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Design of Ball Screw Mechanism for Retro Fit of External Grinding Machine

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Abstract: *To convert the existing grinding machine into a good working machine, a ball screw mechanism is designed and incorporated in the existing grinding machine by retrofitting process. Grinding machine removes material from the work piece by abrasion, which can generate substantial amount of heat. Therefore a coolant System is incorporated to cool the work piece, so that it does not overheat and go out of its tolerance. Grinding practice is a large and diverse area of manufacturing and tool making. It can also rough out large volume of metal quite rapidly. It is usually better suited to the machining of hard materials. Cylindrical grinding is also called center type grinding. It is used in the removing the cylindrical surface and shoulders of the work piece. The five type of cylindrical grinding are outside diameter (OD) grinding. Inside diameter (ID) grinding, plunge grinding, creep feed grinding and center less grinding.It is used in the industries for grinding the nozzle body. The grinding machine can be changed to automatic machine according to one of the latest technologies called PLC's controller. The manually operated grinding machine has some of the in-accuracies and disadvantages compared to new modern CNC grinding machines.Based on the case study of both manual and CNC grinding machine, the manual machine is converted into automatic machine for the better accuracy and efficiency. The main replacement of the machine parts are hydraulic cylinder and stepper motor by ball screw mechanisms and servo motor.*

Key words: *- Retrofitting, Cylindrical Grinding, Servo Drives, Ball Screw*

I. INTRODUCTION

Grinding is a distinctive technology that uses abrasives or synthetic minerals in loose or bonded form. Grinding is one of most important technologies used by manufacturing today. Grinding is the only method available to engineers to machine and finish ceramics or composite material. In other cases, grinding competes with other technologies and offers the most economical way to produce precision component. As compared with other machining processes, grinding is a costly operation that should be utilized under optimal conditions (6-8).

Grinding is a finishing process used to improve surface finish, abrade hard materials and tighten the tolerance on flat and cylindrical surfaces by removing a small amount of material. In grinding, an abrasive material (6) rubs against the metal part and removes tiny pieces of material. The abrasive material is typically on the surface of a wheel or belt and abrades material in a way similar to sanding. On a microscopic scale (8), the chip formation in grinding is the same as that found in other machining processes. The abrasive action of grinding generates excessive heat so that flooding of the cutting area with fluid is necessary.

II. RETROFITTING

Retrofit projects replace or add equipment to existing machine to improve their energy efficiency, increase their output and extend their lifespan, while decreasing emissions. Principally retrofitting describes the measures taken in the manufacturing industry to allow new or updated parts to be fitted to old or out dated assemblies (like blades to wind turbines). The production of retrofit parts is necessary in manufacture when the design of a large assembly is changed or revised. If, after the changes have been implemented, a customer (with an old version of the product) wishes to purchase a replacement part then retrofit parts and assembling techniques will have to be used so that the revised parts will fit suitably onto the older assembly. (6-10)

2.1 CONSTRUCTION OF THE SYSTEM

In old machine the feed is given by the hydraulic system. But in the retrofit the machine feed is given by the ball screw. Ball screw is one of the latest technologies used in the industry.

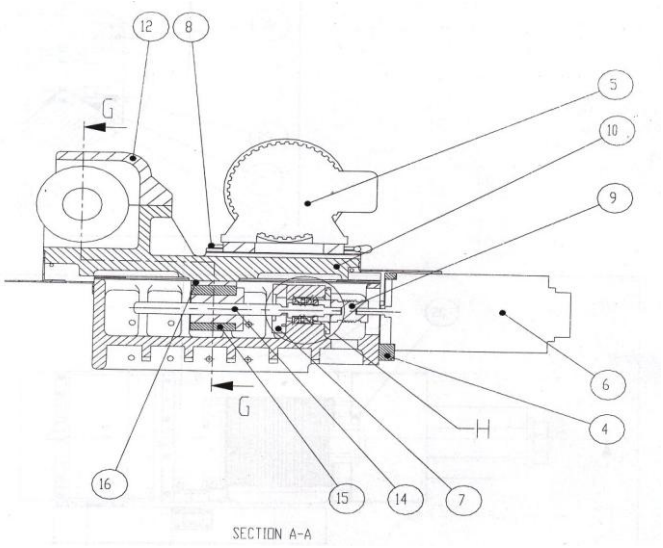


Figure1. Feed Table Sectional View

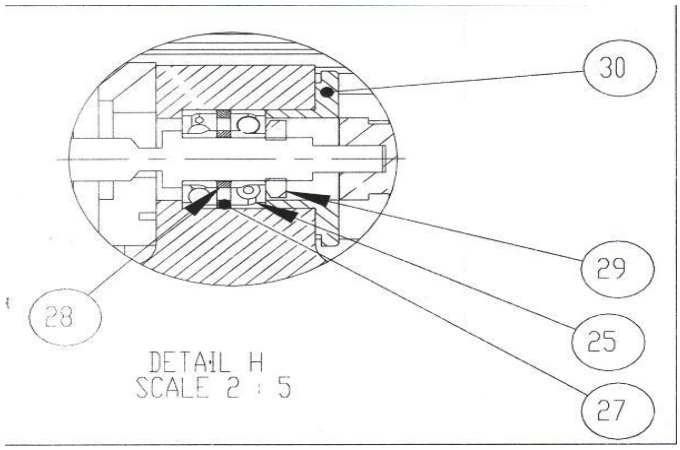


Figure2. Ball Screw Sectional View

The ball screw section view is given above after fitting to the external grinding machine.

Sr.No	Description
1	Motor Pulley Bore Ø24 Motor 105/2 Kw/Hp
2	Belt Guard for Dia Roll
3	Belt Gurad Cover For Dia Roll
4	Motor Plate Fanuc
5	Motor 1.5 Kw/2 Hp, 3000 Rpm
6	Servo Motor Fanuc Alpha 8ic
7	Ballscrew Spacer
8	Motor Clamping Plate
9	Coup (Dkn100 / 57-19h7), 11473
10	Dia Roll Slide
11	Dia Roll Spindale Sub Assembly
12	Dia Roll Spindle Mounting Bracket
13	Dia Roll Housing
14	B.S Bnfn2505-2.5rrgo-29lc3, 112598
15	Ball Screw Bracket
25	Brgfag7005ct P4
27	Spacer
28	Spacer
29	Lock Nut Km-5
30	Cover

Table 1. Description of Numerical Notation

2.2 TABLE FEED

Table is without servo axis.Table is fitted with lead screw and reduction gears to adjust the table position manually.For table locking there is one spring plate provided in the front which after table position must be locked.

2.4 FEED TABLE FRONT VIEW

After fitting the ball screw mechanism the side view of the feed table is shown below.

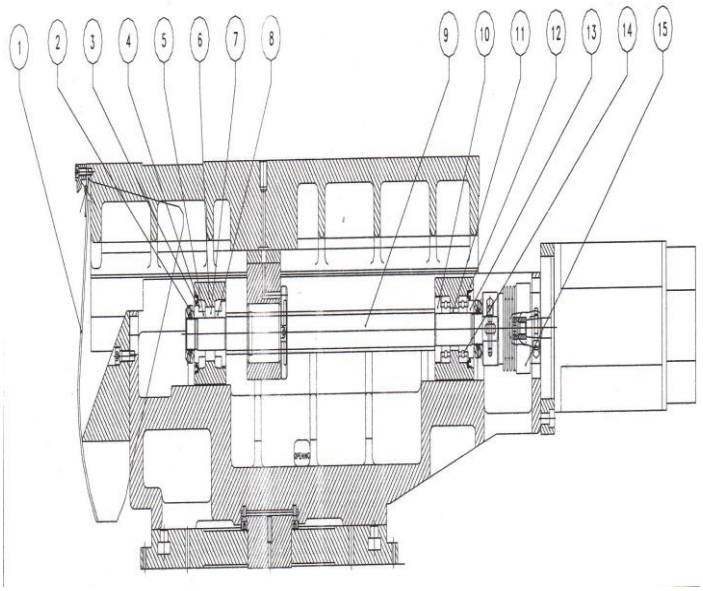


Figure3. Feed Table Front View

2.5 FEED TABLE SIDE VIEW

After fitting the ball screw mechanism the side view of the feed table is shown below.

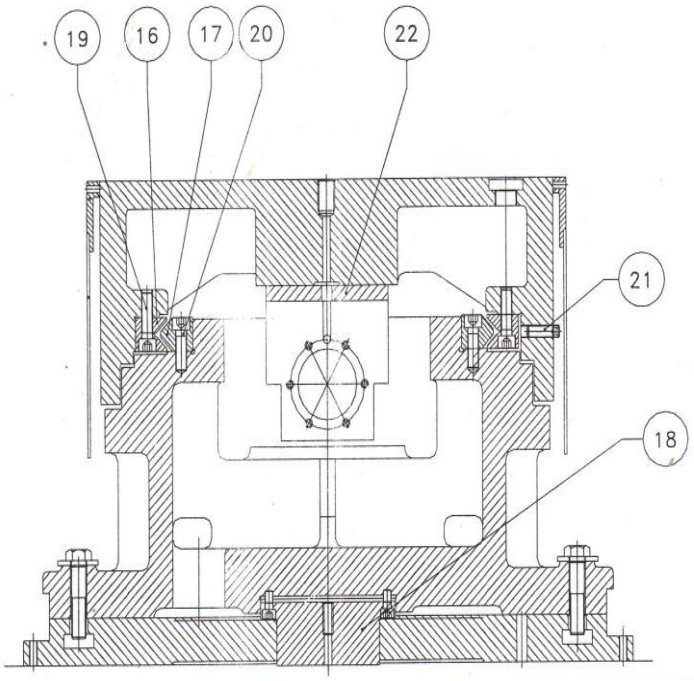


Figure4. Feed Table Front View

Sr. No	Description
1	FRONT COOLANT GUARD
2	LOCK NUT M30X1.5
3	OIL SEAL 50X68X8/8.5
4	THRUST BALL BEARING 51108-Y P5
5	SPACER
6	BEARING BLOCK
7	NEEDLE ROLLER BEARING NKIS 30/52 INA
8	SPACER
9	BALL SCREW DIF 4010-6RRGO-613LC2
10	SPACER
11	SPACER
12	BEARING BLOCK
13	SPACER
14	BALL BEARING 6206 ZZ
15	SMARTFLEX CPLG 1.932.343, DIA 16 1:10TAP, DIA24H
16	LINEAR BEARING N 920625 600
17	LINEAR BEARING O 920625 600
18	PIVOT PIN(FOR CARRAGE ROTAION)
19	ALLEN BOLT 8X30
20	ALLEN BOLT 8X25
21	GRUB SCREW 8X30
22	SPACER

Table2.Description of Numerical Notation

2.5 BOLL SCREW SETTING

Remove the coupling from motor and replaced make sure that coupling is properly on motor taper shaft. Mount the servo motor on motor plate and clamp the coupling at ball screw end. Make sure that whole assembly of coupling and servo motor is properly done. Assemble the rear cover and tight mounting screw. Move slide to make sure that movement is ok.

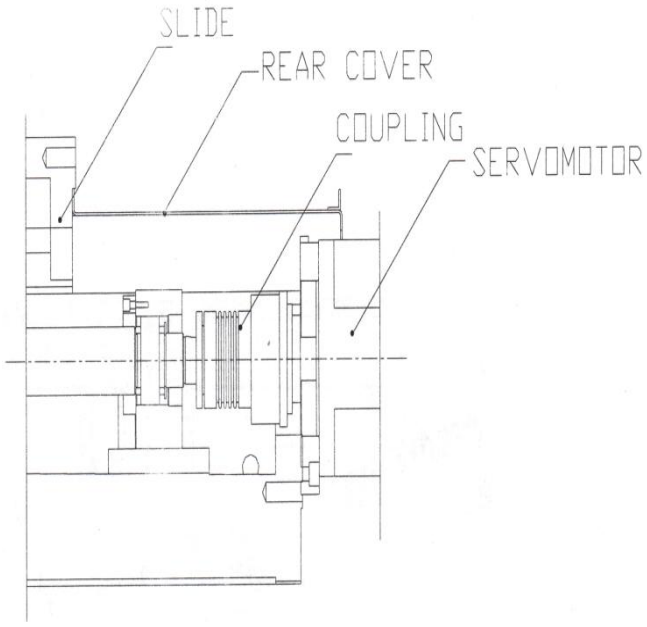


Figure6. Ball Screw Arrangement

2.6 TECHNICAL SPECIFICATION

The technical specifications of grinding machine are given below (5).

DESCRIPTION CAPACITY	UNIT	GCE350 X500
Swing Over Table	mm	350
ABC / MAX Grinding Length	mm	500
CARRIAGE (X-AXIS)		
Slide Stroke	mm	280
Minimum Increment/Pulse	mm	0.001
Feed Servomotor Torque	Nm	8
WHEEL HEAD		
Grinding Wheel Size (OD×ID×W)	mm	Φ500× Φ 203.2× Φ25/40
Spindle Motor Power (Induction Type)	KW	7.5
Peripheral(Surface) Speed	m/s	45
WORK HEAD		
Canter Taper	No	MT-5
Quill Travel	rpm	30-600
Taper Correction Range	N/m	12
TAIL STOCK		
Canter Taper	No	MT-4
Spindle Speed (Infinitely Variable)	mm	40
Spindle Motor Power	mm	+_0.040
HYDRAULIC UNIT		
Tank Capacity	Ltrs	40
Motor Power	KW	0.55
Machine Weight	Kg	4000
CROSS FEED		
System Rapid Approach	mm	60
Total In Feed On Radius	mm	20
In Feed Rate On Die	Mm/min	0-45
Micro Feed Hand Wheel	mm	0.001
Total Power Requirement	kw	15
GROUND FEEED ACCURACY		
ROUNDNESS OF LIVE SPINDLE		
Standard	mm	0.002
Special	mm	0.001
Cylinder/Grinding Length	mm/micro n	0.004/500
MAXIMUM WORK PIECE WEIGHT		
Between Centre	kg	80
MAXIMUM TORQUE		
On Live Spindle/Chuck	kg	500
Total Weight Of Machine	kg	3600
PACKING CASE DIMENSION		
Length	inch	150
Width	`inch	150
Height	inch	150

Table3.Technical Specification

III. MECHANICAL DESIGN

3.0 LOAD CALCULATION (1-5)

3.1 CYLINDER FORCE=P × A

F1 = 0.002N

3.2 STORKE LENGTH

STROKE LENGTH 35MM = 0.035M

∴ FORCE REQUIRED FOR 35 M.M PISTON MOMENT

= 0.00098 N FOR 35M.M MOMENT

3.2 LOAD REQUIRED FOR GRINDING
T (F2) = ΠDN/60
T= 26.17 N/M²

3.3 TOTAL FORCE REQUIRED
F= F1 + F2
= 0.002+26.17
F= 26.17 N/M²

3.4 FACTOR OF SEAFTY (25%)
TOTAL= 26.17+6.54
F= 32.71 N/M² (NET FORCE)

3.5 POWER CALCULATION FOR SERVO DRIVE
WE KNOW THAT FORCE REQUIRED FOR MOMENT
P1=W TAN (A+A)
P1=5.59N

3.6 CUTTING (GRINDING) FORCE
T=Π∂N/60
T=26N/M²
TOTAL POWER=P1+T
P=P1 + T
P= 5.59+26
P=31.6N-M

3.7 TORQUE REQURIED FOR BALL SCREW MOMENT
T=P×D/2
T=354.3N/M²
TO FIND R.P.M
N=(SPEED IN M.M/MINT)/(P.C.D)
=300/5=N=60R.P.M

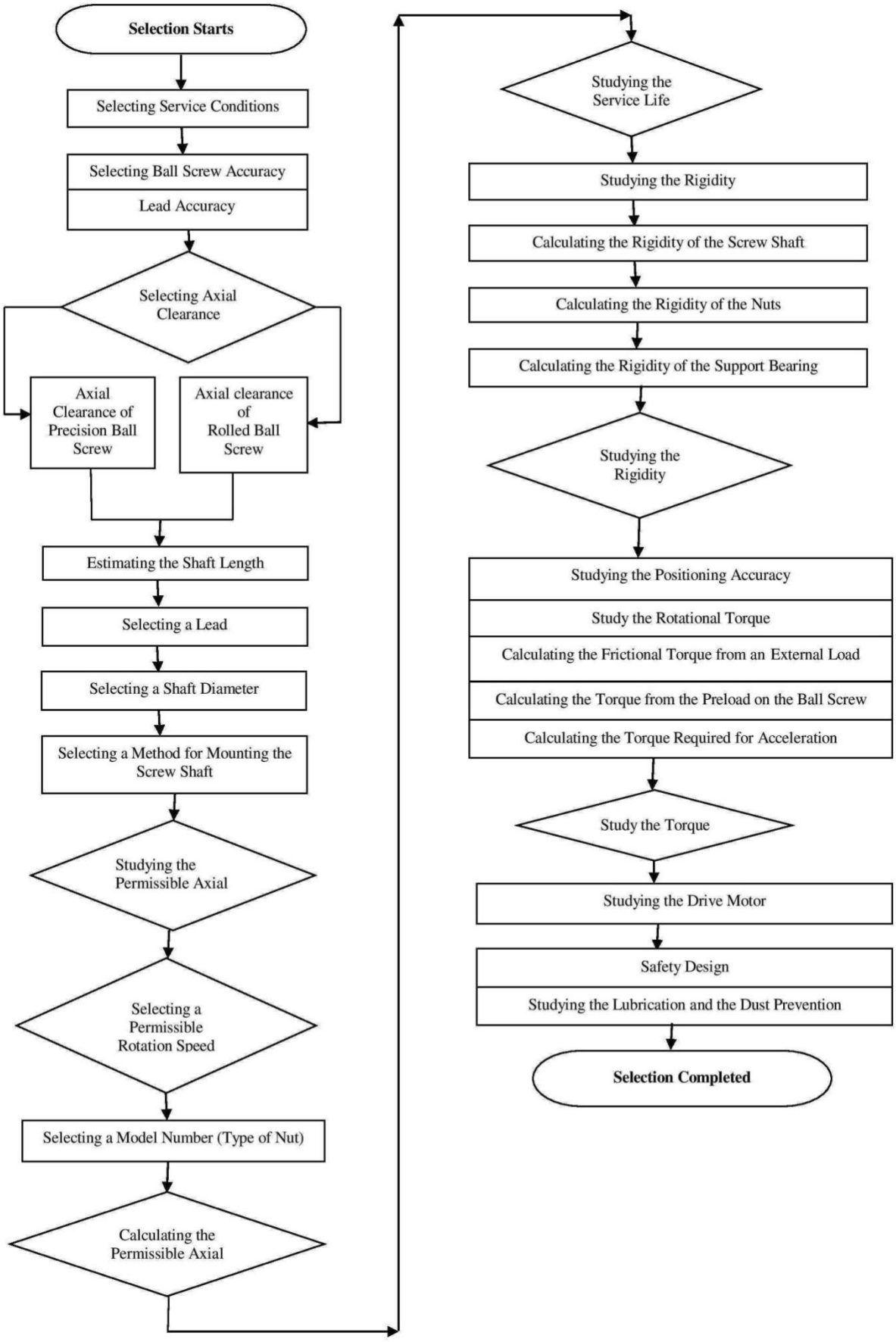
3.8 ANGULAR SPEED
Ω=6.2 RED/SEC

3.9 POWER OF MOTOR=Ω.T
P=2197.129W
3.10 POWER OF MOTOR= 2.1KW

IV. FLOW CHART FOR SELECTING A BALL SCREW

4.1 STEPS FOR SELECTING A BALL SCREW

When selecting a Ball Screw, it is necessary to make a selection from various angles. The following is a flow chart as a measuring stick for selecting a Ball Screw.(4)


Selection Starts
Selecting Service Conditions
Selecting Ball Screw Accuracy
Lead Accuracy
Selecting Axial Clearance
Axial Clearance of Precision Ball Screw
Axial clearance of Rolled Ball Screw
Estimating the Shaft Length
Selecting a Lead
Selecting a Shaft Diameter
Selecting a Method for Mounting the Screw Shaft
Studying the Permissible Axial
Selecting a Permissible Rotation Speed
Selecting a Model Number (Type of Nut)
Calculating the Permissible Axial
Studying the Service Life
Studying the Rigidity
Calculating the Rigidity of the Screw Shaft
Calculating the Rigidity of the Nuts
Calculating the Rigidity of the Support Bearing
Studying the Rigidity
Studying the Positioning Accuracy
Study the Rotational Torque
Calculating the Frictional Torque from an External Load
Calculating the Torque from the Preload on the Ball Screw
Calculating the Torque Required for Acceleration
Study the Torque
Studying the Drive Motor
Safety Design
Studying the Lubrication and the Dust Prevention
Selection Completed

V. SAFETY

5.1 BEFORE STARTING THE MACHINE

- Switch On Main Power
- Switch the Isolator
- Switch the Hydraulic
- Switch the Grinding Wheel
- Switch the Mist Collector

5.2 AFTER STARTING TO CHECK THE MACHINE

- Release the Emergency Bottom
- Coolant hob&Position
- D2.5 Ball In Tail Stock
- Dressing Frequency 1/15 Nos
- Home Position
- IVDT Position
- Open Main Air Valve

5.3 OPERATIONS

- Select The Mode Change Button To Auto Mode.
- Pick U/P The Nozzle Body From The Input Try.
- Check Must Be Oil Cross/Feed Hole & Injection Hole Check By Visual.
- Load the component one by one in the loading chute.
- Press Cycle Start Machine.
- After Completion The Component Will Be Collected In Output Tray.
- Take Component By Opening Machine Guard.
- Check Head Diameter.
- If over Size Rework Undersize.
- Next Operation.

VI. CONTROL PLAN

Quality list	**Specification**
Capacity	30μ
Dim distance Seat chamber	10.11+0.02mm
Diameter head	18.95+0.015mm
Diameter shaft	13.885+0-015mm

VII. CONCLUSION

Conversion of old machine into working machine to full fill the markets demand. Because now a day's very competition market so after retrofitting of machine the machine running cost will decrease , so the production cost will also decrease. Therefore the company will gate maximum profit.

The accuracy of output product will be increase. After retro fitting the machine the machine running cost will be also decrease. It will provide more comfort to the worker. As compare to CNC machine the retrofitted machine cost is less. The replacement of main machine parts is hydraulic to servo drive with plc control.

Thus the old machine is retrofitted and ready to use. The accuracy and performance of the machine is very god as compare to CNC machine.

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