Optimization and Analysis of Super Finishing Lathe Attachment

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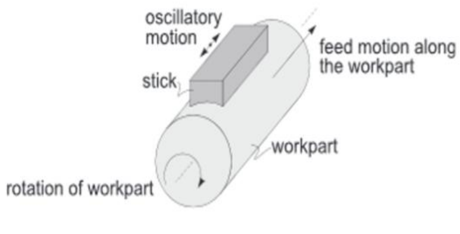
Abstract*: This paper presents the research work done to solve the problem faced by super-finishing attachment used in lathe machine, which cannot be continuously operated for mass production as it is possible in a full-fledged super finishing machine. Research work is implemented in 50LT attachment and converted it into continuous working machine there by making it suitable for mass production without having to purchase costly Super finishing machine and getting similar production only with an attachment on lathe machine. The research work also provides solution for the problem faced by attachment when operated in cold working condition wherein the shrinking of the part takes place and the machine gets jam and it becomes impossible to operate, the solution thereby makes the attachment to work in adverse environment also.

***Index Terms*: Friction, heat generated, super-finishing machine, OHNS, Ebonite Coating.**

I. INTRODUCTION

The super finishing is called as micro machining method, micro finishing and smooth grinding is metal removal process that makes surface shiny and geometrical shape improves. This is obtained by removing only thin shapeless layer it left at the end of process with abrasive tape or stone. This layer is generally about 1μm in size and final finished unwanted polish it generates a smooth and shiny finish generates a cross hatch section on the job.

Super finishing is an alternative process similar to honing. This is also used as bonded abrasive stick moves with reciprocating motion and leaning against the surface to be finished. The relative movement between the abrasive stick and the workpiece varies so that the individual grains do not retrace the same path.



Schematics of the superfinishig process.

Figure: Super finishing Process.

The cutting fluid is used in the process to cool the workpiece-tool interface. The coolant also removes the tiny chips produced during the process. The time required for super finishing is very small. The part can be super finished with a roughness of the order of 0.075μm within 50 seconds

The main applications of super finishing are the finishing of computer memory drums, sewing machine parts, automobile cylinders, brake drums, bearing components, piston rods, shafts, pins, axes, shafts, clutch disks, guide

shafts, etc. be continued up to 3 minutes for a very good quality finish. Super finishing can be differentiated from break-in in the following ways

(a) The finishing stroke length is relatively short but the frequency is greater. It's up to 1500 shots / minute. b) It requires a low pressure application compared to the running-in process. (c) During the feeding process is given to the workpiece, the feeding rate in case of super finishing operation is lower than that of the break-in. (d) The size of the abrasive used for super finishing is smaller than that used for grinding wheels.

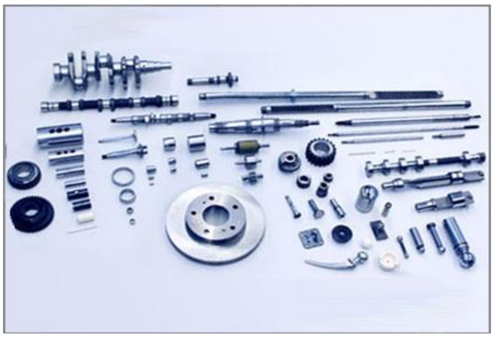


Fig1: Super finished Components.

The key applications of super finishing are the finishing of computer memory drum, sewing machine components, automobile thin shells, brake drum, bearing parts, piston shafts & rods, pin, axel, shaft, clutch disk, guiding shafts, etc. be continued up to 3 minutes for a very good quality finish. Super finishing can be differentiated from break-in in the following ways

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II. SUPER FINISHING PROCESS

When a metal part has been ground to an initial finish, it will be super finished with a finer fine grain abrasive. The abrasion is mainly because of rotation of the workpiece in the opposite direction; it is these movements that cause cross-hatching.

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The geometry of the abrasive is totally dependent upon the geometry of the surface of the part. a stone (rectangular in geometry) is used for cylindrical jobs and the cup & wheel is used for flat & spherical geometries. A liquid medium called as lubrication medium is used to reduce the heat, which will change the material properties, and to abandon the chips. Kerosene is highly used as lubrication medium.

The abrasive cuts the surface of the part in three phases. In the initial phase abrasive comes in contact with the surface of the part sluggish grains of the abrasive break and fall, leaving a new sharp cutting surface. During next phase, the abrasive "self-dresses" while the bulk of the stock is eradicate. At last abrasive grains will be dull as and when they work, which improves the geometrical shape of the surface.

The average speed of rotation of the grinding wheel and / or the abrasive portion is between 1 and 15 m / min and preferably between 6 and 14 m / min; it is very slow as compared to grinding speed up to 1800 to 3500 m / min. The pressure applied at the abrasive is very less, in between 0.02 and 0.07 MPa (3 to 10 psi), but can reach 2.06 MPa (299 psi). The break-in is typically between 3.4 and 6.9 MPa (490 and 1000 psi) and grinding between 13.7 and 137.3 MPa (1,990 to 19,910 psi). When it is tested on a stone, it has been oscillating in the range of 200 -1000 cycles with an amplitude of 1 - 5 mm (0.039 to 0.197 in)

The super finish can give a surface finish of 0.01 µm.

TYPES:

There are three types of super-finishes: direct feeding, diving and wheels.

Through-feed:-

These kind of super finish is usually preferred for cylindrical objects. The object rotates between two mating rotating rollers, which will cause to move the machine. 4 - 8 more and finer abrasive stones are used to overlap the piece. The angle between stones & the workpiece is 90 ° and oscillate axially. Examples of jobs are produced by this process include tapered roller, piston pin, shock rod, needle & shaft.

Plunge:-

This kind is used for finishing odd shaped surfaces. The piece is turned while the abrasive dives on the desired surfaces.

Wheels:-

Abrasive cuts or grinding wheels are used for the super finishing of flat and spherical surfaces. The wheel and the workpiece rotate in opposite directions, creating cross-hatching. In case of parallel, the result will be flat finish, when the wheel is slightly inclined, either convex or concave surface will form.

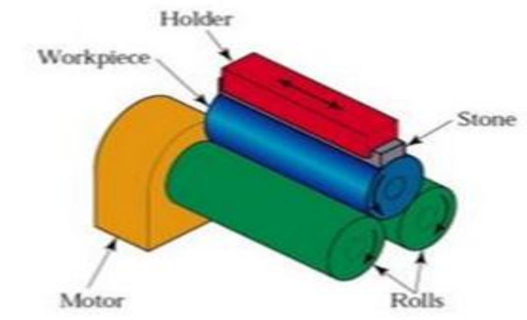

Fig 2: arrangement on complete Super Finishing Machine.

SUPER FINISHING MACHINES AND ATTACHMENT ARE USED BASED ON QUANTITY OF SUPER FINISHED WORK PIECE REQUIRED:

Cylindrical part which can be super finished by means of a "feed-through" super finishing operation in which the workpiece is rotated and the tool (stone) oscillates axially, if necessary to be manufactured in the range of 3 -4 lakhs pieces per month, must obligatorily be manufactured on

Complete super finishing machines that cost about 35 to 50 lakhs and come in different ranges.

On the other hand, if the number of superfine parts required is approximately 2 to 3,000 pieces per month, the same can be achieved by using a super finishing accessory on a lathe machine. The rotation of the workpiece is achieved by holding it between the centers of the lathe machine. This seizure normally costs between 2 and 2.5 lakhs and can be easily brought by a small industry.

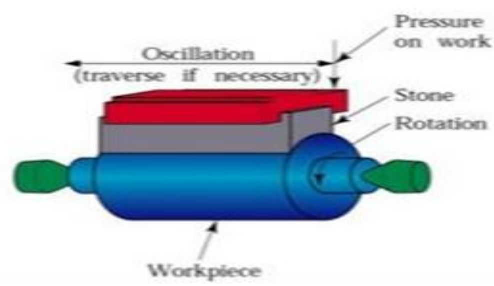

Fig3: Arrangement on Lathe Attachment Super finishing

SUPER FINISHING LATHE ATTSACHMENT:

The above images clearly show how a super finishing fixture is mounted on a lathe machine and the workpiece rotates between the center of the lathe.

The main working principle of this accessory is the oscillation of the tool (stone) that performs the super finishing work. This oscillation of the tool is obtained by a piston-cylinder pneumatic arrangement.

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Fig 4: Super Finishing Lathe attachment.

The cylinder has a unique set of holes and the piston has a cylindrical slot that allows the assembly to easily create an oscillating movement that can go up to 2500 oscillations / minute.

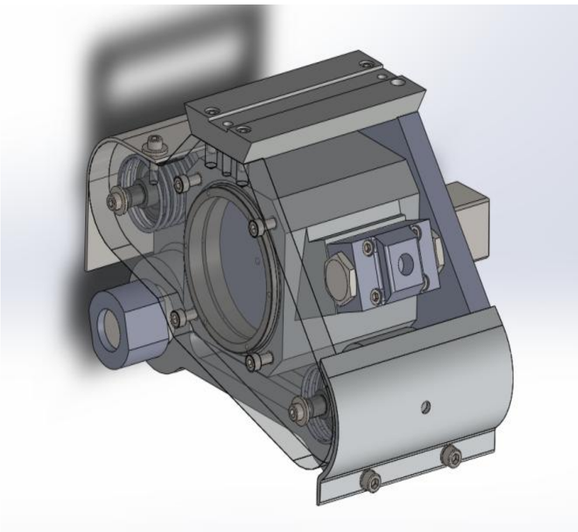

Fig 5: CAD of Super Finishing Lathe Attachment.

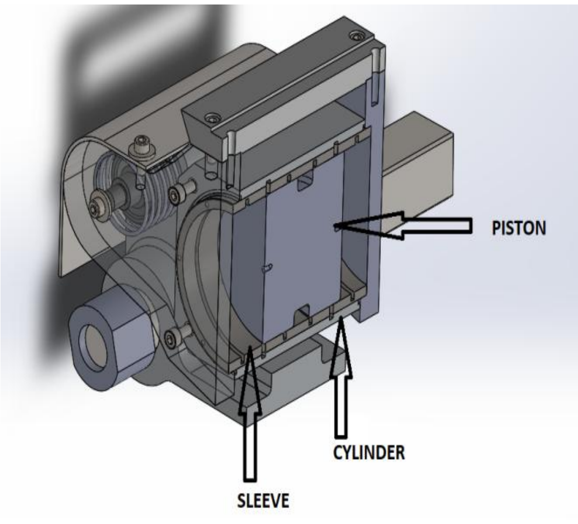

Fig 6: Cut CAD Model of Piston Cylinder and Sleeve Arrangement

PROBLEM DEFINITION:

The definition of the problem draws our attention to the practical operation of Super Finishing tower fixation, in which oscillations are possible only if a space of 5 microns is maintained between the piston and the sleeve.

To be very frank, the maintenance of this space of 5 microns in continuous operation is not possible at such oscillations (2500 / min). The friction between the piston and the sleeve produces heat which, in turn, expands the materials of the piston and the sleeve, thereby creating a blockage between the two. Because of this this accessory can not be used for continuous operation and has to be braked from time to time for cooling, which ultimately affects the production.

Another major problem faced by this attachment is that because of this friction between the sleeve and piston the life of the attachment is only around two years and must be reworked by changing the piston and the sleeve, which is still an expensive affair.

To find the exact problem, that is to say that an expansion of the material was carried out during the FE analysis, the heat produced was first calculated using the manual and applied method as that of FEA.

FORMULA

Formula to calculate Heat Generated “Q”

Q = μ*u*N

Where μ =coefficient of friction (is unit less and its value is 0.0618 for polish finish of material.)

U = Velocity of Piston Sleeve arrangement

U = 2500*2.4 mm(stroke length)

U = 6000mm/min

U = 6m/min

U =6/60=0.1m/s

N=force (It should be found from pressure)

P = 1 bar = 101325 Pascal = 0.1N/mm2

Pressure = F/A

F=P*A

F (i.e N) = $0.1*\pi/4*(70)^2$

F = N = 3846.5N

Q = 0.30*0.1*384.65

Q = 11.54W

This value of Q is calculated during the analysis in the ANSYS software by carrying out a coupled field analysis, namely the coupling of the structural and thermal analysis.

ANALYSIS (OHNS – OHNS)

1) Material Properties:

Material properties of the material OHNS (non-shrinkable steel hardened with oil) is indicated in the figure below:

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Outline of Schematic B2, C2: Engineering Data

	A	B	C	D
1	Contents of Engineering Data		urc	Description
2	Material			
3	OHNS			Fatigue Data at zero mean stress comes from 1998 ASME BPV Code, Section 8, Div 2, Table 5-110.1
4	Structural Steel			Fatigue Data at zero mean stress comes from 1998 ASME BPV Code, Section 8, Div 2, Table 5-110.1

Properties of Outline Row 3: OHNS

	A	B	C	D	E
1	Property	Value	Unit		
2	Density	7.83	g cm^-3		
3	Isotropic Secant Coefficient of Thermal Expansion				
4	Coefficient of Thermal Expansion	1.08E-05	C^-1		
5	Reference Temperature	38	C		
6	Isotropic Elasticity				
7	Derive from	Young's M...			
8	Young's Modulus	2.14E+05	MPa		
9	Poisson's Ratio	0.3			
10	Bulk Modulus	1.7833E+11	Pa		
11	Shear Modulus	8.2308E+10	Pa		
12	Alternating Stress Mean Stress	Tabular			
16	Strain-Life Parameters				
24	Tensile Yield Strength	1500	MPa		
25	Compressive Yield Strength	2.5E+08	Pa		
26	Tensile Ultimate Strength	1690	MPa		
27	Compressive Ultimate Strength	0	Pa		
28	Isotropic Thermal Conductivity	60.5	W m^-1 ...		

Fig 7: Material properties of OHNS

2) Boundary Condition (Thermal)

a) The thermal boundary condition applied to the sleeve is" Q" Heat Generated obtained through manual calculation, as shown in figure Fig 8 below:

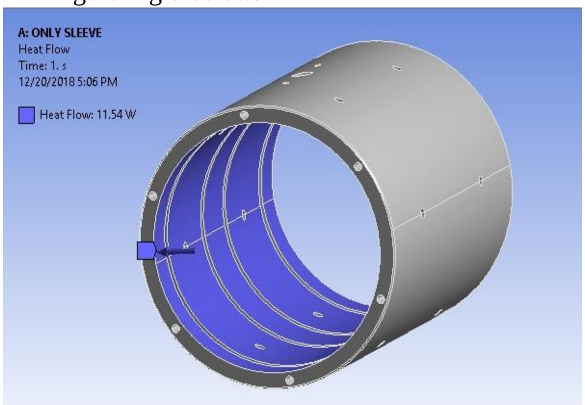

Fig 8

b) Another thermal boundary condition consists of Convection because of the flow of the air through the sleeve as shown in figure Fig 9 below:

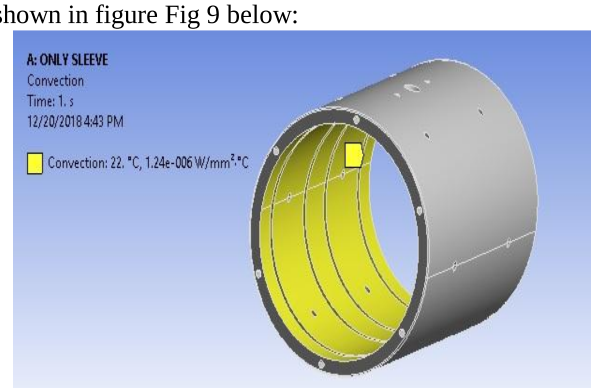

Fig 9

3) Boundary Condition (Structural)

a) The outer periphery of the sleeve is press fitted in an Aluminum body hence a fixed boundary condition is applied on the same, as shown in figure Fig-10 below:

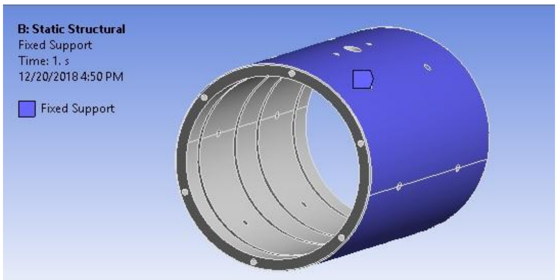

Fig 10

4) Meshing / Discritization; The mathematical model is converted into flexible model by meshing process. The discritized model is as shown in figure Fig-11 below:

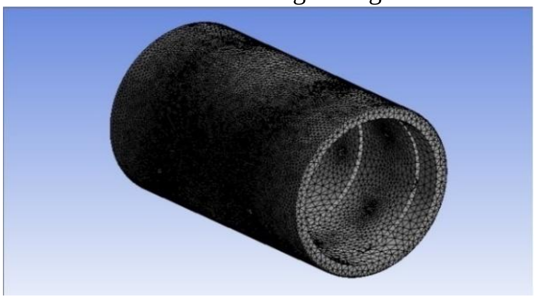

Fig 11

5) Results:

a) Temperature Distribution Fig-12

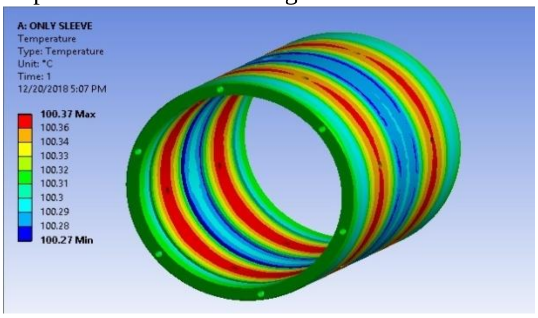

Fig 12

b) Total Deformation Fig-13

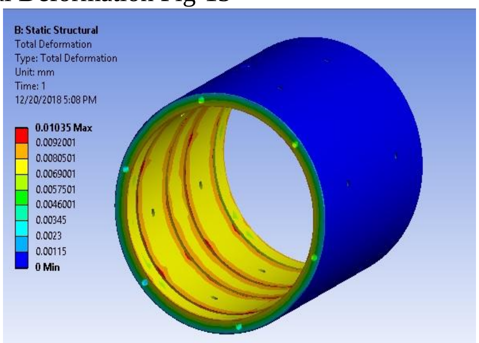

Fig 13

From the above results it is clearly seen that the Continuous operation of the attachment generates lot of heat which in turn result in expansion of the sleeve. As seen from the analysis result a total deformation of 10 microns shown in fig-13, which makes a jam between the piston and sleeve, as it needs around 5-micron gap for the free sliding of the Piston in the sleeve. So, a research has been made to coat the inner of the sleeve with a material having very low thermal conductivity.

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So it is decided to coat to the inner with Ebonite which has following Mechanical properties which serve our requirement.

Ebonite: 1.15 to 1.68 g/cm^3
Young's modulus: 2000 to 3000MPA
Tensile Strength: 52-67 MN/m^2
Thermal Conductivity: 0.17 W/MK
Thermal Expansion: 42.8 micro inch / inch oF.
Poisson's Ratio: 0.39.

ANALYSIS (EBONITE – OHNS)

1) The 3D Geometry after ebonite coating is as seen in the figure Fig -14 below.

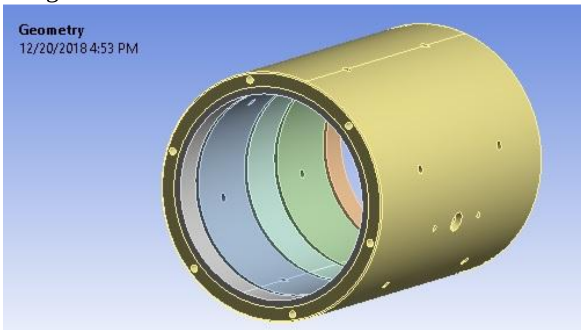

Fig 14

2) Meshed assembly of Ebonite coated OHNS Sleeve is as shown in figure-15 below.

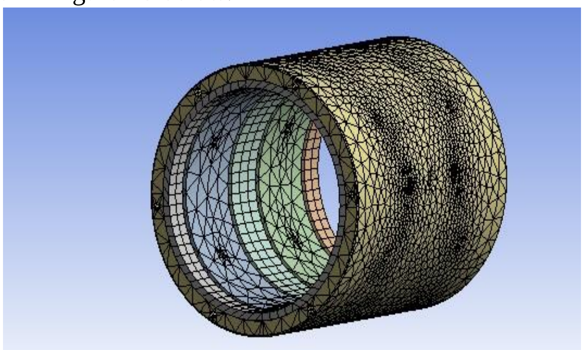

Fig. 15

3) The thermal boundary condition applied to the sleeve is" Q" Heat Generated obtained through manual calculation, as shown in figure Fig -16 below:

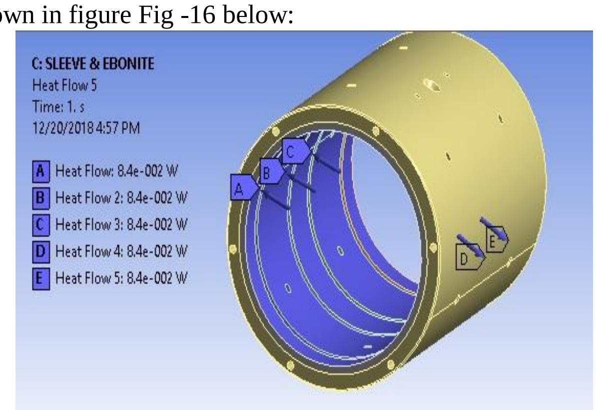

Fig 16

4) Convection Boundary condition is as shown below in Fig-17

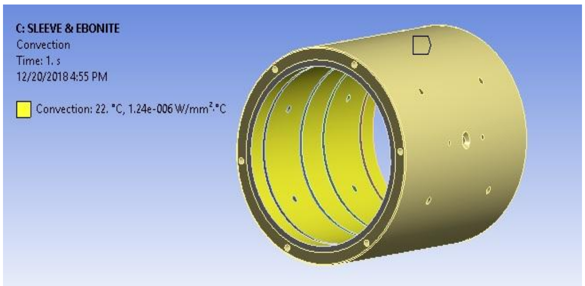

Fig 17

5) Internal Pressure is applied is as shown in fig-18 below.

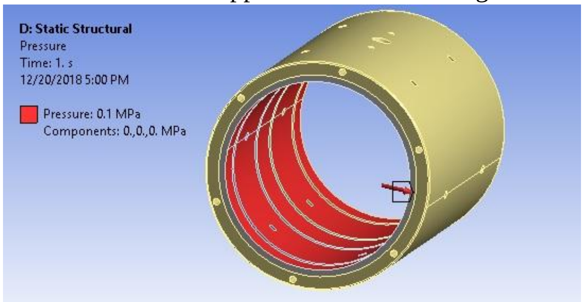

Fig 18

6) Results:

a) Temperature rise is as shown in fig-19 below

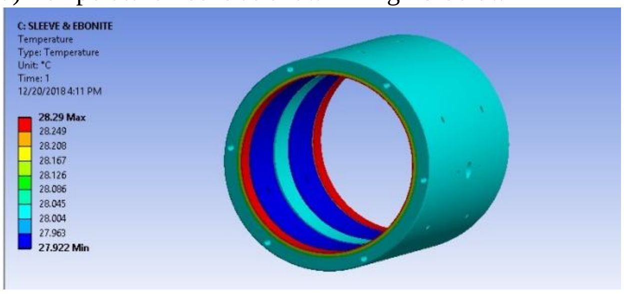

Fig 19

b) Total deformation is as shown in fig-20 below

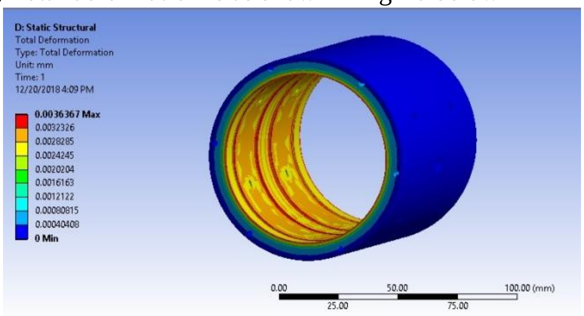

Fig 20

CONCLUSION:

1) As seen from the analysis above (Ebonite – OHNS) the total deformation is 3 micron which is less than 5 micron, which is required for the free sliding of the piston in the sleeve.

2) A practical has been conducted with Ebonite coating and running machine continuously gave excellent results both at high temperature and at places where the ambient in winter are very low, because this also avoids shrinkage of material. This is possible because the Thermal conductivity of Ebonite is very low.

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