

Precision Engineered Finish

Greenhouse emissions and energy efficiency are the critical aspects pushing the limits of Powertrain Engineering in the automotive industry. 'Lightweighting' and 'Friction Reduction' are two key strategies in this aspect. Deploying both strategies makes the designers of the engines resort to stringent surface finish parameters on critical powertrain components. Microfinishing is a critical process that is required to achieve these specifications.

The process of microfinishing with film backed abrasives was developed to achieve consistently uniform finishes faster and more efficiently. Microfinishing generates lubricating characteristics at surface contact through a highly engineered

surface finish so that the surface provides maximum bearing area to take up heavy loads and at the same time retain enough oil in the surface for adequate lubrication.

Milestones in this technology in the past few years include the process capability of achieving precision engineered finishes, as well as advancements to process more and more variety of components using film backed abrasives. The major improvements in machine technology include flexible manufacturing systems that are capable of

multi variants and more energy efficient machines with ultra user friendly interfaces.

What is Micro-Finishing?

Micro-Finishing is a method or process to remove the surface material of a dimensionally finished part in order to provide a precise fit to the mating part. An examination of the texture left on a metal surface as a result of machining operation will reveal tool marks, fragmented metal, chatter, etc. It is the micro-finishing operation that must be used to generate the final surface texture required for service life, performance and reliability of a product.

A non-microfinished surface can be compared to a snow covered lake. A person's weight will produce foot prints in the snow and the ice will provide support to the concentrated pressure of a person on ice skates. When a metal or steel part is machined, the surface becomes fragmented and also annealed if a heat generating grinding process is used. This type of surface will not support high bearing loads. Microfinishing is the process that removes the fragmented and annealed surface, leaving the base metal for greater bearing loads.

Meeting advanced specifications of state of the art crankshafts

Crankshaft is the heart of an engine. This mission critical component transmits power from the combustion chamber to the powertrain. Specifications on a crankshaft have undergone major advances globally in the past few years. While Friction Reduction has demanded finer and finer finishes,



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The Grind Master NANOFINISH range of machines includes Microfinishing and Superfinishing machines.

Source: Grind Master Machines Pvt Ltd

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Lightweighting (and the resulting downscaling of engines to 2 and 3 cylinder engines instead of 4 cylinder engines) has led to more bearing loads on the crankshafts features. At the same time, the user experience demands higher speeds, longer engine life and the lowest NVH (Noise, Vibration and Heat). All these factors have all led to tighter and tighter expectations from the crankshaft.

In order to reduce friction the crankshaft requires the following features:

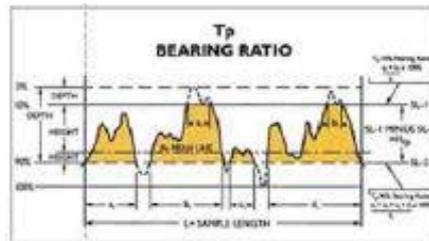
- ▶ Surface Finish Ra values to be lesser than typically Ra 0.1 microns on Main and Pin journals, Finish Ra values to be lesser than typically Ra 0.15 microns on thrust walls,
- ▶ Tighter oil seal finish requirements to use thinner oils,
- ▶ Bearing area Htp requirements on all journals
- ▶ Tighter geometrical tolerances including roundness, straightness, cylindricity. New specifications on profiles, crowning, lobing.
- ▶ Consistent stock removal – Maintaining size tolerances.

Most modern automotive crankshafts are microfinished using multiple level processes, such as Level II or Level III Microfinish. Some of the case studies below will illustrate the results achieved on such crankshafts.

Case Study: Achieving parameters on automotive crankshafts for passenger car

Qualifying higher energy efficiency and emission norms had generated stringent requirements on the journal surface so that the engine NVH performance could improve. Tribology experts and engine designers came to a conclusion that to achieve the stringent requirements the bearing ratio parameters needed major enhancements, along with improvements in other specifications.

The bearing ratio is illustrated in the figure below:



Tp - Bearing Ratio
Percentage value of sum of flat areas over total length

Microfinishing with Level II process along with optimization for various process parameters led to achieving remarkable results with consistency as indicated below:

- Bearing Ratio
- 5-20% Htp: 0.15 microns Depth
- 5-80% Htp: 0.25 microns Depth
- 5-90% Htp: 0.35 microns Depth
- Surface Finish: Ra 0.1 microns

The above parameters were achieved with a consistency indicated by statistical process control parameters Cp (achieved Cp > 2.0 and Cpk > 1.67)

Besides Finish, the corrections in geometry such as roundness correction by 50 per cent below 3 microns, cylindricity controlled within 3 microns also indicate

the process capability of microfinishing (refer to the graphic given below).

In one specific realization for passenger car crankshafts, a special size control feature with online gauging was deployed on a machine to achieve a diameter tolerance $\pm 3 \mu\text{m}$ with PP 2.19 and PPK 2.16.

Case Study: Microfinishing replaces stone finishing technology for camshafts

Stone Finishing is a traditional technology for finishing of shafts like components, including camshafts. Microfinishing with film backed abrasives provides several advantages over stone such as consistency of results, lesser maintenance and adjustments, lower energy consumption, etc. Due to the above mentioned reasons, Microfinishing has replaced conventional stone lapping in majority of shaft type components. In one particular instance, a global leader in engine technologies made use of a combination of stone and film to achieve very stringent surface finish specifications.

The earlier 3 level finish process was replaced with a 2 level process using film alone. The surface finish achieved is mentioned below:

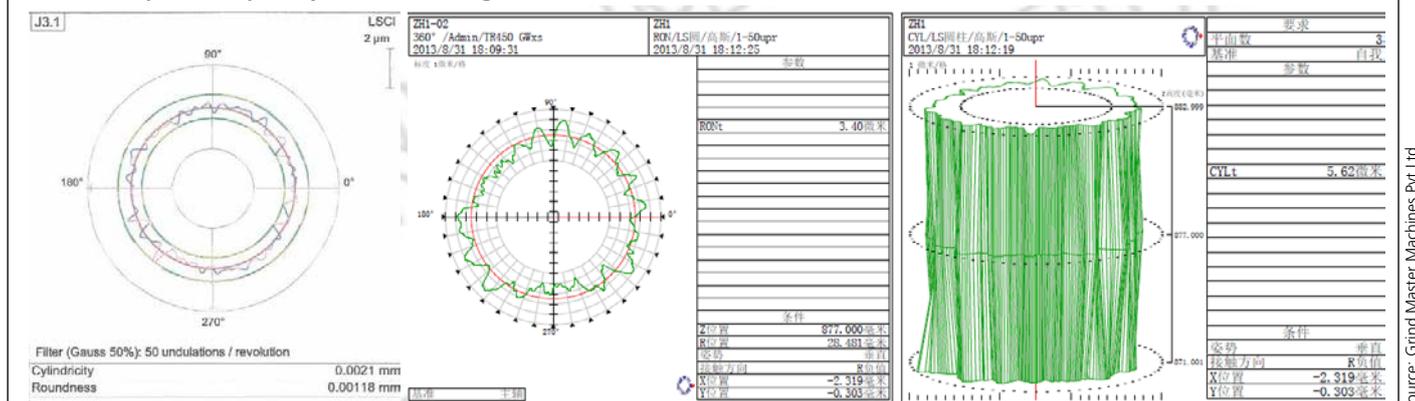
- Ra < 0.067 microns with Cpm > 1.67
- Rtm < 0.412
- Wt < 0.45
- Wc < 0.12

The resulting consistency and low-energy operation as well as lower cycle time truly delighted the customer.

Microfinishing automotive transmission components

Traditionally automotive transmission components such as geared shafts (Input shaft, output shaft, main shaft) and

Graphic: The corrections in geometry such as roundness correction by 50% below 3 microns, cylindricity controlled within 3 microns also indicate the process capability of Microfinishing.



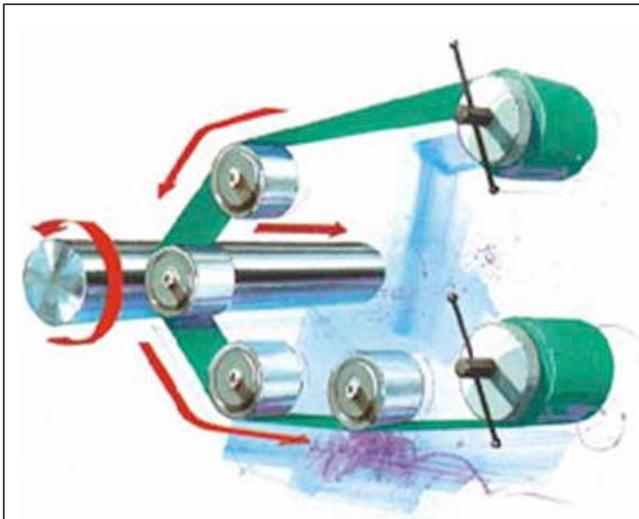


Figure 1: Superfinishing technology with contact roller for line contact.

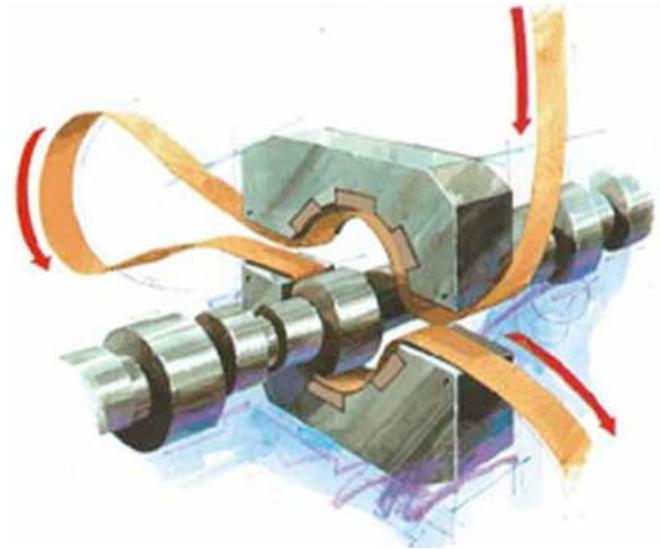


Figure 2: Microfinishing with Shoes for Surface Contact.

Source: Grind Master Machines Pvt Ltd

synchrocones, differential housings, etc only have surface finish specifications such as Ra values. The specifications on transmission parts have been upgrading over the years, thus necessitating the use of microfinishing technology instead of superfinishing.

Apart from Ra values, many components are now specified with Rk, Tp, Rmr and Lead angle specifications. Geometry specifications such as roundness, cylindricity and size are also being tightened on such components.

Microfinishing is distinguished from Superfinishing based on the type of contact between the abrasive film and component as illustrated by the figures 1 and 2.

Microfinishing provides better consistency in surface finish and the bearing ratios are much quicker than superfinishing. Geometry corrections are not possible with Superfinishing, whereas it is guaranteed in Microfinishing. Several

successful projects including Microfinishing for balancer shafts, differential gear housing, main shaft, etc illustrate the benefits.

Milestones in Microfinishing

Microfinishing is a key process technology in automotive powertrain for achieving engine performance in terms of energy efficiency and emissions. The capability to achieve superior finishes enables reduced friction in the powertrain and low NVH. In the future, specifications on finish for components such as crankshafts, camshafts and various powertrain parts are likely to get more and more stringent. Advances in Microfinishing technology also helps to achieve these parameters with consistency.

Grind Master NANOFINISH Microfinishing Machines

The Grind Master NANOFINISH range

of machines includes Microfinishing and Superfinishing machines. A wide variety of Microfinishing machines covers the full range of crankshafts and camshafts, from 200 mm to 3500 mm.

The machines are based on a modular design concept and can be optimized for specific applications with configurable stations including a number of arms, arm positioning mechanisms and automation systems and peripheral systems. Optional additions include Deburring Units. The machines are controlled by an engineered software—NANOFINISH Control System—built for finishing machines.

The state of the art machines are packed with several features that make them a market winner. Optimized cycle times, quick setup change, quick tooling change, ease of maintenance are some of these. Grind Master provides a complete Microfinishing solution to its customers. **MMI**