THE STRENGTH OF THE SMOOTHNESS

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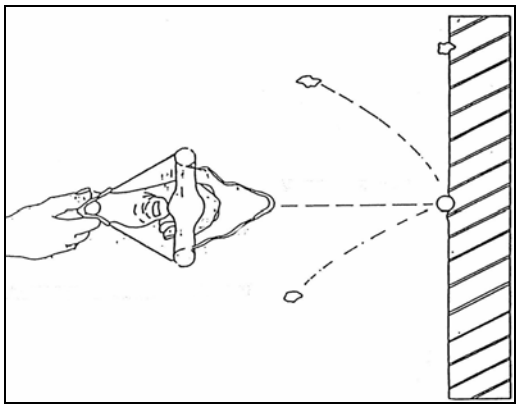
Introduction: This short article will aim to present two techniques used to enhance fatigue strength and fatigue life of components such as gears as well as other transmission components.

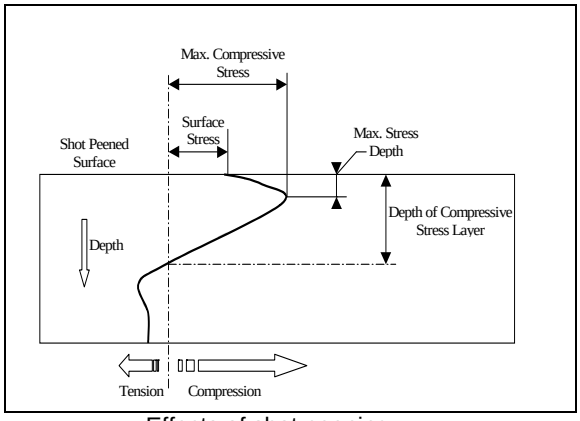
Shot Peening

Shot peening is a cold working process in which a stream of small spherical shots, propelled at high velocity and under fully controlled conditions, are bombarded onto a metallic component or target causing a thin layer of the exposed surface to deform plastically.



The shot peening principle

The immediate effect of bombarding high velocity shots onto a component (e.g. gear) is the creation of a thin layer of high magnitude compressive residual stress at or near the surface, which is balanced by a small tensile stress in the deeper core.



Effects of shot peening

The predictable magnitude of the compressive stress introduced is obviously a function of the material targeted, as well as the shot peening condition and can reach values as high as 50 to 60% of ultimate tensile strength of the material. Its depth is largely dependent on the peening intensity and the relative hardness of the impinging shot and the targeted component; practically, it can be from up to 200µm (hard materials, i.e. 700HV-60HRC) to 1000µm (soft materials, i.e. 300HV-31HRC).

The compressive residual stress introduced will benefit the treated component as it will reduce, and even negate any residual or subsequently imposed tensile stress at the surface. It is well known that most fatigue failures and stress corrosion normally initiate at or near the surface stressed in tension. Therefore, by reducing the net tensile stresses at and near the surface of components, fatigue crack initiation and stress corrosion can be delayed, improving the fatigue life of the processed parts. The fatigue strength of components such as carburised gears can be increased from 100 to 150%.

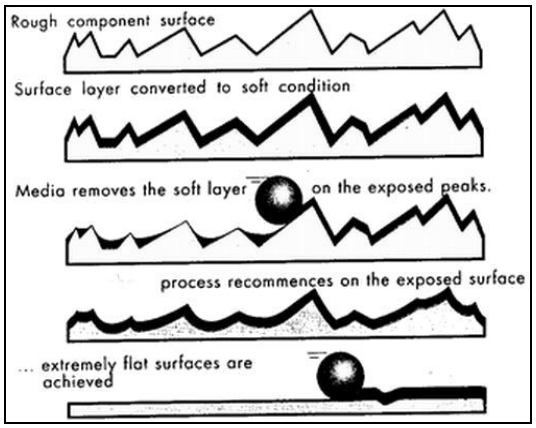
The benefits of shot peening are therefore vital for several industries (automotive, aerospace), which are constantly developing lighter components of which the strength and fatigue life will be expected to be high.

Shot peening, as a stand-alone process, provided it is fully controlled, can achieve very good results and greatly enhance the mechanical properties of the components treated. The use of a second technique, as a complementing process, aims at giving the component a surface finish of high quality as well as a great look: the superfinishing process, also called REM®.

Superfinishing: the REM® process

The technique of superfinishing, often assimilated to vibrofinishing, has been developed by REM® and is currently used by Impact Finishers to process critical transmission components. Indeed, Hewland Engineering Ltd., who supplies high quality transmission components (Lola), requested that components traditionally shot peened should also be superfinished afterwards. Since the benefits of shot peening are well known, it is important to describe the superfinishing process to understand why both processes are providing such enthusiasm.

The superfinishing process is a technique used to gently reduce the surface finish and produce a smooth and shiny surface.
The principle of the process is fairly simple. A vibratory bowl is filled with non-abrasive ceramic stones and combined with a chemical accelerator (REM® FML575 IFP). The ceramic beads, under the action of the machine, roll and turn, with the components moving inside. The chemical is added, at controlled concentration and flow rate. The combined actions of the beads and the chemical provides the high quality finished parts.



Principle of the superfinishing process

As described in the diagram above, the surface layer of the component is gently oxidised and the moving media removes the soft layer formed from the high points of the original rough surface. The chemical coating also prevents oxidation and removal of the recesses and grooves, leading the geometry of the treated component to maintain its original design. Since the media is constantly moving while the chemical is constantly added, a succession of soft layers will be wiped and more of the positive surface areas exposed will be removed, until the surface becomes extremely flat and smooth.

Since the chemical used interacts well with the carbon content of the treated parts, the process was primarily used on carbon and alloy steels, giving very good results on case carburised gears and other transmission components (see following photographs).


Components manufactured by Hewland Engineering; Shot Peened and REM® processed by Impact Finishers.

The same process can also be used on stainless steels, Titanium, Inconel and many Aerospace alloys as well.

From a technical point of view, the superfinishing process on its own will provide finished components with a low R_a finish, which can improve the fatigue life of the treated parts by as much as 30%. As a consequence, significant noise and vibration reductions as well as lower operating temperatures will lead to longer lasting and better performing components.

Last but not least, the REM® products used to carry out the process at the facility in Slough are completely user and environmental friendly.

Conclusion

The combination of the two surface finish processes described are key factors in enhancing and/or developing components subject to high loads or multiple cycles. The compressive stress introduced by the shot peening process allied to the smooth finish provided by the superfinishing lead to increased fatigue strength and fatigue life of the treated components.

Both techniques, fully controlled, will and already help fulfilling the high expectations of manufacturers involved in the car and aerospace industries, as well as many other where their requirements match what both techniques can provide together or independently.

An on going research project will also provide us with a complete evaluation of the improvements provided by both processes and would also help us optimising their use.

Acknowledgements

The superfinishing facility was set up in Slough by Impact Finishers in collaboration with Hewland Engineering, a leading gear manufacturer. The success of this operation led to a strong and open relationship. Their patience, confidence and help have been of great support for our team.

A special word

The creation of the REM® facility at Impact Finishers in Slough has been a tremendous and very rewarding experience for myself thanks to the support and confidence of the following people:

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