MATERIALS MATTER

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Vibratory bowl gear polishing inefficiencies

The individual pieces and the collective mass are important to ensuring effective and efficient gear surface finishing results.

Increasing numbers of gearing projects are specifying isotropic superfinishing processes due to the demonstrated performance and durability increases generated by the reduced roughness and improved surface texture that they generate.

Isotropic super finishing processes are conducted in a vibratory processing bowl fostered by the application of appropriate refinement chemistry, a burnish soap, and the vibratory bowl filled with an appropriate shape of HDNA (high-density, non-abrasive) media. Heat-treated gears (typically fabricated from carbon steel) will react with the refinement chemistry to form a soft conversion coating. In the process, the HDNA media engages the tooth flank surface, not as a mechanical abrasive tool, but rather as a wiping instrument. As the media slides along the flank surface, it wipes the coating from surface asperities beginning a planarization action that over a short period generates an asperity-free surface with an enhanced surface texture for lubricant retention free of lambda-layer asperity breakthrough. A sequential burnish removes the conversion coating leaving tooth flanks with a final Ra value ≤ 0.1µm or ≤ 4µin.

MEDIA VOLUME INEFFICIENCY

The most common inefficiency in isotropic finishing is a low media level. Media is a wear item in the process and has an attrition rate. With each passing hour, each piece of media decreases in volume.

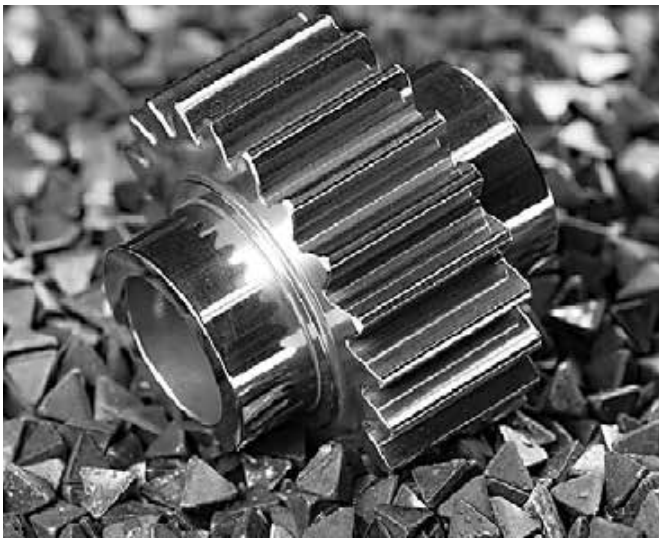
The process is visually non-apparent within the course of a day's production but becomes noticeable over several weeks of processing. Visually, the volume of media in the vibratory machine begins to drop. Low media volume is such an insidious problem that its occurrence impacts performance negatively in a number of ways.

PART-ON-PART CONTACT

Not only is the media mass the tool used to wipe the conversion coating, thus planarizing surface asperities, but it additionally serves to keep gears in the vibratory bowl separated from one another. If ISO Work Instructions or the like are prescribed for gear isotropic superfinishing, operators may load the vibratory bowl accurately with the correct gear count run-after-run, and if media level is allowed to gradually reduce, then the propensity of part-on-part damage is increased simply because the volumetric mass of media present to maintain proper separation is also reduced.

INCREASED PROCESSING TIME

As noted above, media is the tool utilized to wipe the conversion coating, thereby planarizing surface asperities. As the media volume decreases in size, so too does the volume of tooling within the vibratory bowl to perform the planarization process. The counter-effect of having too little media, and therefore too little tooling in the vibratory bowl, translates to a longer processing time required to achieve the desired isotropic final surface finish. There is simply less tooling available to get the job done.



DECREASED APPLIED WIPING FORCE

As the volume of media decreases in the bowl, so too does the column of media above the gears in the machine. Gravity presses the media mass downward onto the gears as they roll. Most notably this action occurs at the vibratory bowl's center hub where the gears and media mass plunge downward. With a low media mass in the vibratory bowl, there is simply a shallower column of media above the parts applying less pressure on tooth flank conversion coating wiping action.

MEDIA LODGING: TOOTH FLANK CONTACT INEFFICIENCY

In a hypothetical example, let us assume that media loaded into your gear processing vibratory bowl is a one-inch cube. Media attrition decreases the volume of each piece of media as a function of processing run time. If the media level is not topped-off periodically — because the operators have found it is far easier to hand unload a vibratory bowl that has a smaller media volume — the amount of force each piece of media can bring to bear on conversion coating wiping action is decreased as well. If the one-inch cube were to decrease in volume to a half-inch cube, arithmetically its dimensions have been halved, but volumetrically its size is one-eighth its original volume. Media attrition is mathematically a function of the cubed root of volume. It takes eight one-half-inch cubes to equal the same volume as the original one-inch cube. The applied weight density of each half-inch media cube onto the surface of the gear tooth flank is one-eighth the weight density of its original one-inch cube volume. Less weight plus a shallower column of media above the gear result in an inefficiency in processing time.

Insidious and ancillary to decreases in media volume per piece is the fact that the media, which at hour zero was at the correct size and shape not to lodge in gear teeth, is probably now at the size and shape where this will occur. If you must provide FOD-free gears to your customer, you are now entering a danger zone.

FLUID RETENTION: SOLUTION GEYSERING

As attrition results in a smaller volume of media in the vibratory bowl, it also results in a tighter packing of the smaller media pieces against one another. Within the media mass, there are void spaces, pockets of air, between each piece of media. Large media does not pack tightly; the void spaces between each piece are large, and processing fluid drains efficiency from the void spaces and the machine. The tighter the media packs, the tinier the void space between each individual media piece. The smaller these pockets become, the more efficiently water surface tension can result in the retention of processing fluids in the bowl. If you have ever seen a vibratory bowl operating wherein geysers of foaming processing soap shoot into the air and fall around the machine leaving a dangerously slippery floor, this is because the media mass is too low and the media remaining is tightly packed, resulting in fluid retention. Geysering is the result of introducing more fluid into the vibratory bowl than you can drain from the machine.

MAINTAINING THE CORRECT MEDIA VOLUME

Media level in a vibratory bowl, as measured at the O.D. rim, should not be lower than a two-inch gap when properly loaded to prevent the above inefficiencies.

SUMMARY/CONCLUSIONS

While a literally small part of the isotropic superfinishing process, media, both the individual pieces and the collective mass, are important to ensuring effective and efficient gear surface finishing results. HDNA media has many advantages over traditional abrasive medias in terms of reducing the frequency of the above described issues (due to its greatly reduced attrition rate), but media volume must still be maintained if one is to obtain the many benefits of isotropic superfinishing.

ABOUT THE AUTHOR

William (Bill) P. Nebiolo received a B.A. from The University of Connecticut and an M.S. in environmental sciences from Long Island University. He has been with REM Surface Engineering since 1989 and currently serves as a sales engineer and as REM's product manager. Since 1978, Nebiolo has been an active member in the National Association for Surface Finishing (NASF) where he has represented the Connecticut chapter as an NASF national delegate and is the 2010, 2014, and 2015 recipient of the NASF National Award of Merit. From 1996 to 2000, he served as one of SME's Mass Finishing technical training program instructors. He has published and presented dozens of technical papers and is the author of the SME Mass Finishing Training Book. Nebiolo can be reached at bnebiolo@remchem.com.