Constructive and technological problems of modern superfinishing systems

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Abstract

In many technical applications there are systems that can considered composed by two or many identical parts or systems that present some symmetries. These symmetries can be used to simplify the analysis of such systems in order to reduce the dimension of the equations that describe the motion of the system. In the paper are identified some properties to vibrations of a mechanical system showing certain symmetries.

1. INTRODUCTION

In the case of mechanical systems showing certain symmetries, the differential equations describing their evolution in time display a series of specific properties – a consequence of the very existence of these symmetries. The present work sets forth some of these properties which may be used in the numerical resolution of these systems.

Here are some grinding occurrences that will thwart superfinishing consistency:

2. Too Smooth A Finish

Ironically, one of the most common of all grinding problems in relation to superfinishing is too smooth a finish. It is still not widely understood that too smooth a finish from the grinding operation is a negative factor. When the superfinishing stone rides on too smooth a surface, it begins to glaze, causing it to ride on a film of oil and remove very little material from the part. A coarser finish tends to keep the stone open, so it can cut more freely.

Engineers and grinding machinery operators typically take a great deal of pride in their work. Wanting to do their best, they try to get the finish as low as possible. When this happens, the hone stone is unable to bear into the part and remove the amount of stock required to reach the specified result.

Another reason why incoming finish is often reduced from optimum to a low limit is a byproduct of wanting to increase grinding throughput. Extending dress cycles to a bare minimum maximizes throughput but it also results in a dull wheel which does not cut freely. When the wheel is dull, it produces a smoother finish and increases the likelihood of thermal damage, lobing and chatter.

The throughfeed superfinishing operation for an automotive engine component was set up based on an incoming part finish of 6 to 8 Ra, removing 30 to 50 millionths of stock to produce a 1 Ra finish. The finish from the grinding operation was allowed to deteriorate to 3 or 4 Ra. Because the stones could no longer efficiently penetrate the part, superfinishing stock removal fell to about 10 millionths—insufficient to clean up the part. Although Ra was good, many of the parts were visually unappealing and rejected. When the grinding operation was directed to dress more frequently and grind more aggressively (to 6-8 Ra), the cosmetic issues were eliminated.

2.1. Thermal Damage

Trying to do too much finish work in the grinding operation can generate excess heat and cause thermal damage to the subsurface of the part. If the part is burned in grinding, it may still be possible to reach the desired level of superfinish but visual imperfections and metallurgical damage will likely necessitate scrapping the part. Superfinishing is not a fix for burned parts.

2.2. Burnishing

A problem frequently associated with thermal damage is burnishing. When the wheel is not cutting freely because it is dull, it generates excessive heat. Instead of removing metal, it pushes it around on the surface of the part, smearing it into the microscopic valleys. This may result in a smooth surface, but one that is not acceptably prepared for the superfinishing process. It is not as stable under load. Because this type of burnishing leaves softer metal on the surface of the part, it may become less wear resistant. Burnishing can create a situation in which the part looks good and meets specifications, yet is in fact an inferior part.

2.3. High Amplitude Lobing

A certain amount of lobing is associated with all internal and external diameter grinding operations. Lobing is generally caused by deflections in the system between the wheel, the work and the tooling when grinding forces are applied. As a result of these fluctuating forces, no workpiece is ever perfectly round. Instead, the workpiece will have a number of rounded projections call lobes.

When a stone can bridge two or more lobes at a time, it can then work to reduce their amplitude. See Figure 1, at right. Superfinishing can remove a certain amount of lobing—perhaps as much as 50 percent depending on amplitude, frequency and the application.

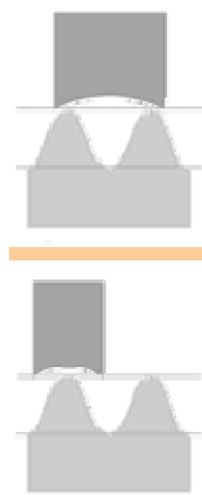

Figure 1. While superfinishing can put a mirror finish on the part, it may also be used to improve roundness, depending on the incoming roundness of the workpieces and the width of the stones. Narrow stones (at left, above) ride up and down on the lobes to improve surface finish only. Wider stones (at left, below) can bridge the lobes to reduce their depth (that is, to improve roundness) and impart a high degree of surface finish at the same time.

2.4. High Frequency Chatter

Excessive lobing is not the only reason for chatter. It may also appear on incoming parts. A series of lines, generally a result of induced vibration caused by improper setup, worn equipment or poor wheel performance, is termed chatter. Some of the conditions that create chatter may also cause thermal damage to the part.

Chatter is a high frequency surface aberration superimposed on top of the lobing. It is like ripples on ocean waves. Superfinishing is far more effective in correcting chatter than lobing.Reducing chatter is important because it allows assembled components to operate quietly and with less vibration. It is a major factor in eliminating premature failure.

Ironically, superfinishing can sometimes make excessive chatter generated in the grinding operation look worse. When insufficient stock is removed by the super-finisher, the problem of chatter is actually highlighted. Superfinishing polishes the peaks of the chatter but the valleys remain dull in contrast. Previously invisible to the naked eye, chatter now becomes clearly visible and disturbing. Although it becomes obvious in superfinishing, chatter is a problem that is passed on from grinding.

Highlighted chatter due to insufficient stock removal in superfinishing takes us back full circle to the problem of too smooth an incoming finish. Of course, the superfinishing operation could use a softer stone which breaks down readily and cuts more aggressively. Another way to improve the efficiency of chatter removal is by selecting a stone geometry which presents more surface area to the part. The degree to which stone geometry may be altered depends on part geometry and the superfinishing equipment's capacity.

But changing the stone to compensate for grinding-related problems means less efficient superfinishing. Softer stones also wear out more often. The best solution is maintenance of quality output from the grinding operation.

Table I
Common Superfinishing Problems And how To Correct Them

Condition	Increase	Decrease	Other
Excessive stone wear	spindle RPM	stone/wheel pressure; reciprocation/ oscillation	use harder abrasive product
Insufficient stock removal	abrasive pressure reciprocation/ oscillation rate	spindle RPM	use softer abrasive product; use coarser grit abrasive product
Rough finish	spindle RPM	stone/wheel pressure; reciprocation/ oscillation rate	use finer and/or harder abrasive product
Undesirable smooth finish	reciprocation/ oscillation rate; abrasive pressure	spindle RPM	use coarser and/or softer abrasive product
Excessive heat generated	coolant flow rate	stone/wheel pressure	use softer abrasive product
Out-of-round parts	reciprocation/ oscillation rate	stone/wheel pressure; spindle RPM	use softer abrasive product
Glazing of abrasive surface	reciprocation/ oscillation rate; abrasive pressure	spindle RPM	use finer and/or softer abrasive product
Loading of abrasive surface	reciprocation/ oscillation rate	spindle RPM	use finer and/or softer abrasive product

3. Conclusion

Ideally, grinding and superfinishing operations should be synchronized to achieve the common goal of producing consistently good parts at the end of their interrelated processes. The grinder needs to take the workpiece to size within a prescribed semi-rough finish range and then leave it alone. There is a relatively narrow window in which to operate. Below 10m of surface finish, problems can appear in superfinishing; below 6m, they are almost certain. (Problems attributable to incoming grinding finishes are not the only ones superfinishing can face. Table I (below) presents some other common problems and suggests the appropriate correction.)

To contribute to much more effective superfinishing, the upstream grinder should use free cutting wheels and process parameters that properly prepare the part for superfinishing, while avoiding additional problems like thermal damage, chatter, lobing or burnishing. "We can always catch it later" should not be part of the grinder's thinking.

The grinding operation is the last chance to catch problems that could significantly impact manufacturing yields, even though the rejection may occur downstream and appear to be somebody else's problem. When yields from superfinishing are high and within spec, the grinder deserves much of the credit.

4. References

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