

# RE-EQUIPPING OF GEAR HOBGING MACHINE: NUMERICAL CONTROL INNOVATION BASED ON PLC AND SERVOMECHANISM

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**Abstract-** This research work has been carried out at Top Gear Transmission Pvt. Ltd. plant located at Satara, India. Top Gear Transmission Pvt. Ltd. is a leading name in gearbox manufacturing. Various types of gearboxes are manufactured in the company as per the customer requirements. Company wants to convert conventional gear hobbing machine in to the NC machine due to demand for improved performance of gears, to manufacture better quality gears preferably without using a further finishing process, such as grinding. Teeth gear processing includes one important process i.e. The gear hobbing. Now a days in modern gear processing, traditional gear hobbing process pointed out towards existing problems. To overcome those problems, putting forward efficient reconstruction scheme namely conversion of conventional gear hobbing machine in to NC machine with programmable logic controller and servo mechanism. By using PLC in gear hobbing following transformations has done. In hardware transformations, to minimize the defects of traditional gear hobbing transmission : use of more motor driving mode control process; replacement of middle transmission mechanism; direct connection of motor shaft & planetary gear box with movement; reduce transmission error so as to improve the machining accuracy. To better control, adopted the sensors to follow movement process; use of PLC & feedback better control process. Enhancing the function of gear-hobbing after reforming, adopt touch screen man-machine interface for exchange. After transformation in gear hobbing machine the test results show that numerical control transformation, helps improve efficiency, accuracy, life span of old machine and minimizes complexity for the operator.

**Index Terms-** Gear Manufacturing, Planetary Gearbox, PLC, Servomotors.

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## I. INTRODUCTION

Recently every Gear manufacturing industry is very much conscious about improvement in equipment performance and in this techno part Numerical Control Technology is playing most important role. In mechanical transmission, spur gear and helical gears are widely used. The numerical control technology raising some challenges for research and development to improve the precision, machining accuracy, processing efficiency, and product adaptation of machine. The gear hobbing machine cuts cylindrical spur and helical gear by gear generating method which are largely used at different types of gearboxes, automobiles, machine tools, and other machinery manufacturing industry. The gear hobbing machine is the main gear processing equipment, which is used to manufacture large volumes and high efficiency production of spur and helical gears. Now question comes when there is need to manufacture variable transmission ratio of gears, at that time we need frequently to produce and replace the driving change gears, which bring inconvenience for the industry.

This inconvenience results in decrease in production efficiency, precision, accuracy and processing flexibility. To avoid this major inconvenience we are re- equipping this gear hobbing machine tool with numerical control technology [2].

## II. PRINCIPLE OF PTP 0690 GEAR HOBGING MACHINE

The PTP 0690 universal gear hobbing machine was originally a conventional mechanical transmission machine. PTP 0690 machine includes hob spindle, disk flywheel, standard hob head, work table, change gears, hydraulic driving and cooling system, electric control system and so on. It drives by a single main motor, with all motions of the machine, such as rotation of the hob and work table achieved by using mechanical change gears and corresponding index ratios. The main drive motor is a single speed 3 phase AC 5.0 hp induction motor. Different speeds can be achieved through a pulley belt. Index ratio between the work table and the Hob get changed by using index gears which are located in the back of the machine. The proper constant timed relationship between the revolution of the hob and the work table maintained with help of index change gears and feed change gears. Separate system is used to affects the rotation of the work gear and correlates the feed motion through a separate change gear system (known as differential change gears) for obtaining the correct lead. The differential imparts slight supplemental increment or decrement motion of the work table independent of index change gears and feed change gears. Work table is mounted on large bearing surface to improve the damping against the intermittent cutting action of a

hob. A worm wheel of a size bigger than maximum size of gear to be hobbled drives the work table on the machine. The mechanical drive to the work table is via a single worm-wheel, and suits both right hand and left hand hobs, achieved by an extra gear in the indexing arrangement. The arrangement is also suitable for both climb cutting and conventional hobbing. Cutter spindle holds the hob arbor and ensures that the hob arbor and cutter assembly run true on its own axis during cutting. Cutter spindle mounted on a swivelling head is tilted to bring the hob teeth in line with gear teeth. To minimize the effect on the intermittent cutting action of the hobbing process, hob shift arrangement has done including the flywheel. Limit switches get used as a safety cut out or basically as signal switches. An Electric pump supplies the coolant oil to the hob head whilst cutting. The electrical control gear cabinet is mounted on the machine rear and has the entire contactor switch gear and machine control relays. In the front of the machine, a push button panel has located. Principle behind hobbing i.e. a continuous generating process, in which the cutting tool (the hob) rotates continuously in mesh with the gear being hobbled, progressively cutting all the teeth at the same time. As the hob rotates, its multiple cutting edges, which all lie on an enveloping helicoid worm surface, cut out in space the flanks of a virtual generating rack of infinite length which continuously rolls with the gear blank to generate the required tooth form. Rotation of the hob in mesh with the work piece in this way, with no other relative motion, would generate conjugate teeth on the gear. The transmission principle is shown in Fig. 1.

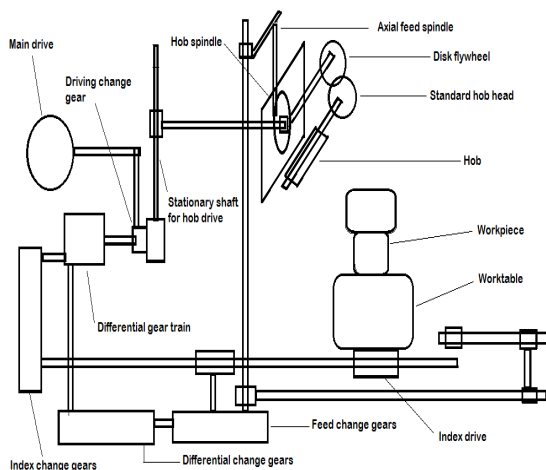


Figure 1. Transmission principle of generating movement for old gear hobbing machine

In the process of cutting different teeth of gear or different ratio of gear pair, the transmission system must be adjusted. Fig.1 showing change gears, which must be adjusted with the transmission ratio of the produced gear couple and the teeth number of produced gears. In this complete process change gears are essential to hob different gears since the index

ratio depends on the number of teeth of the gear and the hob and the type of gear that has to be manufactured. When the produced gear is changed, the change gears must be calculated and manufactured. This increases not only complexity but also the processing costs and adjusting time for manufacturing and fixing the change gears and results in inconvenience.

### III. SYSTEM DESIGN AND IMPLEMENTATION

#### A. Hardware structure

The NC system of mechanical transmission is focused at the motion. Three AC servo motors separately control the rotation of work table, rotation of hob and table in depth of cut respectively. These three motors help to improve accuracy and provide large enough torque and transmit movement to the work table, hob and depth of cut. Remaining one axis require AC motor with planetary gearbox which control tool movement in feed/rapid. Planetary gearboxes are selected to eliminate the conventional change gear system. To achieve smooth motion, efficiency and precision conventional lead screw get replaced by ball screw.

#### Work table and drive system

The AC servomotor and drives were selected to cover full range of operating condition from one extreme of high ratio worm to other extreme of low ratio. The MDME102GCG and MHMD042G1U motors manufactured by Panasonic are selected to drive the worktable (table rotation and table feed) with 1kW motor for table rotation and 0.4kW motor for table feed and rated torque of motor is 4.77 N·m for table rotation and 1.27 N·m for table feed and maximum rpm of motor is 3000 rpm for table feed and table rotation [10].

#### Vertical drive system and tool rotation

The AC EFF2 series motor, manufactured by Hindustan electric motors is used to control the vertical feed of the machine and also perform a rapid transverse of vertical drive. In its original form machine feed was driven by a main motor via lead screw and change gear, whilst the transverse was performed manually. The AC servomotor of Panasonic MDME102GCG is selected to drive the tool rotation. For these AC servomotor specifications of Power, rated torque and motor rpm are respectively 1kW , 4.77 N·m and 2000 rpm [10].

#### Planetary gearbox

Planetary gearboxes are selected to eliminate the conventional change gear system because at present condition change gears are required to change according to the different types of jobs and their

corresponding teeth, also planetary gearboxes are selected to achieve the accuracy in the transmission.

We have used gear boxes as follows:

Work table and drive system

Table rotation: KH 90 (Kojin Precision, Taiwan)

Table feed: KH 90 (Kojin Precision, Taiwan)

Vertical drive system and tool rotation

Tool rotation: KH 90 (Kojin Precision, Taiwan)

Too ( feed / rapid ): 4130 (Top Gear Transmission, India)

Planetary gearbox has several advantages over traditional gearbox. This gearbox is unique combination of both compactness and outstanding power transmission efficiencies. Planetary gearing could increase torque and reduce load inertia while slowdown the speed. One more important advantage of the planetary gearbox arrangement is load distribution. Because the load being transmitted is shared between multiple planets, torque capability is greatly increased. Greater load ability, as well as higher torque density is obtained with more planets in the system. Due to the even distribution of mass, planetary gearbox has Better stability and with that rotational stiffness also increases [9], [11]. The detail specifications of selected planetary gearbox and motors are shown in table. 1.

Table 1. Specifications of planetary gearbox and motor

Purpose	Motor / Reducer	Gearbox Model	Gearbox torque (N-m)	Gearbox ratio	Motor Model	Power (kW)	Motor RPM
Table rotation	M 1 R 1	KH 90	110	7:1	MDME102GCG	1	3000
Table (depth of cut)	M 2 R 2	KH 90	117	50:1	MHMD042G1U	0.4	3000
Tool rotation	M 3 R 3	KH 90	120	20:1	MDME102GCG	1	2000
Tool ( feed / rapid )	M4 R 4	4130	575	366.92:1	EFF2	0.18	1360

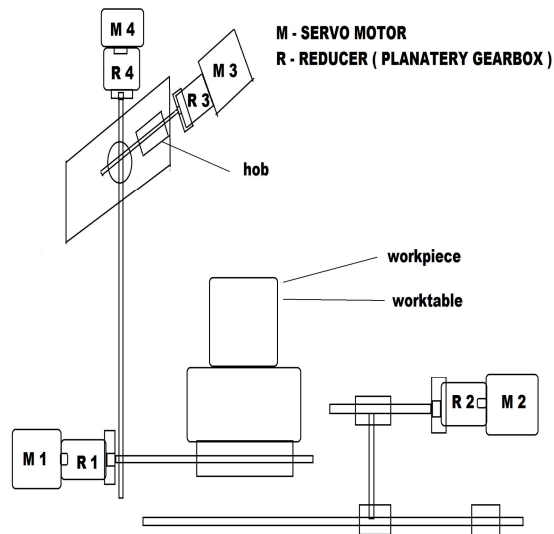


Figure . 2 Transmission principle of generating motion of new innovated gear hobbing machine

B. Software structure

According to motion requirement, three axis require three servomotor with three planetary gearbox. Remaining one axis require AC motor with planetary gearbox. For controlling four axis, high performance slim PLC (DVP – SV2) manufactured by Delta is used. This is new generation DVP - SV2 high end model of Delta DVP – S series. It provides larger program capacities and data registers for more demanding and complex applications. It has high speed pulse output i.e. maximum 4 sets of 200KHz pulse output. It increases many motion control instruction to meet the applications that require high speed and high positioning control such as labeling machine, packing machine & printing machine. It has auto backup function to prevent losing programs and data even when battery runs out [8].

IV. PLC PROGRAM AND OPERATION

According to the processing characteristics of innovated CNC gear hobbing machine and PLC (DVP – SV2) system, total production procedure is designed and this PLC program is edited. For producing different gears, some main parameters are edited in the PLC program which includes no. of teeth, module, pressure angle, span over teeth, pin diameter and so on. Parameters are registered in the PLC system. There is no need to change mechanical transmission parts and PLC program too. It not only helps to reduce the adjust difficulty for the operator but also simplifies the operation. This total process has great advantages of the efficiency and flexibility features of PLC control system. Due to use of planetary gear boxes, servomotors and most important PLC control system, transmission chain get shortened, process get flexible and gear quality also improved. With all above conversions, producing efficiency has improved over conventional gear hobbing machine.



Figure 3. Spur gear produced by CNC gear hobbing machine

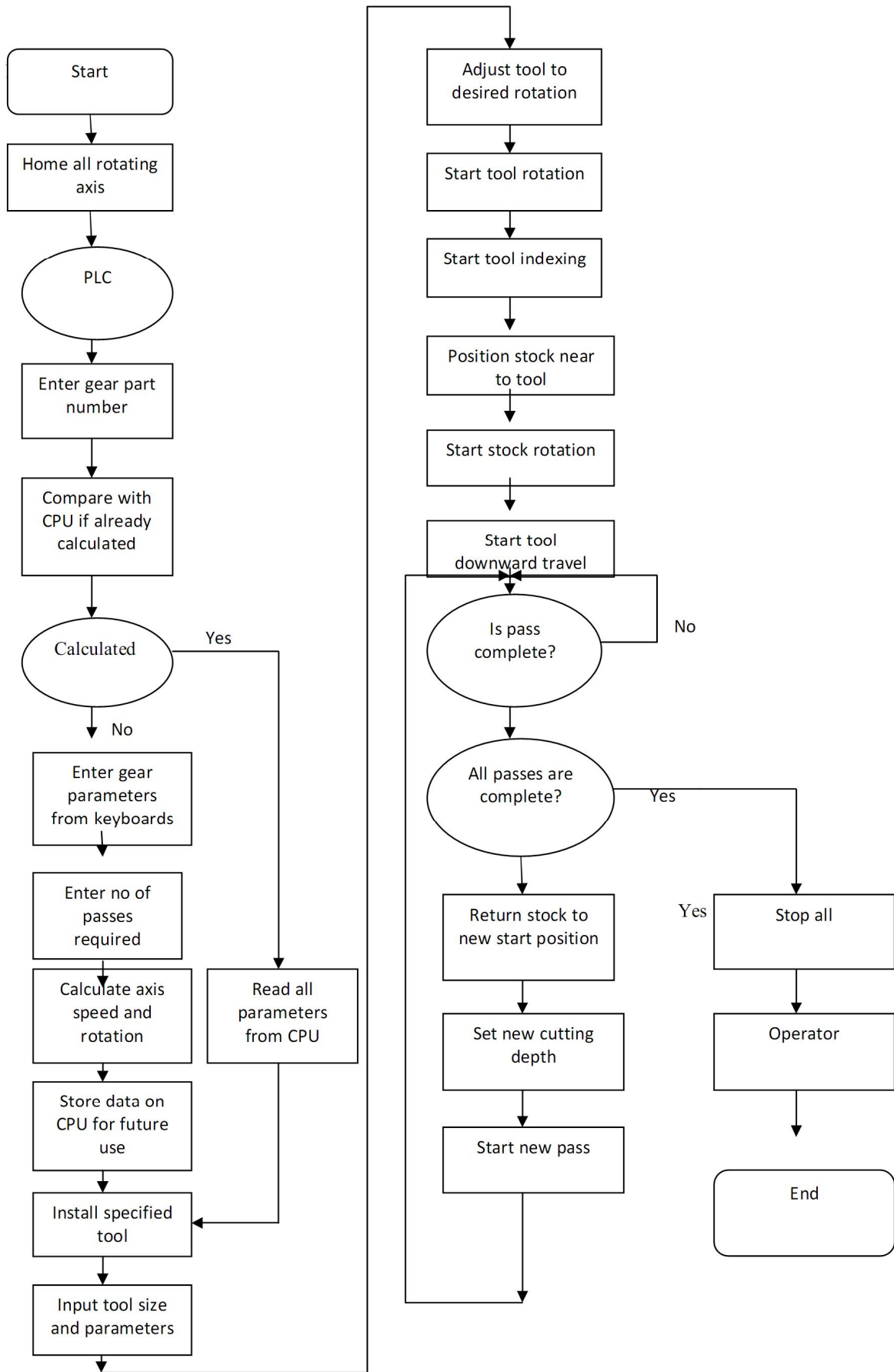


Figure 4. Production procedure for CNC gear hobbing machine

## CONCLUSION

Retrofitting is nothing but replacement or addition of equipments to existing machine tools to improve not only energy efficiency but extend their lifespan. So, ultimately increase their general output also. In this paper, we attempted Retrofitting for gear hobbing machine. Addition of new technology or features to older systems helps improve efficiency and accuracy regarding hardware as well software transformations. Also, numerical innovation simplifies the operations and minimizes the complexity for the operator. So, this retrofitting with numerical control innovation has been globally recognized and accepted in the gear production industries.

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