Design and Development of Ball Burnishing tool

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Abstract

- The present project work deals with the design and development of ball burnishing tool.
- The study aims is to produce smooth surface finish without removing the materials on the work piece and gets better hardness on the work piece without any extra process.
- Burnishing is an economical process where skill workers are not required.

Continue….

- This process can be effectively used in many fields such as aerospace industries, automobiles manufacturing sector, production of machine tools, hydraulic cylinder etc….

What is burnishing?

- Burnishing is a method of finishing metal surfaces by plastic deformation under cold working conditions by application of pressure through either a hard steel ball or roller.
- Burnishing causes work hardening and creation of beneficial compressive stresses in the surface layers which, in turn, increase the micro hardness, wear resistance and fatigue strength of the surface layer of the component.

How it work?

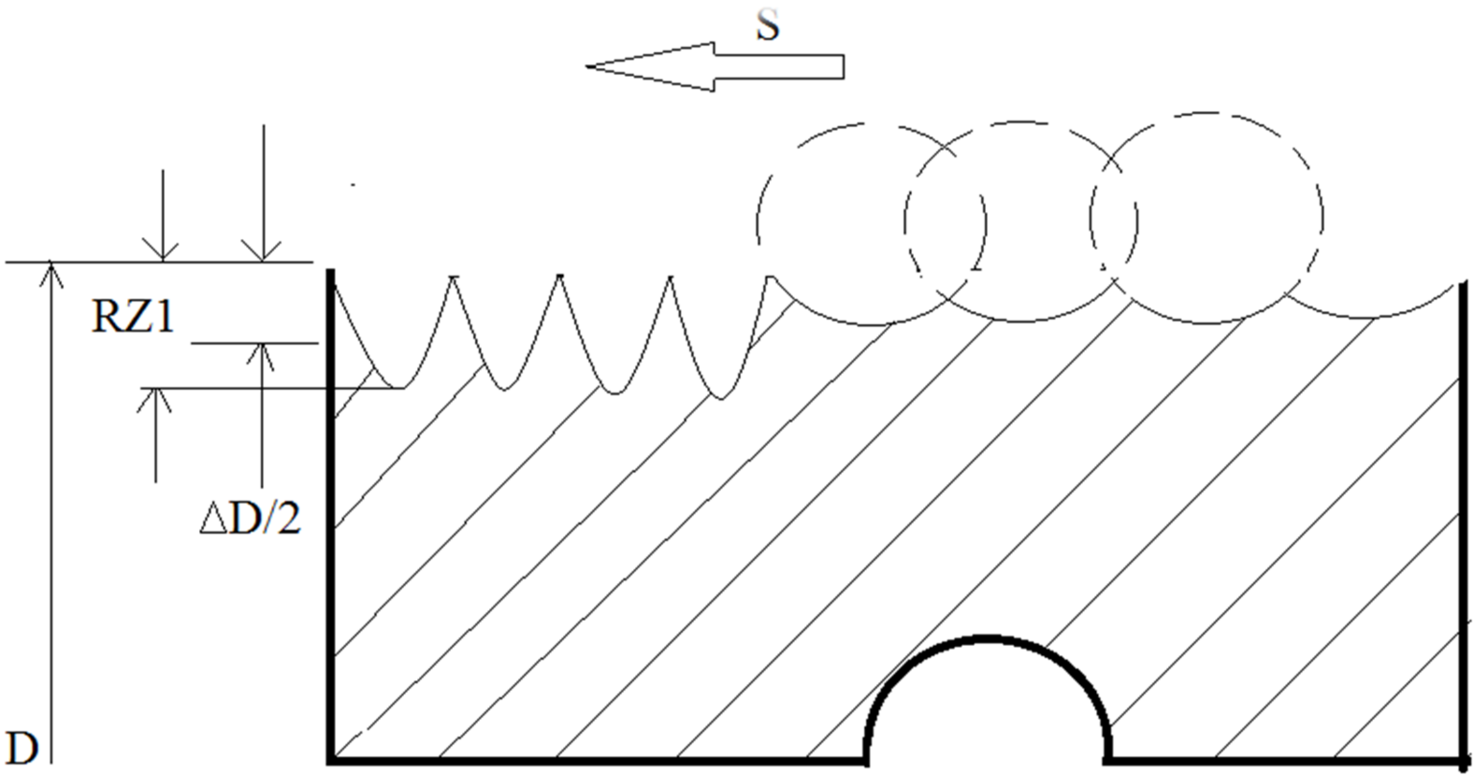


FIG: DEFORMATION OF THE SURFACE IN BURNISHING

Classification of burnishing process

A) Based on motion of the tool on surface.

i. Normal or Ordinary burnishing

ii. Vibratory burnishing

B) Based on shape of deforming element

i. Ball burnishing

ii. Roller burnishing

BALL BURNISHING	ROLLER BURNISHING
Deforming element is a hard steel ball.	Deforming element is a hard steel roller.
Point contact and rolling friction between ball and work piece.	Line contact and sliding friction between roller and work piece.
Deformation is localized in zone adjacent to the ball.	More chances of deformation of the entire blank compared to the ball burnishing.
For the same radial force, gives high specific pressure, better surface finish, more fatigue strength, micro hardness and depth of work hardened layer.	It gives less specific pressure, poor surface, lower fatigue strength, micro hardness and depth of work hardened layer.
Low production rate	High production rate.

Components of ball burnishing tool

- Mainly six components

1. Ball
2. Compression spring
3. Main tool body
4. Sleeve
5. Nut
6. Front cover plate

Detailed properties of material use

COMPONENT	MATERIAL USED	COMPOSITION	PROPERTIES	WHY USE?
BALL	STAINLESS STEEL	10% CARBON 18% CHROMIUM 8% NICKEL	NON MAGNETIC HOT HARDNESS LESS WEAR	LESS WEAR
MAIN SLEEVE	STAINLESS STEEL	10% CARBON 18% CHROMIUM 8% NICKEL	NON MAGNETIC HOT HARDNESS LESS WEAR STRENGTH	HIGH STRENGTH
FRONT COVER PLATE	STAINLESS STEEL	10% CARBON 18% CHROMIUM 8% NICKEL	NON MAGNETIC HOT HARDNESS LESS WEAR STRENGTH	HIGH STRENGTH
SPRING	OIL HARDENED AND TEMLERED STEEL			HIGH STIFFNESS
SLEEVE	MILD STEEL			
NUT	MILD STEEL			

DESIGN

CALCULATE NORMAL BURNISHING FORCE

- Normal burnishing force = P_y
- $P_y = \pi$ □ HR^2

  □ = relative depth of penetration

  □ = 0.002 to 0.003

  R = radious of ball

  H = Vickers hardness for work materials

So, $P_y = 3.14 * 0.0025*170*(4.75)^2$

$= 30$ kg

$= 295$ N

CALCULATION OF FEED FORCE

Feed force, $P_x = (0.04 \text{ to } 0.20) * P_y$

$= 0.1 * 295$

$= 29.5$ N

Taking maximum normal burnishing force

$P_y = 1.2 * 295$

$= 354$ N

Culculation of induced contact stress

- Material for tool body = C-40
- Rockwell hardness number = 55 HRC
- Ball material = hardened alloy steel
- Minimun hardness = 60HRC
- Daimeter of ball = 9.5 mm
- Peripherial length of contact , a = $2\pi R \sin 60$

  $= 25.85$ mm

- Maximum Stress = 0.418 $[\frac{P'E}{R}]^{1/2}$
- P’ = $\frac{PY}{\alpha}$ = 0.36/2.585 =13.6 N/mm
- Stresss = 316.31 N/mm^2

Design of spring

- Ultimate stress : 1500 N/mm^2
- Shear stress τ = 0.5 * 1500

= 750 N/mm^2

Design shear stress $\tau = \dfrac{\tau}{F.O.S}$

= 750/1.5

= 500 N/mm^2

- Spring index C = 5.14

$$dw^2 = \frac{K \, \varepsilon \, PY \, C}{\pi \, \tau}$$

$$= \frac{1.2 * 8 * 353.16 * 5.14}{3.14 * 500}$$

$$dw^2 = 11.09$$

$$= 3.5 \text{ mm}$$

- No. of active coils,

$$n = \frac{G * dw}{8 * C3 * q}$$

$$= 23 \text{ turns}$$

for ground and square ends,

total no. of turns = 23+2 = 25 turns

- Total free length of the spring

$$L_f = p\,n + 2dw$$

$$= (4.52)(25) + 2(3.5)$$

$$= 120 \text{ mm}$$

Dimension of the spring

- Wire diameter = 3.5 mm
- Minimum coil diameter = 16.5 mm
- Mean coil diameter = 18 mm
- Maximum coil diameter = 20 mm
- Total no. of turns = 23+2 = 25 turns
- Length of spring = 120 mm
- Pitch of the spring = 4.5 mm
- Stiffness of the spring = 10 N/mm

Dimension of other components

1. Ball

   diameter of ball = 9.5 mm

2. Main tool body

   total length = 190 mm

   diameter a) ϕ11mm

   b) ϕ 20 mm

   c) ϕ 25mm

3. Nut

external shape = hexagonal (each side of 18.475mm)

total length = 100 mm

diameter = 25 mm

External thread : BSW (British standard witworth)

pitch : 12 TPI Or 2.1 mm

4. Sleeve

external shape = hexagonal (each side of 18.475mm)

Total length = 160 mm

diameter a) 25 mm

Internal thread : BSW (British standard witworth)

pitch : 12 TPI Or 2.1 mm

5. Front cover plate

diameter = 20 mm

6. Screw

diameter : 3 mm

length : 12 mm

3 – D MODELING OF EACH COMPONENTS

- 1 . BALL

BALL.ipt

2. SLEEVE

SLEEVE.ipt

3. NUT

NUT.ipt

4. MAIN TOOL BODY

MAIN TOOL BODY.ipt

- 5. SPRING

SPRING.ipt

6. FRONT COVER PLATE

FRONT COVER PLATE.ipt

7. SCREW

SCREW.ipt

HOW TO ASSEMBLE ?

Explosion1_244.wmv

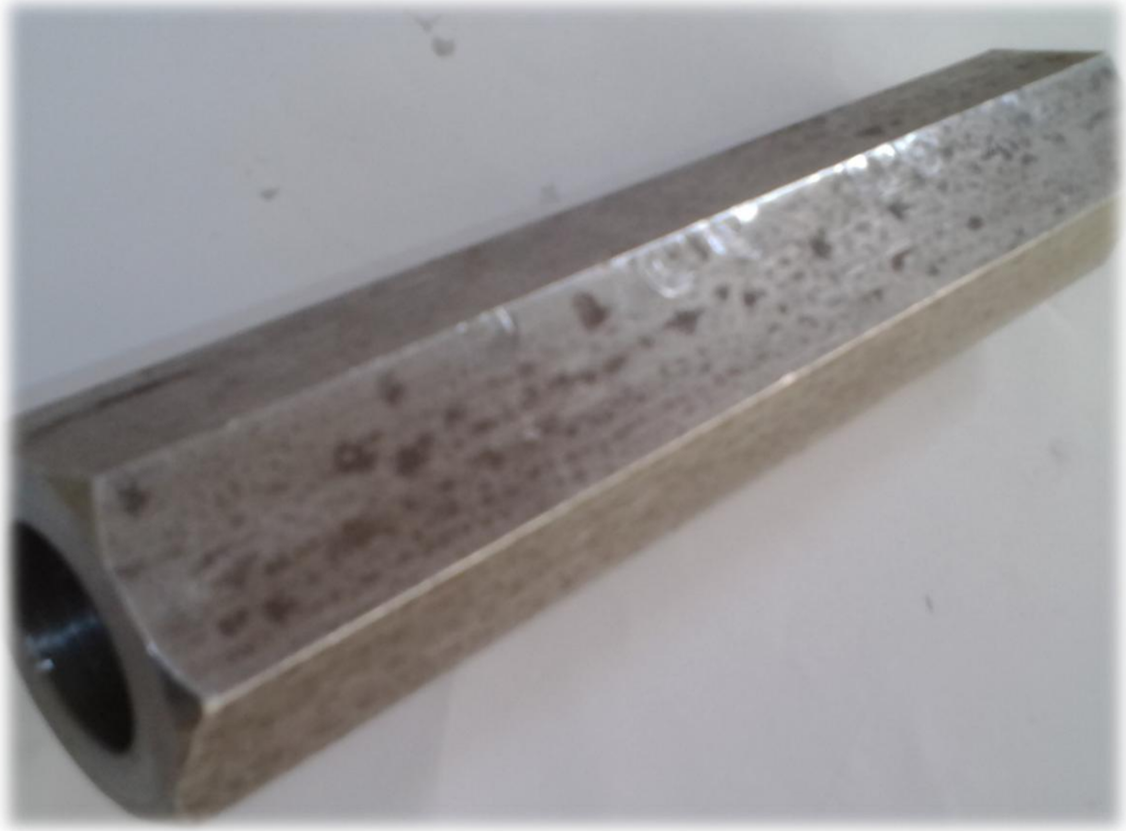
DEVELOPMENT

Main tool body

Material : stainless steel

Operation : turning , facing

Sleeve



Material : mild steel

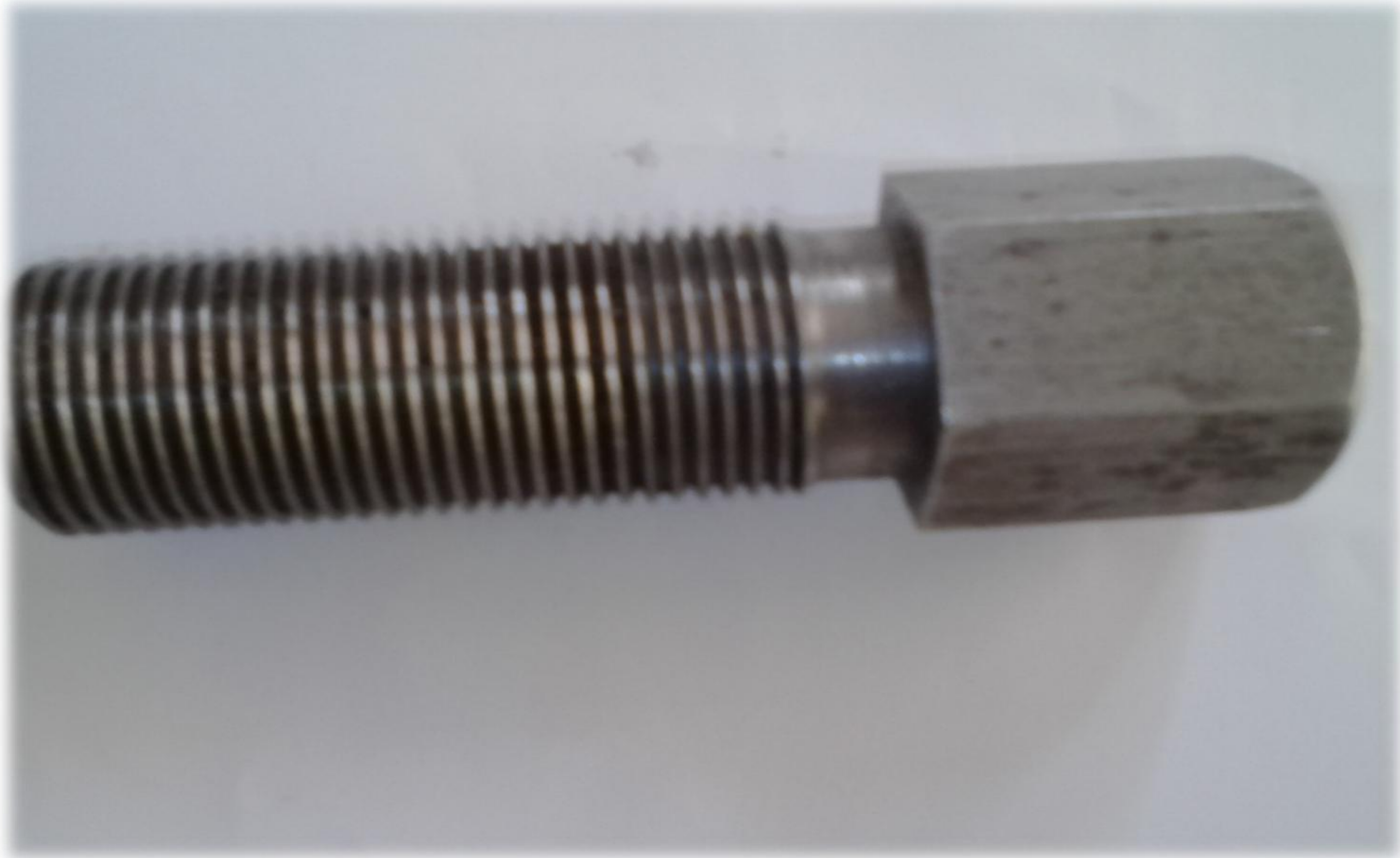
Operation : drilling , boring , internal threading , chamfering

Front cover plate

Material : stainless steel

Operation : turning , facing , drilling

Nut



Material : mild steel

Operation : turning , driling , threading, chamfering

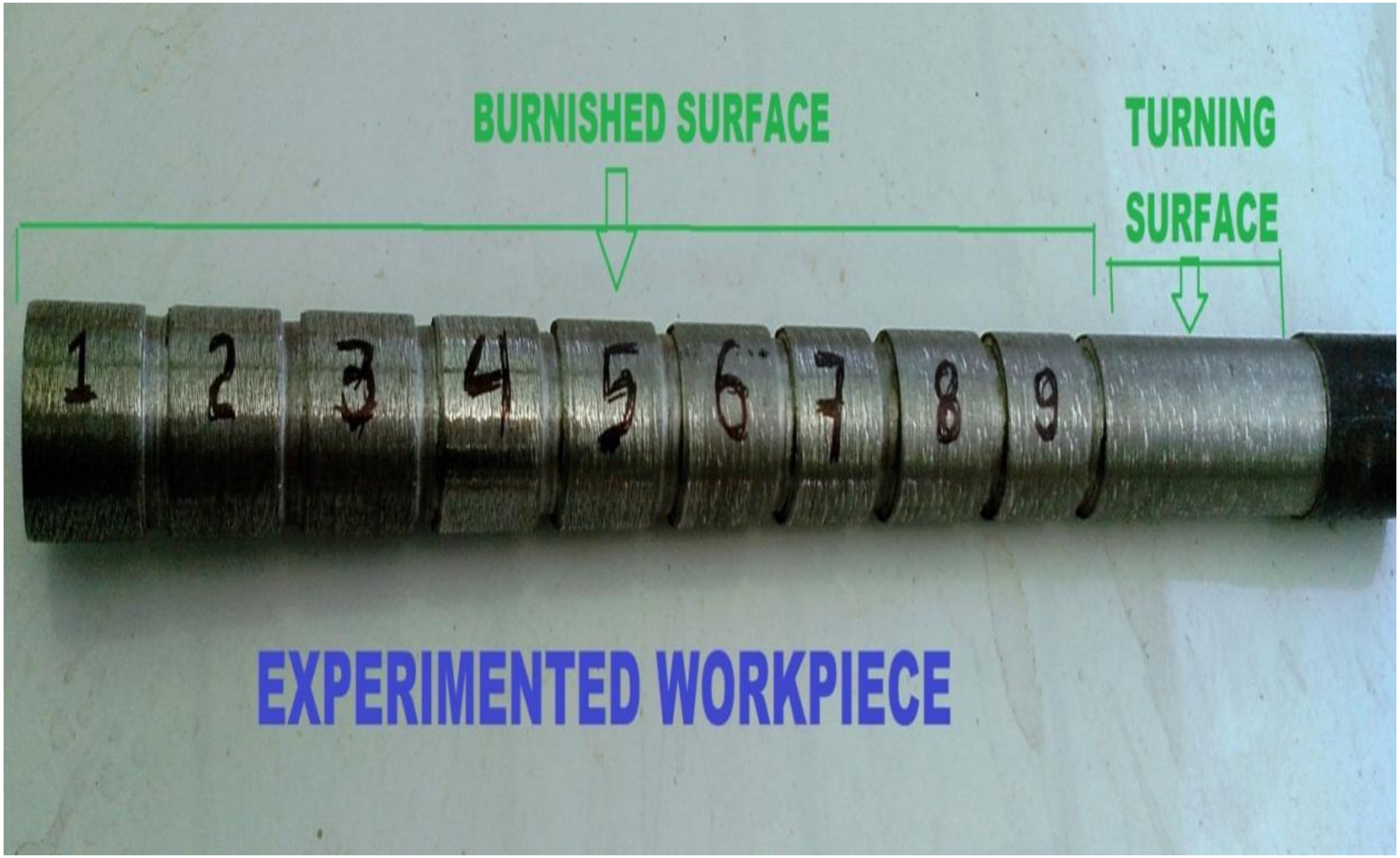
Ball, spring, & screw

- Ball
- Material : stailess steel

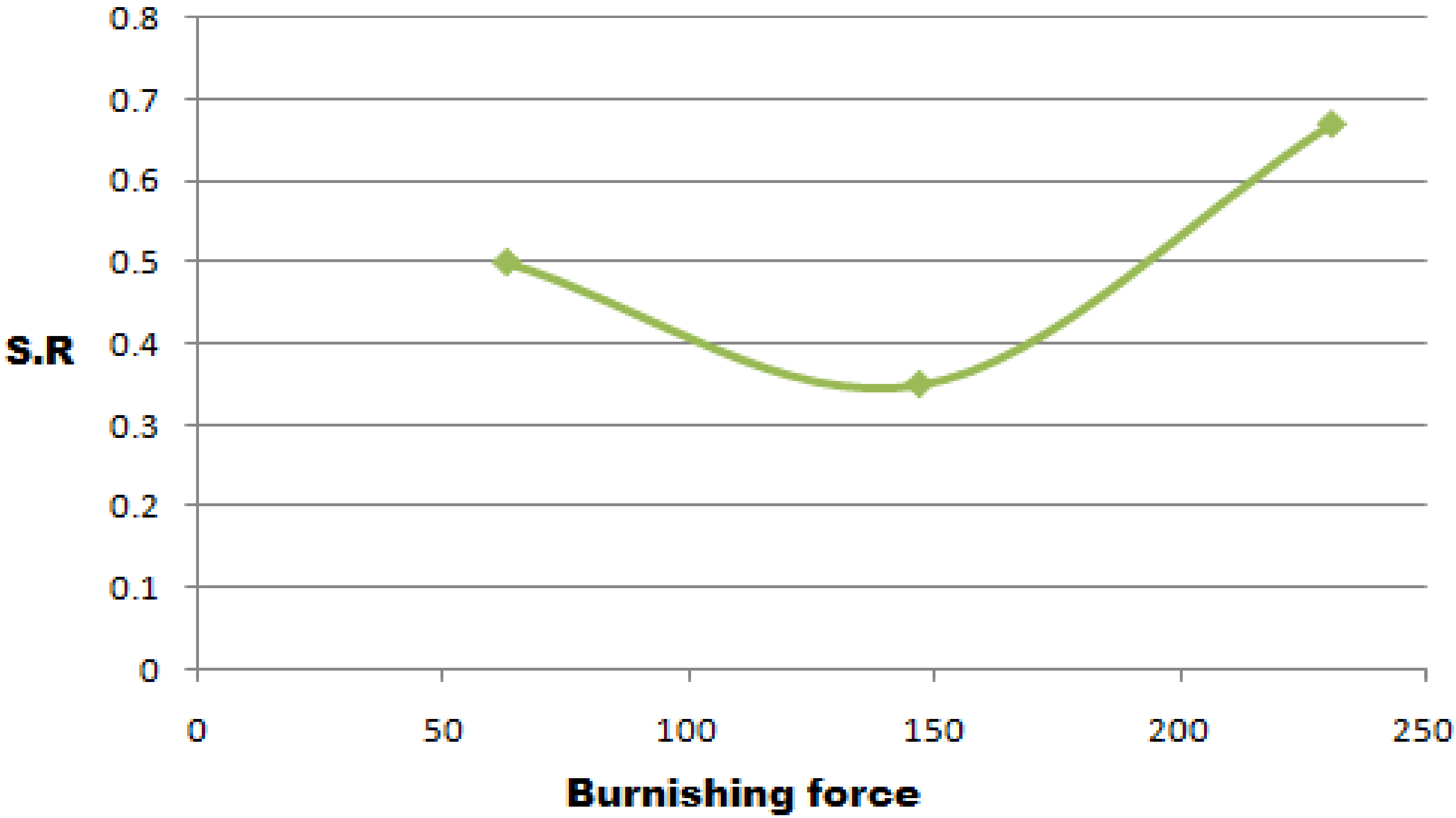
- Spring
- Material : oil hardened and tempered steel

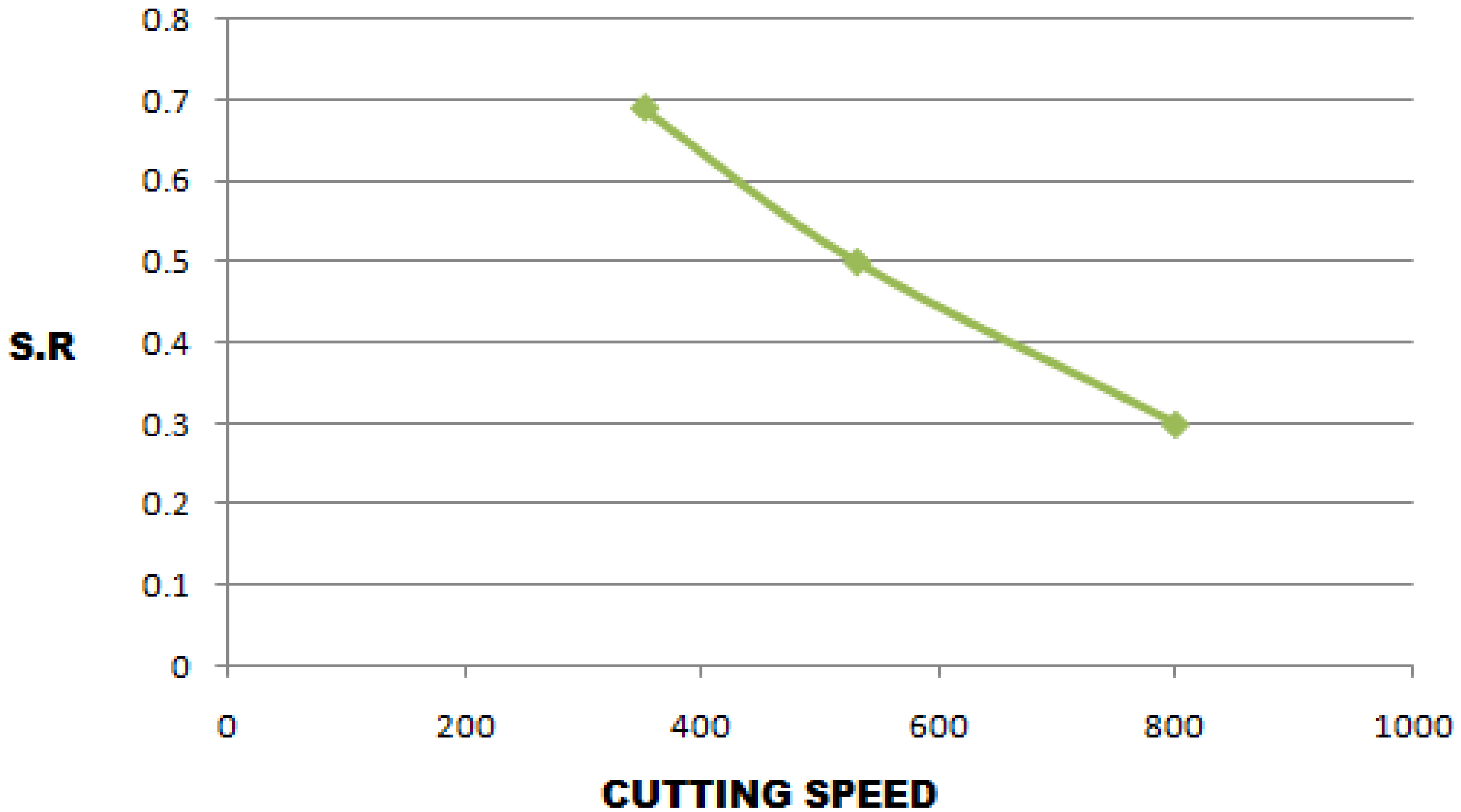
- Screw
- Material : mild steel

EXPERIMENTAL SET UP


BURNISHED SURFACE
TURNING SURFACE
1
2
3
4
5
6
7
8
9
EXPERIMENTED WORKPIECE

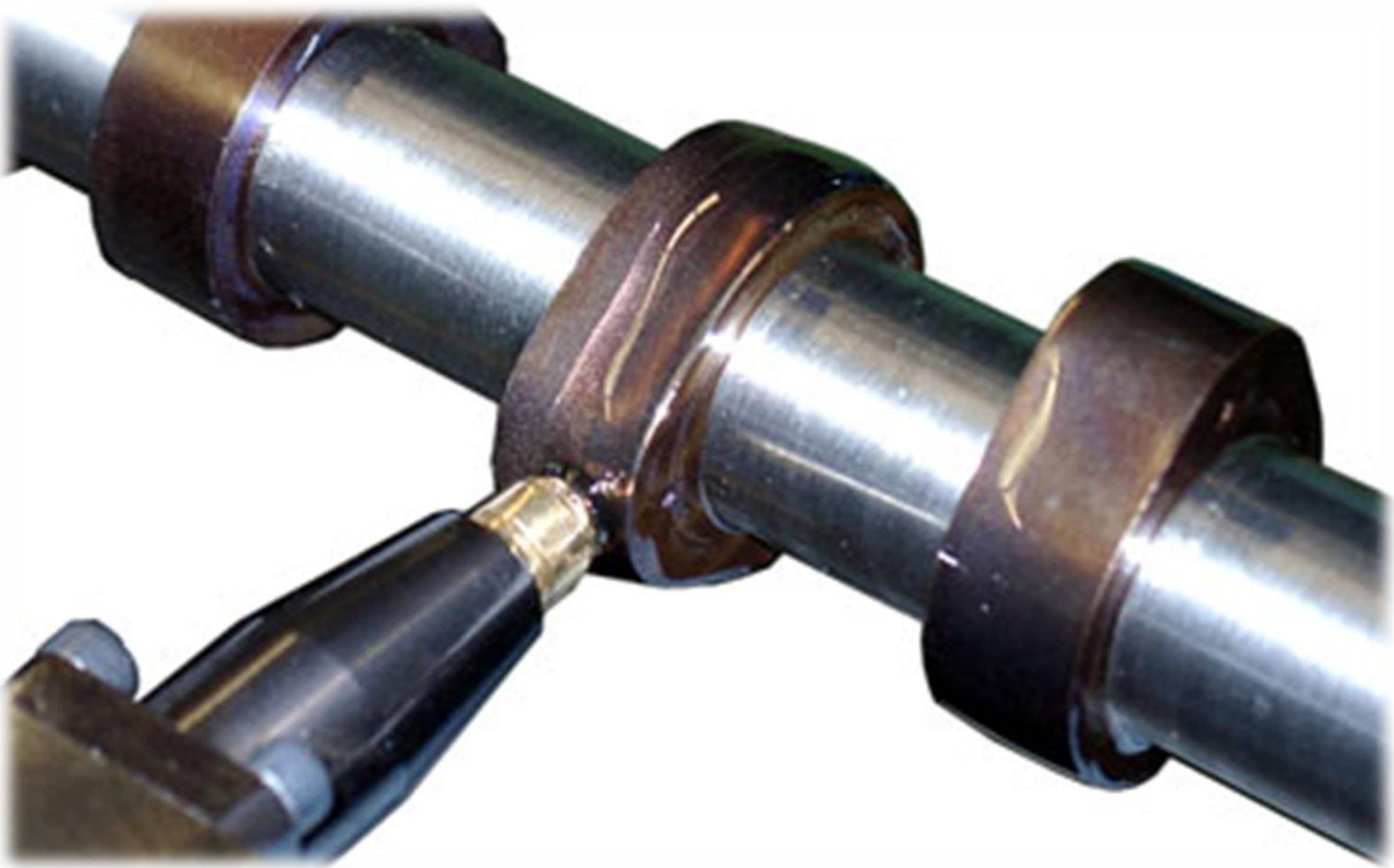
SR.NO	BURNISHING FORCE (NEWTON)	CUTTING SPEED (RPM)	FEED RATE (MM/MIN)	SURFACE ROUGHNESS (MICRON)
1	63	800	0.2	0.48
2	63	530	0.2	0.45
3	63	350	0.2	0.43
4	147	800	0.2	0.30
5	147	530	0.2	0.32
6	147	350	0.2	0.36
7	231	800	0.2	0.71
8	231	530	0.2	0.60
9	231	350	0.2	0.69


S.R
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
50
100
150
200
250
Burnishing force

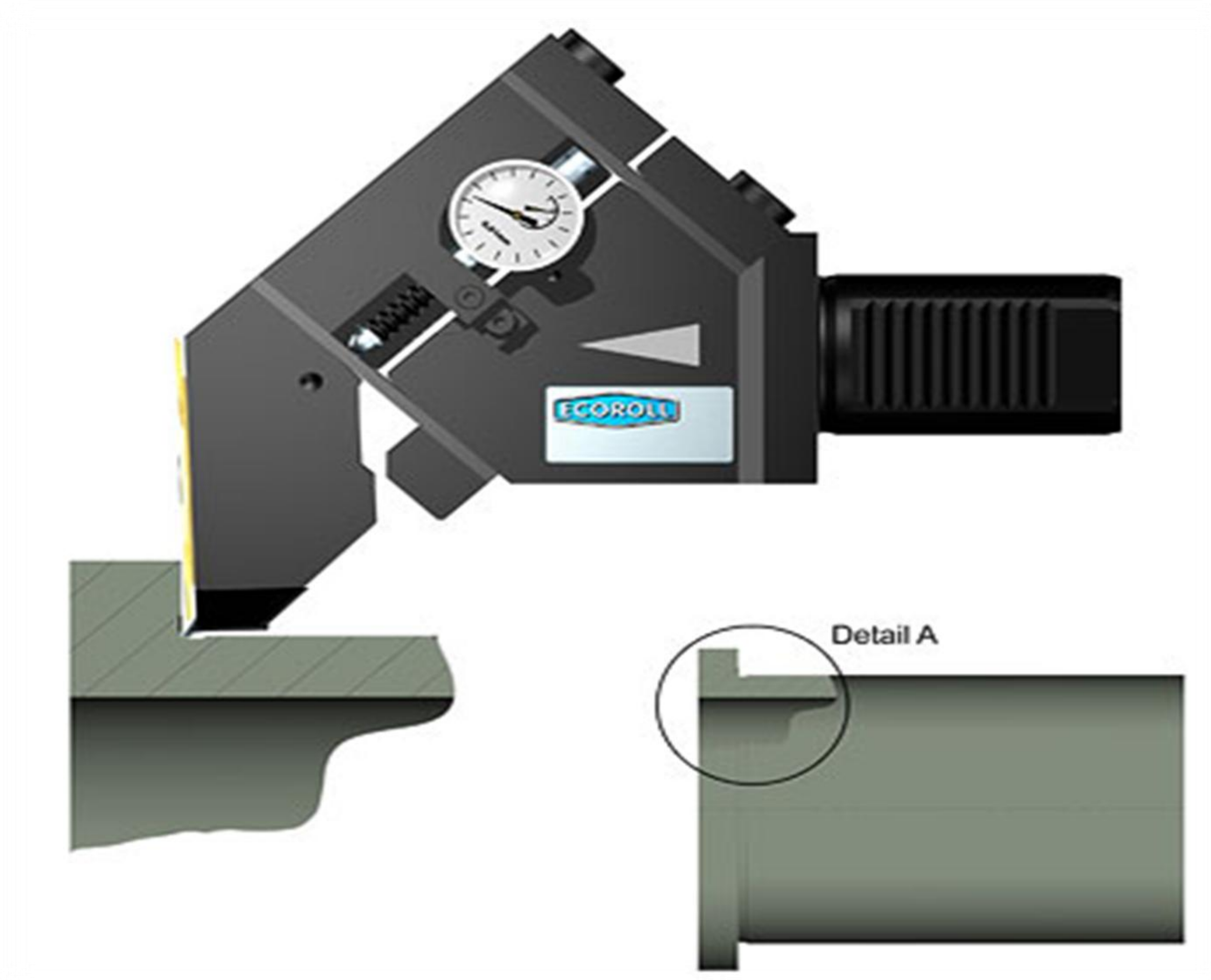

S.R
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
200
400
600
800
1000
CUTTING SPEED

APPLICATIONS

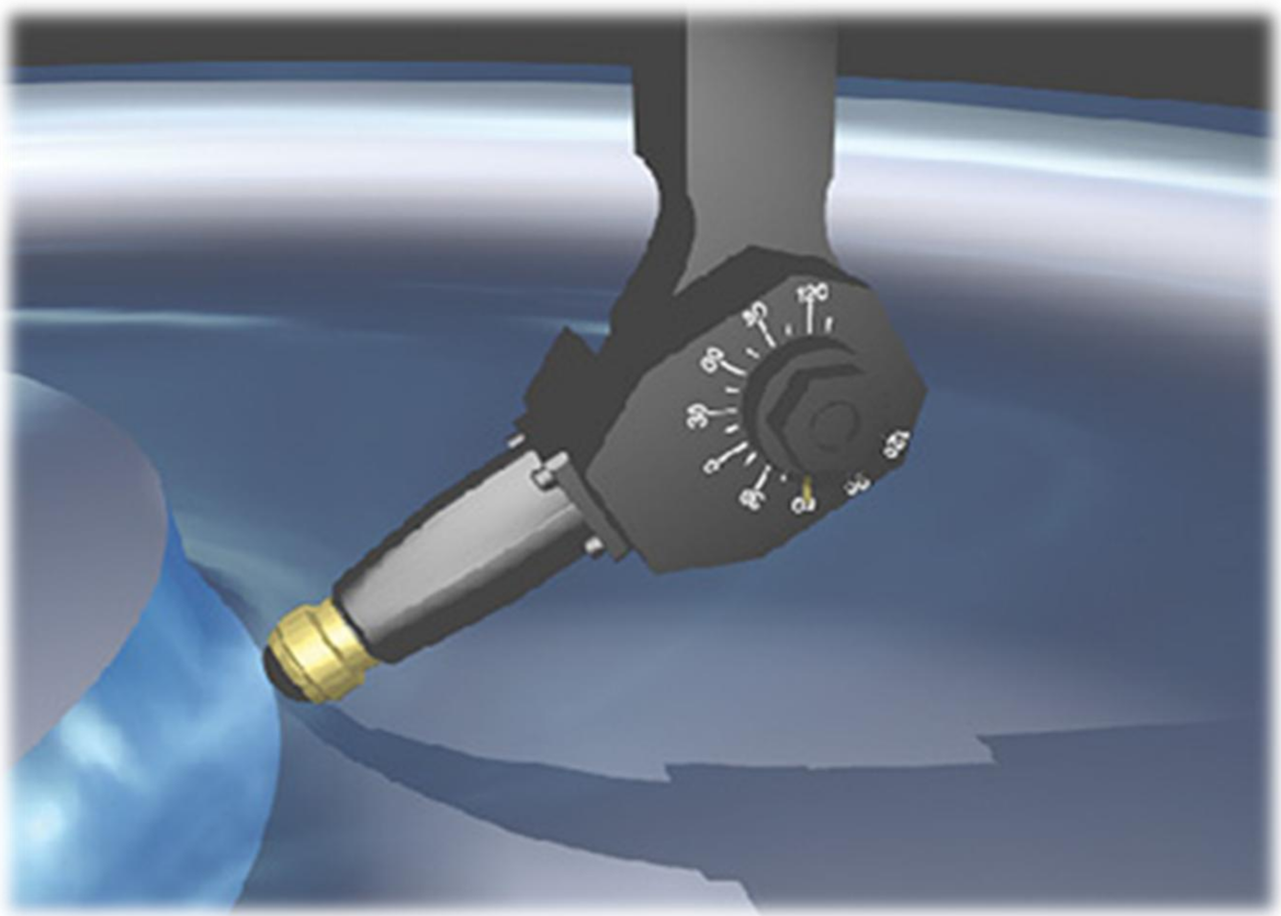
Cam shafts



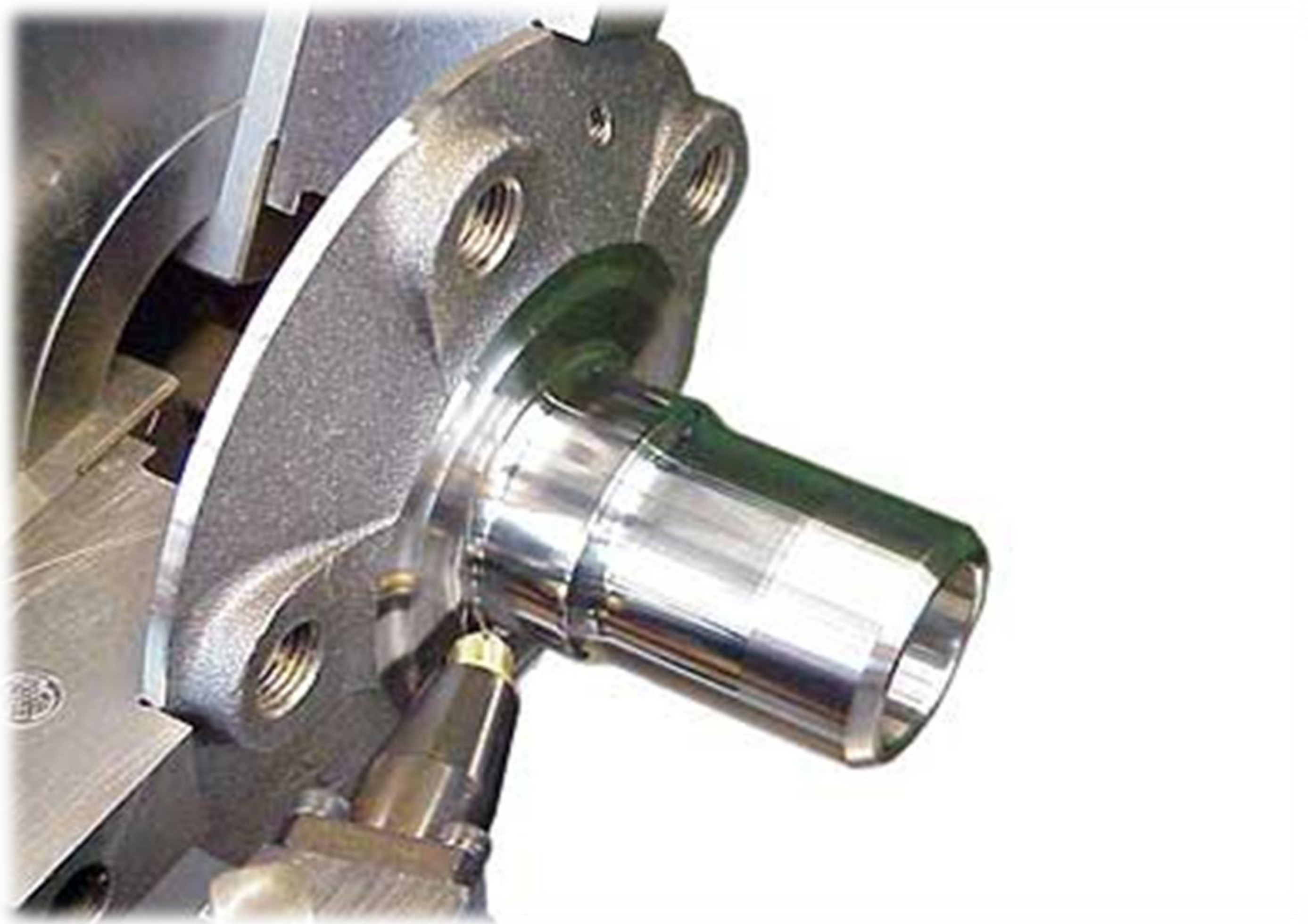
Cylinder liners



Deep rolling a turbine blade

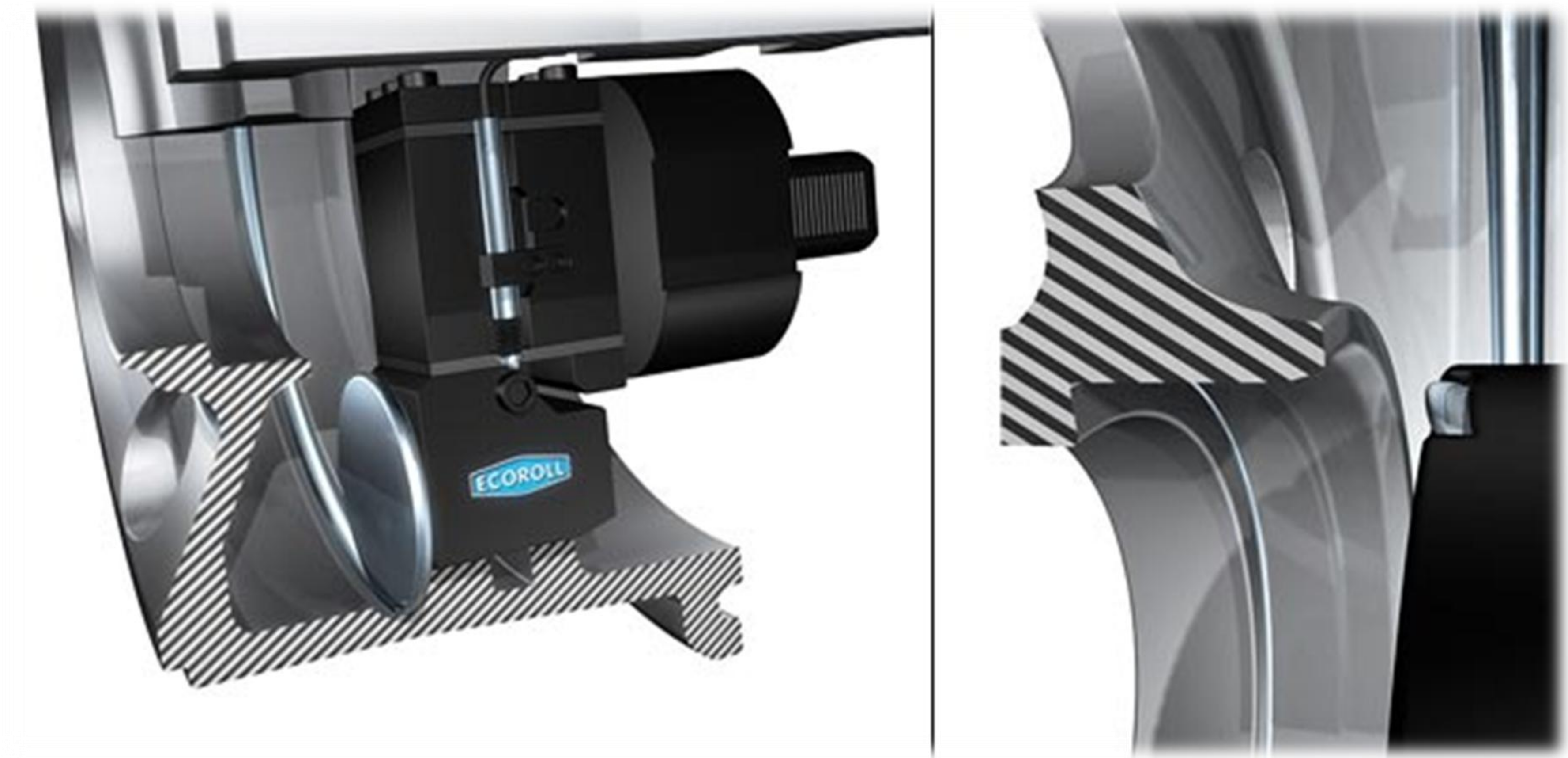


Deep rolling a wheel flange

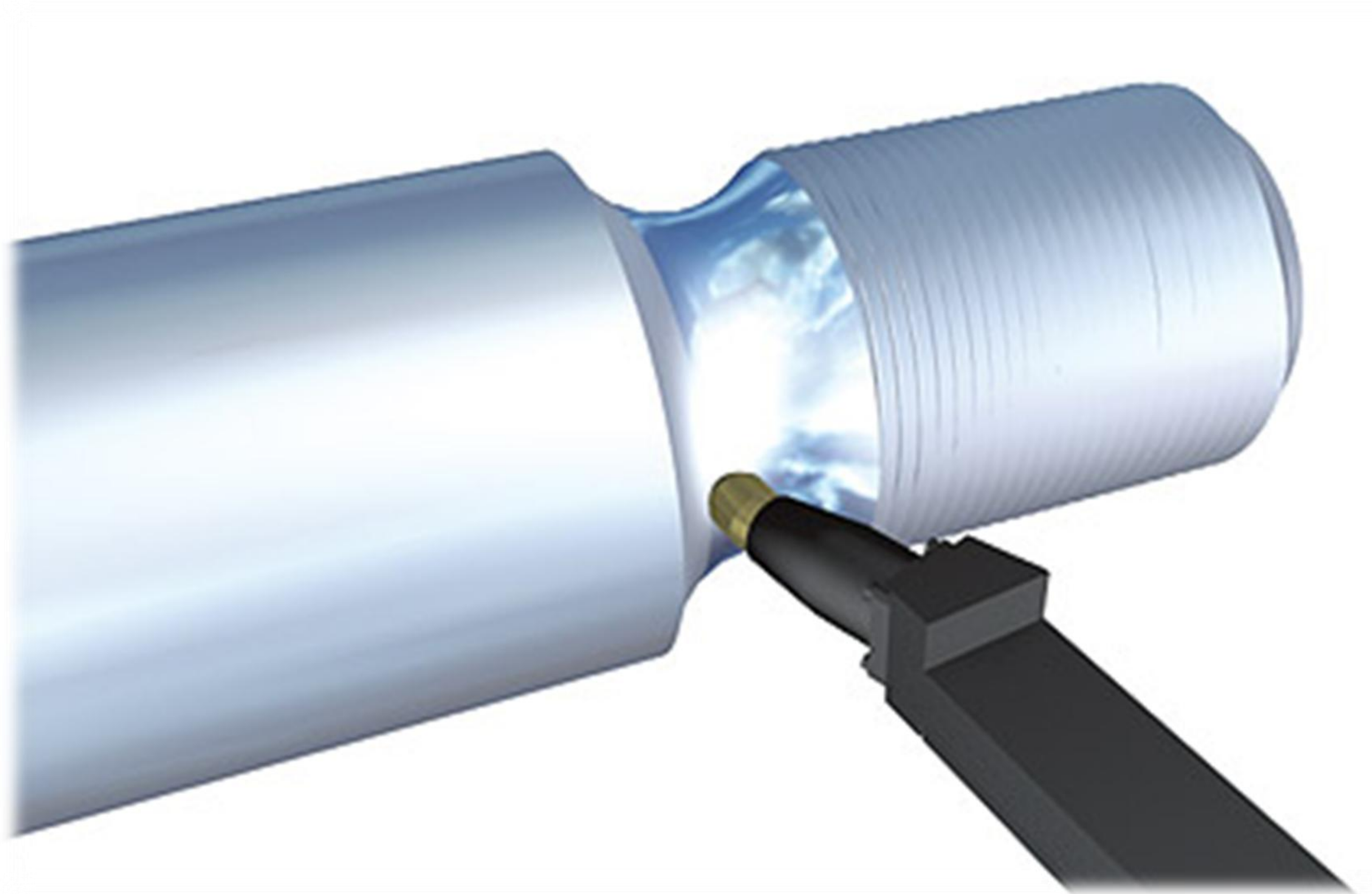


Deep rolling an aircraft shock strut

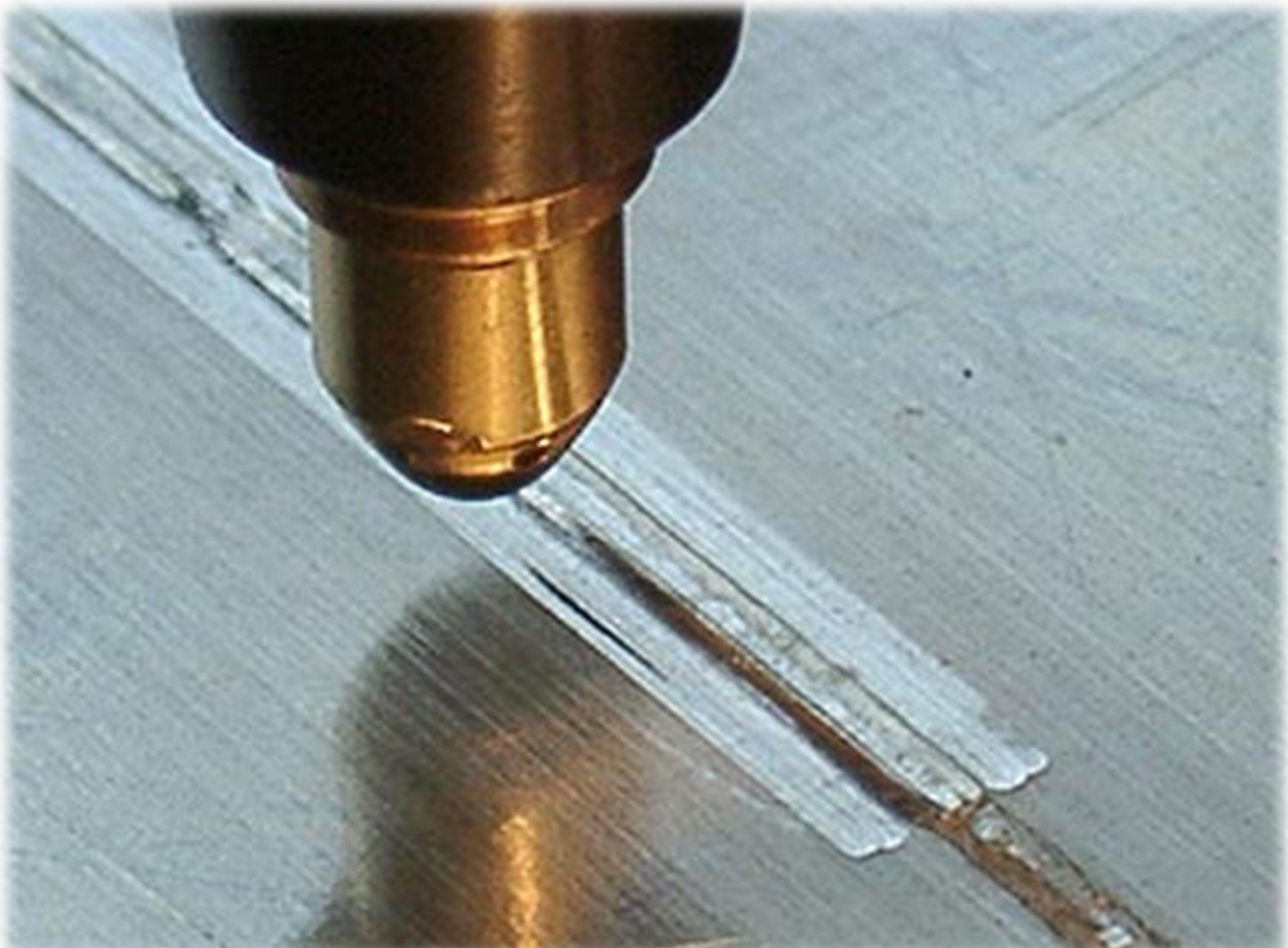
Deep rolling two area of an aircraft wheel rim



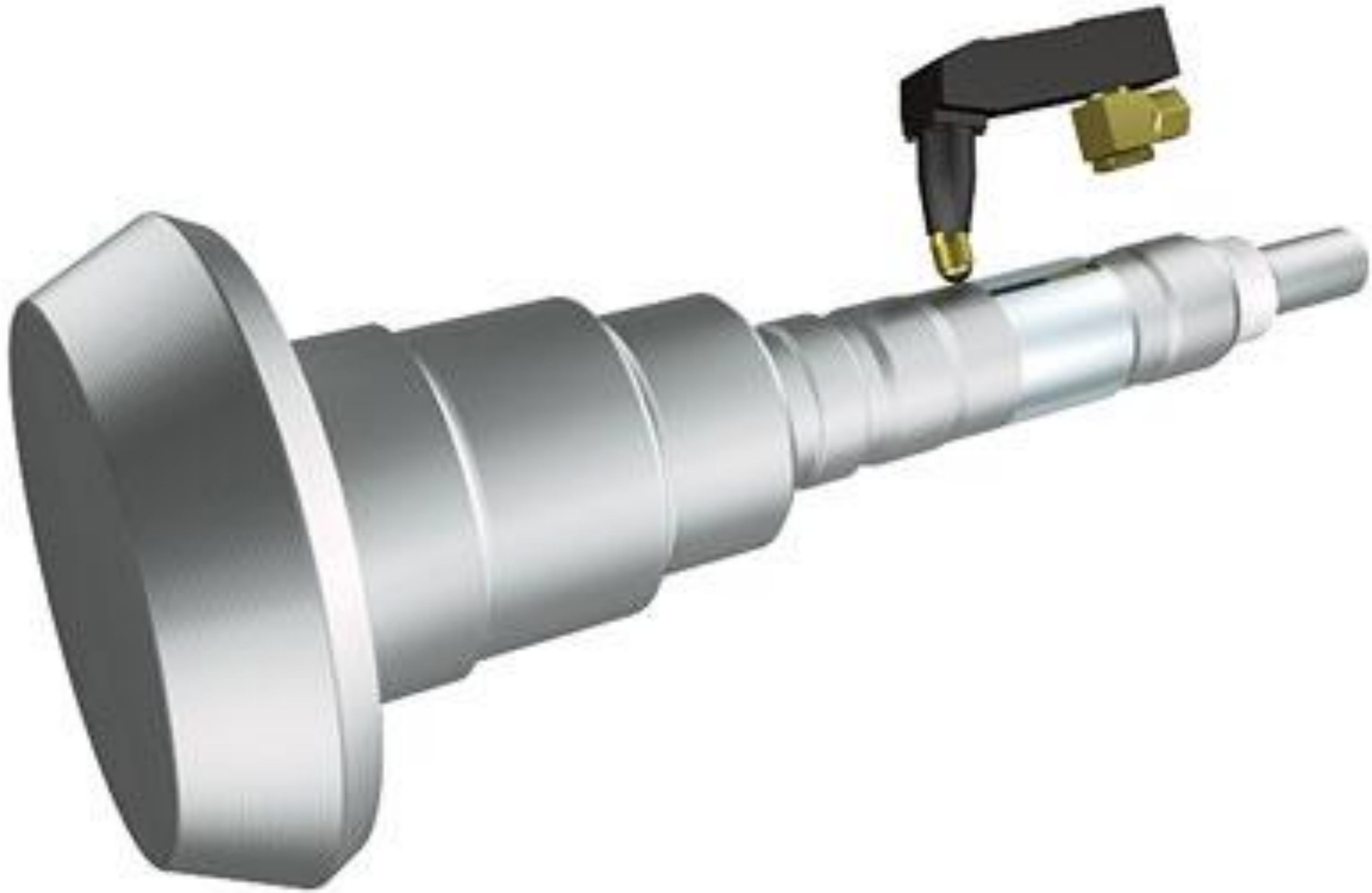
Tension rods in injection-molding machine



Weld seams



Gear shaft



Other application

Burnishing tools are being used in sectors like

- Automobile,
- Aircraft,
- Defense,Space craft, Railways,
- Textile, Machine Tool, Motors and Pump Industry
- Hydraulic and Pneumatic Farm Equipment,
- Home Appliances etc., and
- areas where close tolerance and superior surface finish is required.

Benefits

- Short cycle time and elimination of set up and auxiliary processing time.
- For use with either conventional or CNC controlled machines.
- Complete processing in one setting.
- Removes no material and generates no waste
- Easily reproducible
- Low lubricant requirements.
- Low noise emission.
- Long tool life.
- No dimensional change through tool wear.

CONCLUSION

- (1) The surface roughness of plain turning process on lathe m/c is obtain 0.71micron and by burnishing process this surface roughness is reduced to 0.30micron thus, the surface finish is greatly enhanced by ball burnishing process.

- (2) The minimum surface finish is obtain at 231N burnishing force with constant speed 350rpm, feed 0.2m/min, initially surface finish improved from 147N force to 63N force after than it deteriorate due to fankiness micro structure of material or strain hardening effect

- (3) Good surface finish is obtained at 800rpm speed with constant force 147N , feed 0.2m/min as speed increase is surface finish improve due to more amount of surface periphery of work material comes in contact of ball burnishing tool per unit time.

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THANK YOU….