



Microfinishing for next gen automotive powertrain parts

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. The article discusses how microfinishing technology has crossed several milestones and made possible key advances in vehicle performance.



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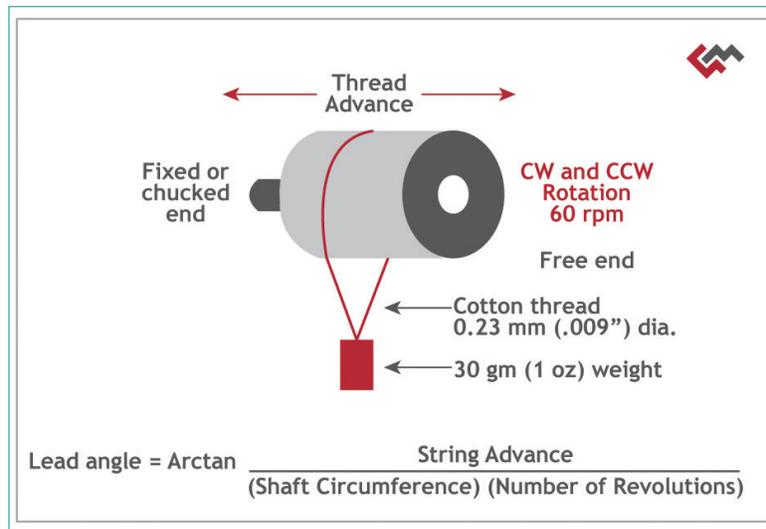
Process of microfinishing with film backed abrasives was developed to achieve consistently uniform finishes faster and more efficiently. Microfinishing generates lubricating characteristics at surface contact through a highly-engineered surface finish so that the surface provides maximum bearing area to take up heavy loads and at the same time retain enough oil in the surface for adequate lubrication.

High performance automotive powertrains require stringent specifications to be delivered by the microfinishing process. Finer surface finish parameters for friction reduction, specialised

surface texture characteristics for oil retention, improved noise-vibration characteristic using roundness characterisation are some of the required updates. There is a clear benefit in vehicle performance as a result of achieving these specifications, which the automotive industry cannot afford to ignore.

What is microfinishing?

Microfinishing is a method or process to remove the surface material of a dimensionally finished part to provide a



Machining processes such as turning and grinding create a natural lead angle. Microfinishing process is used to ensure that the finished component is with no lead. The specifications for such are typically within 0.2 degrees lead.

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 relates to a snow covered lake. A person's weight will produce foot prints in the snow whereas, the ice will even provide support for 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 base metal for greater bearing loads.

Surface finish and friction reduction

The condition of hydrodynamic lubrication is desired for smooth motion. In order to achieve this, the thickness of the oil layer must be greater than the variations in the surface (i.e. surface roughness). The thickness of the oil layer also gives rise to energy losses. There are two approaches to reducing these energy losses—reducing oil layer thickness and reducing oil viscosity. Applying both the approaches requires a finer surface finish which can retain a finer film of oil.

Traditionally, microfinished components have been specified with surface finish values in the range of Ra 0.15-0.2 microns. Next generation automotive powertrain requires surface finish values in the range of Ra 0.06 – Ra 0.1 microns to enable a finer oil film and, thus, reduce energy losses in powertrain to a substantial extent.

Roundness characterisation and noise reduction

Traditional specifications on geometry of powertrain components have included roundness, straightness, cylindricity. Next generation parts, especially high speed gearbox shafts and camshafts need to have specifications that characterise roundness. Roundness profile can be broken down into constituent parts consisting of undulations around the profile. These undulations are produced usually by manufacturing process and affect the way in which a part will behave. Terms important in this respect are UPR (Undulations per Revolution) and FFT (Fast Fourier Transforms)

Upon making a FFT analysis of a roundness profile, it is found that the profile consists of different amplitudes at different UPR values. The amplitude at 1 UPR reflects the roundness value and so on. For a given roundness, it is desirable that the amplitudes at higher UPR values are lower and lower. The noise characteristic of the component in motion is highly dependent on the amplitude at a particular frequency of rotational motion.

Manufacturing processes such as turning or grinding usually generate a fine chatter that reflects in the FFT analysis. Since the nature of the machining process is itself generating this chatter, finer machining is unable to reduce the amplitudes. Advanced microfinishing process is able to do this, as illustrated in the figure below. Such a control of roundness characteristic has tremendous benefits in noise reduction.

Surface texture characteristic and oil retention

Several powertrain shafts, such as crankshafts, gearbox shafts and sometimes camshafts have oil seal diameters. Traditionally, a 'straight line finish' was specified on these

diameters to ensure oil retention. Next generation powertrain uses lower viscosity oils, requiring a characterisation of the straight line with a number 'lead angle' and a tight control over this number.

Case study: Specifications of 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, 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, user experience demands higher speeds, longer engine Life and lowest NVH (Noise, Vibration and Heat) have all led to tighter and tighter expectations from the crankshaft.

Some of the specifications for next generation crankshafts include:

1. Surface Finish Ra values to be lesser than typically Ra 0.1 microns on Main and Pin Journals Tighter Oil Seal Finish requirements required to use thinner oils
2. Bearing Area Htp requirements on all journals
 - 5-20% Htp : 0.15 microns depth
 - 5-80% Htp : 0.25 microns depth
 - 5-90% Htp : 0.35 microns depth
3. Dynamic unbalance typically less than 10 gm cm

Most modern automotive crankshafts are microfinished using multiple level processes, such as Level II or Level III microfinish and dynamically balanced on an automatic precision balancing machine.

Conclusion

Microfinishing is a key process technology in the automotive powertrain sector for achieving vehicle performance in terms of energy efficiency and noise reduction. Stringent specifications on surface finish and geometry characteristics of crankshafts, camshafts and gearbox shafts lead to significant benefits in powertrain performance. In particular, finer surface finish enables energy efficiency by reducing oil film frictional losses in all components, roundness characterisation and control reduces noise level, especially for camshafts and gearbox shafts, and lead angle specifications enable use of lower viscosity oils without leakage. □

Perfect again.

