# "IMPROVEMENT IN SURFACE FINISH BY LAPPING PROCESS"- A REVIEW

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## Abstract

Surface finish is the allowable deviation from a perfectly flat surface that is made by some manufacturing process. All machining processes will produces some roughness on the surface. This roughness is attributed to cutting tool, material removal rate, environmental conditions and the type of material. . In the era of nanotechnology, deterministic high precision finishing methods are of utmost importance and are the need of present manufacturing scenario.The surface finish may have implications for friction, wear, and maintenance or corrosion resistance and must, therefore, also be carefully chosen and clearly specified. Peaks and valleys can be measured and used to define the condition of the surface. The attempts are made to achieve Nano finish using super finishing processes like lapping. This will reduce cost and time. The trend has motivated to carry out a review on such research work. Such review will help in forming the basis for an intended research work in the similar direction.

**Keywords**- Lapping, Nano finish, Cutting Speed, Abrasive Material

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## 1. INTRODUCTION

Surface finish is an important element in any specification of stainless steel regardless of the intended use. For those applications where Appearance is important; finish is a design element and must be specified. In non-decorative applications the surface finish may have implications for friction, wear, and maintenance or corrosion resistance and must, therefore, also be carefully chosen and clearly specified. The choice of finish should never be left to the supplier, or the specification loosely worded, such as "Type 304 with a 180 grit finish". The finish should be properly identified by a standard industry designation or by a trade name therefore, also be carefully chosen and clearly specified.

The machining processes were classifieds into three categories on the basis of achievable accuracy viz. (1) Conventional machining (2) precision machining (3) Ultra-precision machining

Ultra precision machining are the processes by which the highest possible dimensional accuracy is, or has been achieved at a given point of time. It has been predicted that by 2000 AD, machining accuracies in conventional processes would reach 1 µm, while in precision and ultra-precision machining would reach0.01µm (10nm) and 0.001µm (1nm) respectively. These accuracy targets for today's ultra-precision machining can't be achieved by simple extension of conventional machining processes and techniques.

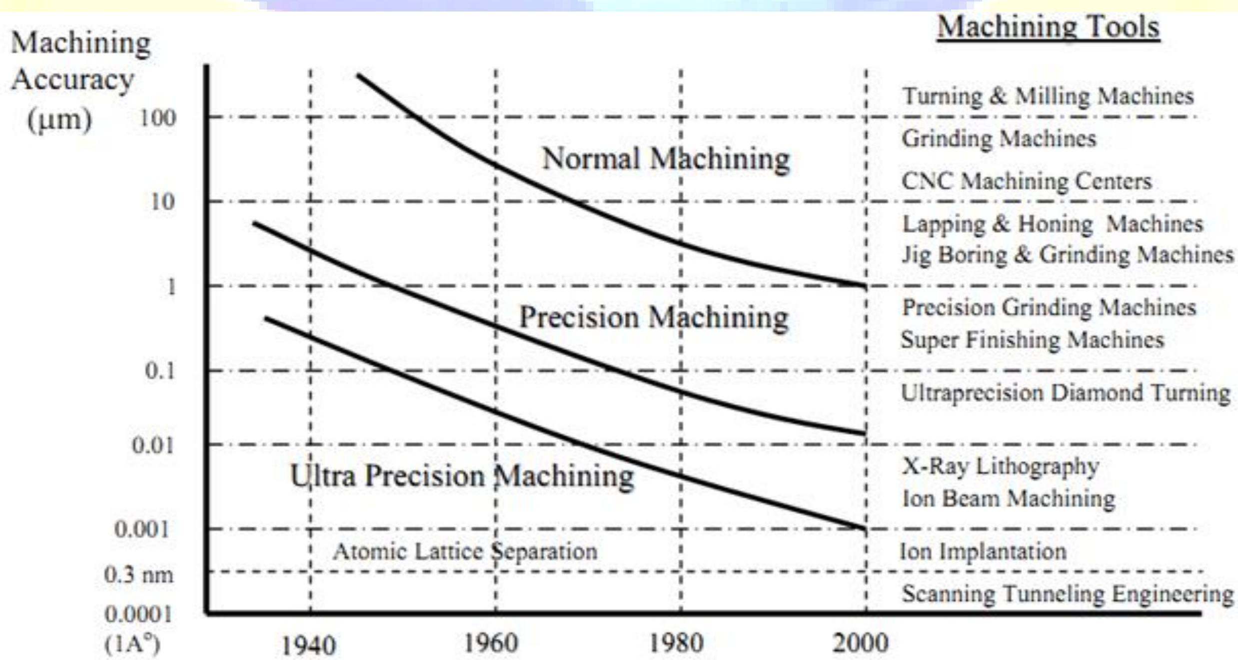
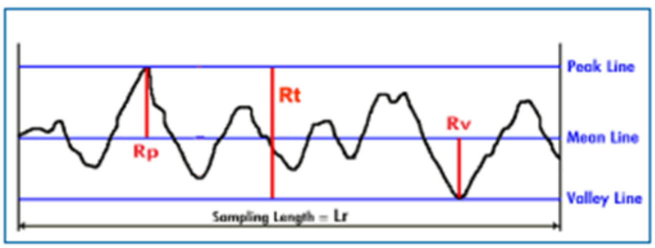


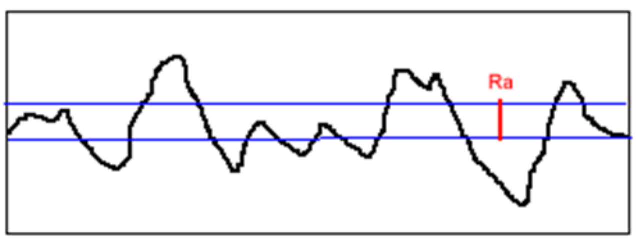
Fig.1 Achievable machining Accuracy [16]

Surface finish is generally broken up into three components such as roughness, waviness, and form.

- Roughness is generally the machined marks made on a surface by the cutting tool.
- Waviness is the result of the vibration of the tool.
- Form surface irregularities caused by worn off machine bad, table etc.

All three surface finish components exist simultaneously. They simply overlap one another. We often look at each (roughness, waviness, and form) separately, so we make the assumption that roughness has a shorter wavelength than waviness, which in turn has a shorter wavelength than form.




Ra = the average variation from mean line.

Rt = Distance from the highest peak to the deepest valley.

Rz = the average Rt over a given length.

Rz= (Rp1+Rp2+Rp3)+(Rv1+Rv2+Rv3) / 3

Rp = the highest peak above the mean line.

Rv = The deepest valley below the mean line.

### 1.1. LAPPING PROCESS

There are several techniques used for removing material from a particular workpiece (also called specimen in this discussion).Grinding, lapping, polishing, and CMP (chem.-mechanical polishing) are all techniques used for precise removal of material. The lapping process is one of the traditional finishing processes. Lapping is a process by which material is precisely removed from a workpiece (or specimen) to produce a desired dimension, surface finish, or shape. Several materials were machined as mirror like surface using the system. The process of lapping materials has been applied to a wide range of materials and applications, ranging from metals, glasses, optics, semiconductors, and ceramics. Lapping technique is beneficial due to the precision and control with which material can be removed. Surface finishesin the Nano meter range can also be produced using this technique, which makes lapping an attractive method for materials processing.Lapping is the removal of material to produce a smooth, flat, unpolished surface. Lapping processes are used to produce dimensionally accurate specimens to high tolerances (generally less than 2.5µm uniformity). The lapping plate will rotate at a low speed (<80 rpm) and a mid-range abrasive particle (5-20µm) is typically used. Lapping removes subsurface damage caused by sawing or grinding and produces the required thickness and flatness. Although the lapping process is less damaging than grinding, there are two regimes of lapping: free abrasive lapping and fixed abrasive lapping.Free Abrasive Lapping is when abrasive slurry is applied directly to a lapping plate (e.g. cast iron). This is perhaps the most accurate method for producing specimens and causes the least amount of damage. Free abrasive lapping is accurate because of the rigid lapping surface which can be tailored to suit a particular material.Fixed Abrasive Lapping is when an abrasive particle in bonded to a substrate as with abrasive lapping films and SiC (silicon carbide) papers. Abrasive lapping films have various particles bonded to a thin, uniform polyester substrate and are also capable of producing a very flat surface. SiC papers are much thicker than the film and create the potential for rounded edges on the sample.[1]

### 1.1.1 Abrasive Types

There is a wide selection of abrasives to choose from when selecting a lapping process. Selecting an abrasive is dependent upon the specimen hardness, desired surface finish, desired removal rate, life time and price. There are four basic types of abrasives that are used in lapping processes:Silicon Carbide (SiC), Aluminum Oxide Or Alumina (AlO), Boron Carbide (B C), Diamond (C)

| MATERIAL | HARDNESS (KNOOP 100) | DENSITY |
|---|---|---|
| SILICON CARBIDE (SIC) | 2450 | 3.22 |

| | | |
|---|---|---|
| ALUMINA (AlO) | 2000 | 3.97 |
| BORON CARBIDE (BC) | 3000 | 2.51 |
| DIAMOND ( C ) | 6000 | 3.51 |

Table 1: Various Abrasive Materials and Associated

All of these abrasives have distinct properties and are used for different materials and applications.

- Silicon Carbide (SiC):SiC is hard and generally has a needle or blocky structure. Sic is used in many applications where rough lapping is required. It seldom is used for polishing or applications that require smooth surface finishes. Silicon carbide is generally used where rapid stock removal is a requirement.
- Aluminum Oxide Or Alumina (AlO) :AlO is relatively hard and has a sharp, angular structure. Alumina is commonly used where fine surface finishes are required as it breaks down over time and gives excellent surfaces during lapping. Alumina is also relatively inexpensive. Fused aluminium oxide is softer than silicon carbide and is used to improve the finish, especially in lapping comparatively soft metals such as steel and nonferrous metals. Un-fused aluminum oxide is very soft and breaks down rapidly under lapping pressures. It is inefficient for stockremoval, but especially suitable for producing extremely fine finishes.
- Boron Carbide (BC): BC is harder than most other abrasives (excluding diamond) and has a blocky crystal structure. BC provides excellent removal rates and is typically used when fast removal with moderate surface quality is needed.
- Diamond (C): Diamond is the hardest material known and has a sharp, angular structure. Diamond is extremely useful in lapping due to its removal rates and surface finishing qualities. Diamond can produce excellent surface finishes combined with high removal rates.[1]

### 1.1.2. ABRASIVE SIZE

Abrasive size referred to as grits, affects the amount of work achieved as well as the finish produced.Coarse abrasive sizes range between 8-60grit. Coarser grits remove significant material and leave coarser finishes. The coarser grit sizes are a good choice for large weld removal, de-flashing, and de-gating castings, and remove also large amounts of stock.Medium abrasive sizes range between 80-150grits. Medium grits will also remove affair amount of material and leave finer and paintable surfaces. They are also good for spot weld removal radiusing, deburring and finer weld removal. Finer abrasive sizes range between180-400 and super fine up to1200 grits, the material removal is less but are capable of maintaining good rms finishes.[1]

### 1.1.3. Lapping Plates

Lapping processes are performed on a hard, metal plate used in conjunction with abrasive suspensions such as diamond, silicon carbide (SiC), aluminum oxide (Al O), or boron carbide (BC). The metal lapping plate selected depends upon the desired material removal rate, the surface finish desired, the hardness of the specimen being lapped, and the flatness requirement. Plate selection can play a critical role in the production of high quality specimens. Lapping plates can be flat or grooved depending upon the desired application. Grooved plates provide greater removal rates and prevent the abrasive from squeezing out from between the plate and the specimen.

## 2. LITERATURE REVIEW

In this study, a computer-based intelligent decision support system designed to achieve the optimization of the lapping of plane surfaces, by the Taguchi's method of arrays of experiments.[2]

In this work,the mechanical lapping process of diamond cutting tools aims to investigate the influence of tool face orientations and the effects of contact accuracy betweenlapped tool surface and rapid rotating scaife's surface on the sharpened cutting edge radius. [3]

In this study, the plane lapping was performed and analysed by ANOVA table. As a result, effective variables and interaction effects were identified and discussed. Also the optimal variable combination to obtain the largest percentage improvement of surface roughness was selected and confirmatory experiments were performed. Important variables lapping efficiency are abrasive grain size, lapping pressure, lapping speed, quantity of lapping compound supplied and viscosity of the compound, etc. [4]

In this study, Ball screws are being lapped as a finishing process to improve the travel variation, and surface finish in order to provide high precision requirements in various mechanical applications. However, the existing manufacturing method is very labour intensive that needs a highly skilled machinist to perform the hand lapping operations using the conventional laps which have two or three slits.[5]

In this study, they developed an automatic lapping system for moulds and dies. The lapping system consists of simple lapping tools and conventional milling machine. Several materials were machined as mirror like surface using the system. In this study, an intelligent lapping system with the optimum conditions calculated by the lapping model was developed. Specifically, the relationship between the finished quality (surface roughness Rz and improvement rate of Rz) and each parameter of the system, Vickers hardness of work piece and lapping head, lapping pressure, grain size, is investigated. Then, an intelligent lapping system is developed. [6]

In this study, the fundamental mechanism of material removal in lapping process and identifies key areas where further work is required. [7]

In this study, two types of HIPed Si3N4 bearing ball blanks with different surface hardness and fracture toughness were lapped under various loads, speeds, and lubricants using a novel eccentric lapping machine. The lapped surfaces were examined by optical microscope and SEM Different lapping fluids affected the material removal rate at lower lapping loads, but they had much less influence on the material removal rate at higher lapping loads. The preliminary conclusion is that the material removal mechanism during the lapping process of silicon nitride balls using this eccentric lapping machine is mainly mechanical abrasive wear. [8]

In this study,advanced ceramic balls are used extensively in hybrid precision ball bearings and show advantages in high speed, high temperature, high load and hostile environment. Finishing these balls with high quality, good efficiency and low cost is critical to their widespread application. A brief review on the methods of finishing ceramic balls is presented. The design of a novel eccentric lapping machine for finishing advanced ceramic balls is described in this paper. [9]

In this study, it is estimated that the final finishing process and associated handling and inspection of advanced ceramic balls constitutes two thirds of the total manufacturing cost. Finishing advanced ceramic balls at low cost and efficiency while maintaining high surface quality to ensure long fatigue life is critical to its widespread application. [10]

In this study, the paper presents experimental research results obtained by plane surface lapping. Experiments were aimed at measuring the height of the removed material layer of the lapped surfaces for several types of materials, in view of setting up a comprehensive database. In addition to the research results the paper also presents the equipment employed for experimenting. The influence on the height of the removed material layer of various working factors (concentration of the abrasive paste, eccentricity, relative speed, duration of machining, working pressure) is discussed. [11]

## 3. Conclusions

The study shows that important parameter affecting the surface finish are Grit Size, Cutting Speed, Abrasive Material, Pressure on the workpiece (load) and sfpm (Surface Feed per Minute).

Increasing the lapping load, lapping speed and paste concentration parameters causes a corresponding increase in material removal rate. The increase of material removal rate is most significant as the lapping speed parameter increases from 8.5 to 169 rpm. Further increasing the speed to 270 and 500 rpm will not increase the material removal rate.

The most efficient lapping speeds range between 300 and 800 sfpm (Surface Feed per Minute), whether it be the rotation of the lap or movement of the work over a stationery lap. Speeds lower or higher than this range will reduce the rate of cut, but higher speeds will improve the surface finish.

The increase of material removal rate is almost linear (proportional) with the increase of lapping load throughout the parameter range. The amount of pressure applied depends considerably upon the material being lapped, as well as the desired rate of cut and the finish specified. Lapping with loose abrasives or prepared compounds, the pressure will range from 1 to 3 psi for soft materials, including nonferrous metals and alloys and up to 10 psi for hard materials. Excessive pressures will cause rapid breakdown and possibly score the work-piece.

The optimum lapping parameter combination within the experimental level ranges is found to be high speed, high load, 60μm diamond particles and high paste concentration.

The most significant influencing parameter is lapping load, which accounts for 50% of the total effect, followed by lapping speed (31%), particle size and the paste concentration parameters only account for 12% and 7% respectively.

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