as possible. The fixture should also ease the loading and unloading of the workpiece, which will help to reduce the ideal time.

Fig.1 Screw clamping

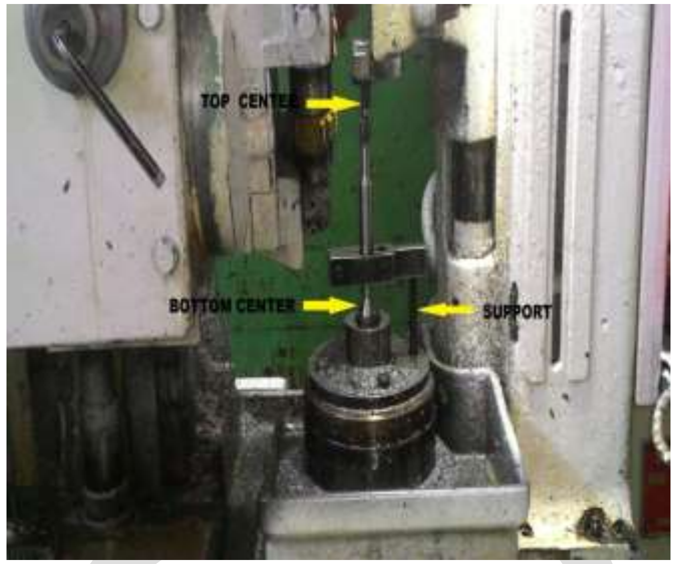

Fig.2 Workpiece with support

The time taken for setting of the workpiece on the machine was quite high. The above figure explains that the operator first need to hold the workpiece in the clamp and tighten the screw, then hold the workpiece between the centres and wait until the top centre of the machine touches the workpiece. Then as the base table starts rotating, the support shown in the figure which connects the extended portion of the clamp and the base, rotates the workpiece along with the base table. As you can see, this technique of setting the workpiece is not reliable and tedious for the operator when a batch of about 150-200 such gears is to be machined. The chances of job rejection are also very high due to the following reasons-
(A conditional runout tolerance of only **25 microns** is permitted)

- The centres cannot hold the workpiece very firmly due to the high cutting forces.
- Due to the tedious repetitive cycle of setting the workpiece the operator might not properly set the extended part of the clamp on the support.

CONDITIONS TO BE CONSIDERED WHILE DESIGNING THE FIXTURE

- Ergonomics

The existing process is very tedious for the operator and he is subjected to fatigue along with various risk factors and thus a simpler clamping system is to be designed.

- Runout tolerance

As the job is used to drive the fuel pump, runout of the job to be maintained is restricted to only **25 microns**. Therefore the fixture should clamp the workpiece uniformly and within the runout limit

- Power operated clamping and de-clamping mechanism

As the primary aim is to reduce the ineffective work introduced due to the manual clamping of the workpiece, we have to use power operated mechanism. Various options were considered like using electric motor, vacuum pump and hydraulic-pneumatic power to actuate the clamps.
Due to lack of space, high operating cost and difficulties in effectively implementing the mechanism, the options like electric motor and vacuum pump were obviated. The most viable solution was to use Hydraulic and Pneumatic power. The implementation of the mechanism using the hydraulic-pneumatic source is explained later in the coming section.

- Tool travel

The upper and lower limit of tool travel from the base is 8.1” and 2.95” respectively. Therefore we have to maintain the portion of the job to be machined within these limits.

DEVELOPMENT OF MECHANISM AND ITS IMPLEMENTATION

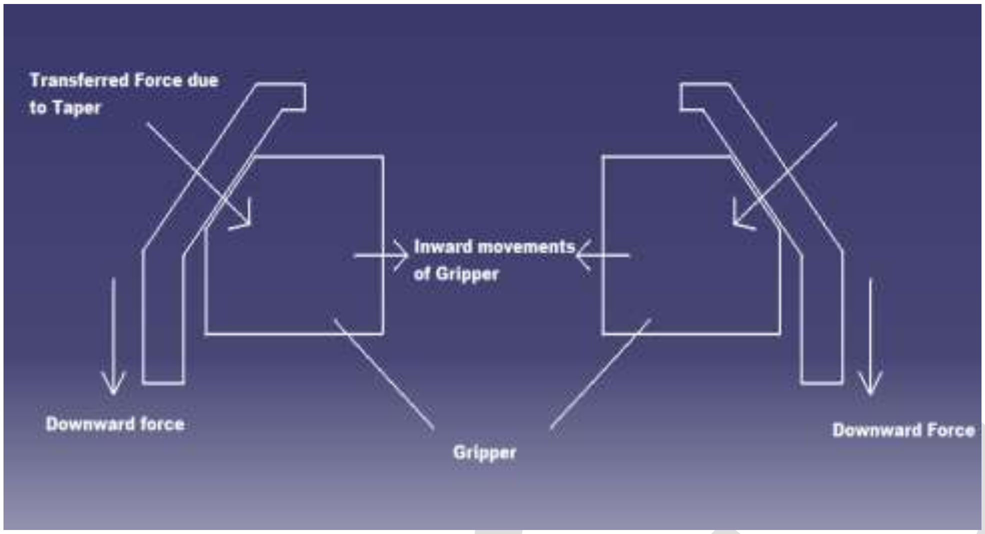

Fig.3 Block Diagram of Basic Mechanism

A simple clamping mechanism is used as shown in figure consisting of grippers and a taper part having linear vertical motion. The taper portion of the outer part is in contact with the taper edge of the gripper. As the outer part moves downwards, the gripper starts moving inwards. This simple principle is used to develop the clamping mechanism of the fixture.

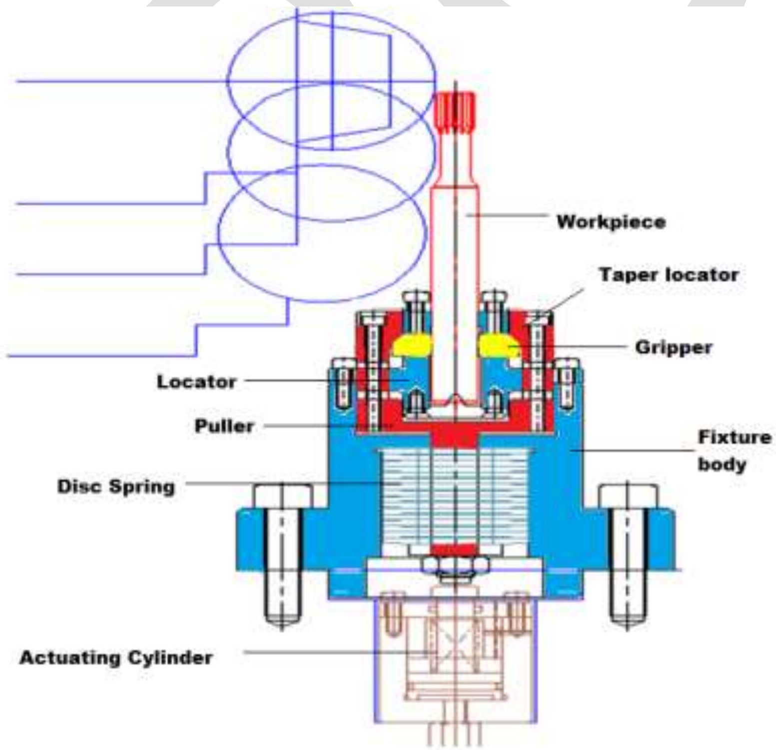

Fig.4 Sectional View of the fixture

Challenges

The challenge while implementing the above described mechanism was that there are two motions to be considered

- Linear Motion of taper locator, puller and gripper during clamping (shown in Red colour)
- Rotation of the total fixture, as it has to be attached to the base plate. (achieved with the help of blue coloured parts)

The Taper Locator and Puller are used to clamp the workpiece in position and have linear vertical motion. The puller by default is pulled downward due to the spring action of disc spring. Due to this downward motion of taper locator, the grippers move inwards and thus clamp the workpiece.

To de-clamp the workpiece an actuating cylinder, attached below the base table, which has a very small clearance between the piston and the puller end, is used. This cylinder is hydraulically powered and pushes the puller upwards which moves the taper locator upwards and thus generates a clearance between the gripper and taper locator. Thus the grippers become free slides in guides provided and they can move outwards and job can be removed.

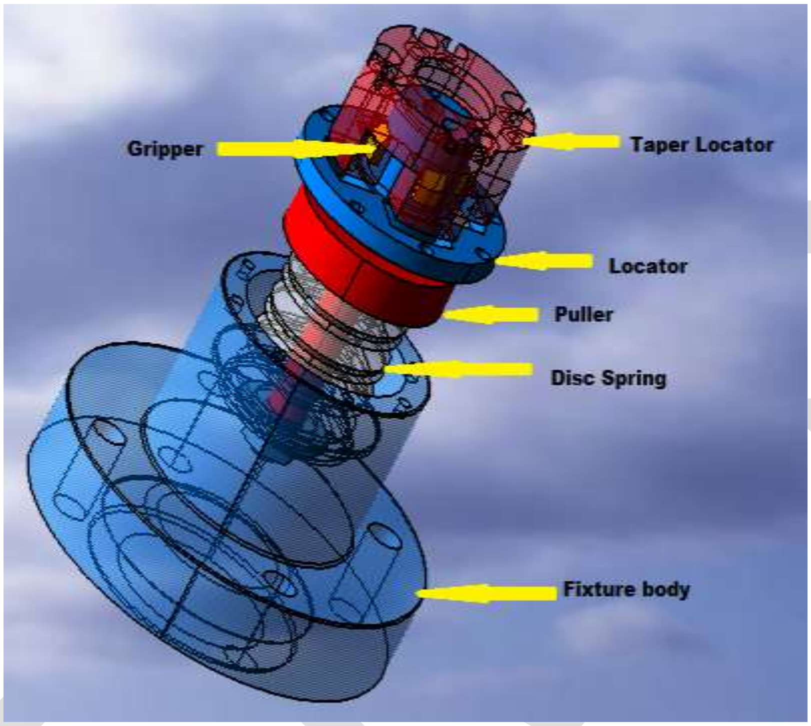

Fig.5 3-D Exploded view of the Fixture

In order to make the fixture rotate with the base table, the Taper Locator is interlocked with the Locator. From the figure, we can see that the taper locator has projected ends which fit into the slots in the locator. The locator is attached to the fixture body which is attached to the base. This arrangement rotates the fixture (hence the workpiece) with the same RPM as that of the table.

DISC SPRINGS

As mentioned in the above condition of Tool Travel, the combined height of the fixture and workpiece should not cross the upper limit of the tool travel. By using conventional helical spring there is a possibility of exceeding this limit, therefore we will be using Disc spring which exerts the same force as that of a helical spring but with lesser space requirement and deflection.

Advantages of Disc Spring are-

- High load capacity with small deflection
- High load to size ratio
- Consistent performance under design loads
- Longer fatigue life
- Flexibility in stack arrangement to meet the desired load requirement

ISSN 2091-2730

HYDRAULIC & PNEUMATIC CIRCUIT

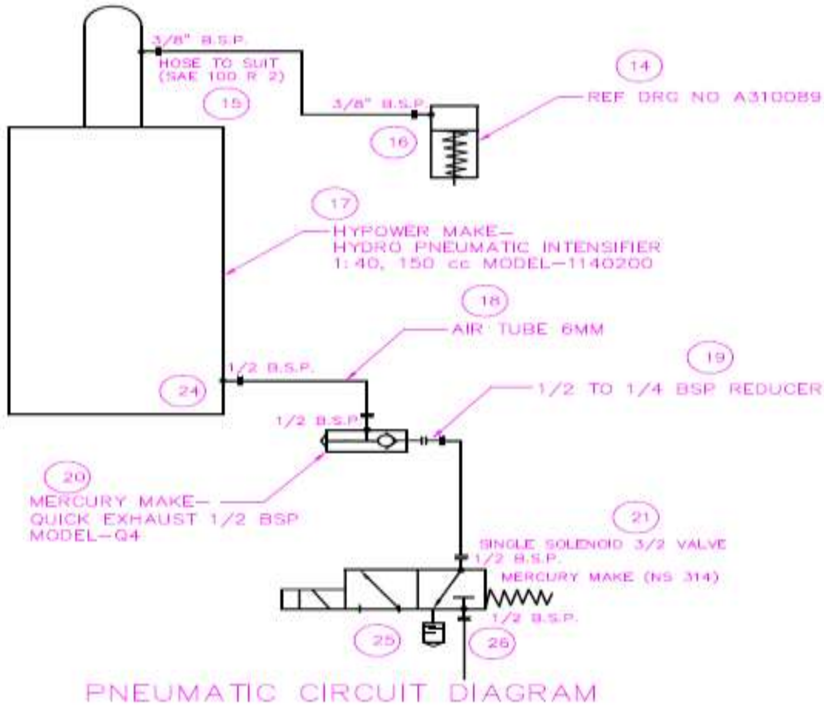

Fig.6 Pneumatic circuit Diagram

The available power supply in the company was Pneumatic supply of 3.5bar which is used for the cleaning of the burr by compressed air gun, this same supply is to be used to actuate the cylinder which in turns de-clamps the job. This pressure isn't enough to de-clamp and also this line is common to all the machines in the plant, there is a possibility of pressure drop as there might be another operator using it. Hence to compensate for this loss and to avoid any interruption in the operation of the fixture mechanism we have used an intensifier in the circuit of ratio 1:40. The line after the intensifier is hydraulic using oil of grade SAE100R2.

RESULTS AND DISCUSSIONS

1. TIME-SAVING

The time measured for setting and handling of the job without fixture was about 11sec and with fixture it is 5sec.

2. ERGONOMICS

BRIEF Survey (Baseline Risk Identification of Ergonomics Factors).The BRIEF Survey is intended to find any ergonomic risk factors that may cause any musculoskeletal symptoms to the employee operating the machine. Lower the score of the survey, greater will be the safety and better ergonomics. The BRIEF Survey of the process shows a very significant improvement from 30 to 8 points.

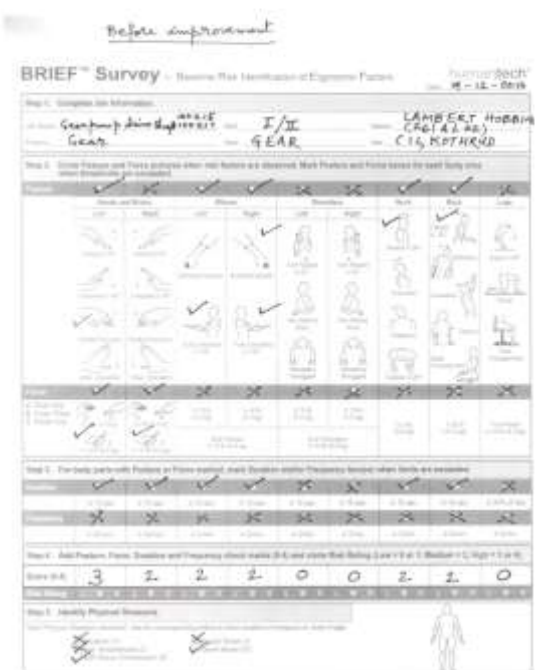

Fig.7
(Before Improvement)

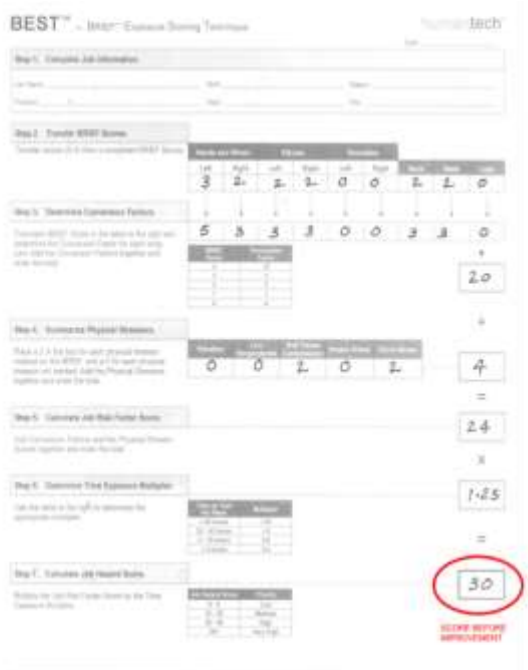

Fig.8
(Before Improvement)

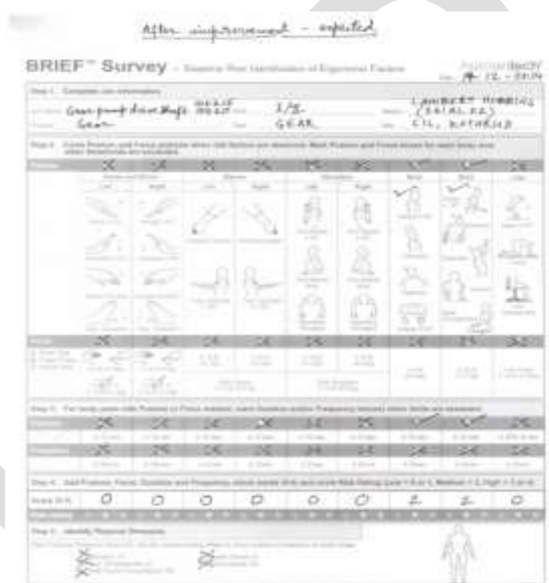

Fig.9
(After Improvement)

Fig.10
(After Improvement)

3. PRODUCTIVITY

Number of jobs rejected per 100 jobs manufactured without fixture = 2
Number of jobs rejected per 100 jobs manufactured with fixture = 0
Therefore, Material Productivity without fixture = 98%
Material productivity with fixture = 100%

ACKNOWLEDGEMENT

We wish to thank our sponsoring company Cummins India Limited and our college to giving us the opportunity to work on this project and also for their consistent guidance and sympathetic attitude words our efforts.

CONCLUSION

With the ever increasing demand and pace of production it is necessary to improve the process of production. The proposed clamping mechanism has successfully reduced the ineffective work and the risk factors and eventually results in an over-all increase in the productivity. The mechanism introduced here can be used to develop similar fixtures which demand clamping of any circular workpiece.

REFERENCES:

[1] Patang Vidyut Chandra "An effort to apply work and time study techniques in a manufacturing unit for enhancing productivity" International Journal of Innovative Research in Science, Engineering and Technology, ISSN: 2319-8753, Vol. 2, Issue 8, August 2013

[2] Dusko Pavletic, Mirko Sokovic "Quality Improvement Model At The Manufacturing Process Preparation Level" International Journal for Quality research, UDK- 658.5, Vol.3, No. 4, 2009

[3] Jennifer N. Schumann "An Analysis of Ergonomic Risk Factors Relating to Strains at Company XYZ" A Research Paper Submitted in Partial Fulfillment of the Requirements for the Master of Science Degree in Risk Control, The Graduate College University of Wisconsin-Stout May, 2007

[4] Shailesh S. Pachbhai, Laukik P. Raut "A Review on Design of Fixtures" International Journal Of Engineering Research and General Science, ISSN 2091-2730, Feb-Mar 2014

[5] Amar Raj Singh Suri, A.P.S. Sethi "Development of Gear Hobbing Fixture Design for Reduction in Machine Setting Time" International Journal of Scientific and Research Publications, ISSN 2250-3153, Volume 2, Issue 10, October 2012

[6] Mihir K. Shah, Vivek A. Deshpande, Ramchandra M. Patil "A Review on Lean Tools & Techniques: Continuous Improvement in Industry" International Journal of Advance Industrial Engineering, E-ISSN 2320 –5539, 16 Dec 2015, Vol.3, No.4 (Dec 2015)

[7] M. Y. Wang "Optimum 3D Fixture Layout Design" Intelligent Control and Automation, Proceedings of the 3rd World Congress, 26 June-2 July 2000

[8] K.V.S. Seshendra Kumar "Design of Gear Cutting Fixture for CNC Gear Hobbing Machine" International Journal of Scientific and Research Publications, ISSN 2250-3153, Volume 2, Issue 9, September 2012

[9] Mutombozana Tapiwa, Mugwindiri Kumbirayi, Chikuku Tauyanashe "The use of Work Study Techniques in Optimizing Manufacturing Plant Maintenance Processes: an Investigation into a Fertilizer Manufacturing Company in Zimbabwe" International Journal of Science and Research (IJSR), ISSN: 2319-7064, Volume 2 Issue 2, February 2013

[10] Sandeep Soni, Ravindra Mane "Design and Modeling of Fixture for Cylinder Liner Honing Operation" Global Journal of Researches in Engineering Mechanical and Mechanics, ISSN: 2249-4596, Volume 13 Issue 7 Version 1.0, 2013

[11] Abdul Talib Bon, Daiyanni Daim "Time Motion Study in Determination of Time Standard in Manpower Process" Proceedings of EnCon2010 3rd Engineering Conference on Advancement in Mechanical and Manufacturing for Sustainable Environment, Kuching, Sarawak, Malaysia, April 14-16, 2010

[12] W. Patrick Neumann "Identifying and Managing Risk in the Design of High Performance Work Systems" Doctoral Thesis, Department of Design Sciences Lund University, Sweden, 2004