CREATING AN IN-HOUSE SHOT PEENING SPECIFICATION FOR GEARS

Part 2

(Part 1 may be found in the Winter 92/93 issue of The Shot Peener)

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Understanding less conventional shot peening methods helps manufacturers develop an in-house specification for gears. This article also relates specification to the part drawing.

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This last of a two-part series, which provides guidelines for developing an in-house shot peening specification for gearing, covers optional peening methods and considerations, and explains how to relate the in-house specification to the part drawing.

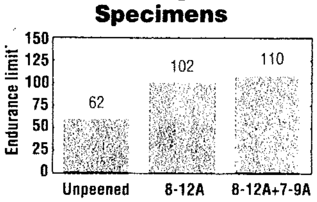
When creating a shot peening specification for any type of gearing, some additional, less conventional peening methods and considerations should be included. These optional methods and techniques follow:

• Strain peening or stress peening. This technique is applied when parts are stressed in one direction only and longer fatigue life is required. The part is shot peened in a stressed, or loaded, condition. Compressive stresses produced by the peening can be as high as the compressive yield stress of the material itself. This technique has been used a great deal in numerous industries.

• Dual intensity peening. This method can produce substantially longer fatigue life than can be obtained by conventional shot peening methods. Research on carburized steel indicates that dual peening, which is high intensity shot peening, followed by lower intensity shot peening with smaller shot, increases the magnitude of surface compressive residual stress.[1] Additional testing on other materials have confirmed this data.[2,3] See Figures 1 and 2.

• Plating and salvage. Shot peening prior to plating can be used when parts with machining discrepancies in production are salvaged or when plating is used for a wear or protective surface.

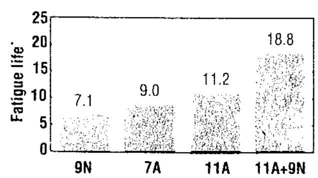
Figure 1
Dura Peening Rene 95 Specimens



*1,000ksi at 10 million cycles

Testing of Rene 95 specimens confirms that dual peening of carburized steel increases the magnitude of surface compressive residual stress.[1]

Figure 2
Dura Peening Titanium 6A1-4V

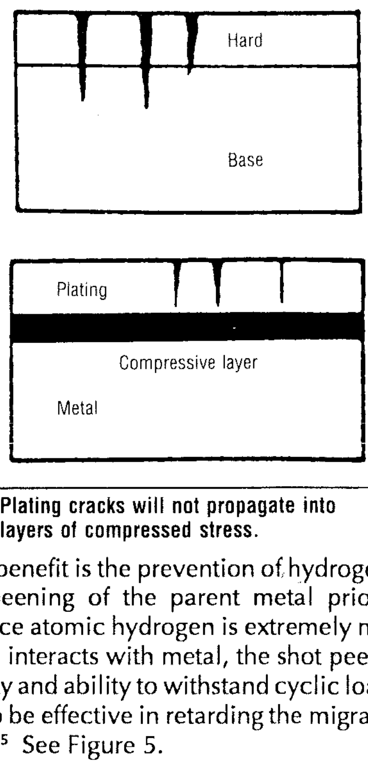


*Average fatigue life, million cycles

As with carburized steel, dual intensity peening of titanium provides longer fatigue life than does conventional shot peening.[2]

The shot peening prevents micro-cracks in the plating from propagating into the parent metal if the part is subjected to a cyclical load. Cracks will not propagate into layers of compressed stress as shown in the before-and-after diagrams in Figure 3. Significant increases in fatigue strength closely approximating original unpeened surfaces are shown in Figure 4. In some cases, shot peening prior to plating may be required by contractual agreements. Specifications such as Federal Specifications QQ-C-320 and MI1-C-26074A require shot peening on steel parts that are chrome or electroless nickel plated.

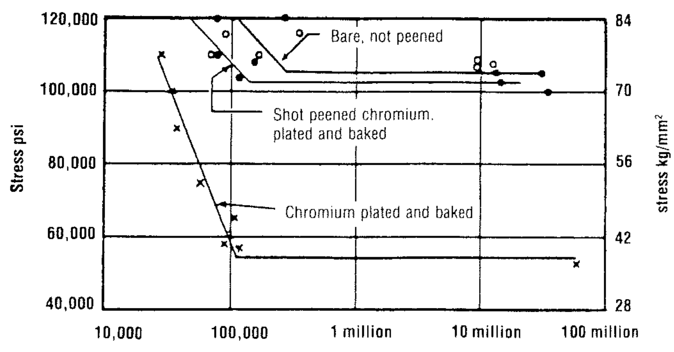
Figure 3
Before and After Shot Peening



Plating cracks will not propagate into layers of compressed stress.

An additional benefit is the prevention of hydrogen embrittlement by the shot peening of the parent metal prior to the plating operation. Since atomic hydrogen is extremely mobile and easily penetrates and interacts with metal, the shot peening reduces the metal's ductility and ability to withstand cyclic loads. Peening has been proven to be effective in retarding the migration of hydrogen through metal.[5] See Figure 5.

Figure 4
Peening Prior to Plating Increases Fatigue Strength



Cycles to failure of 4340 steel, 52-53RC rotating beam fatigue

Shot peening prior to plating significantly increases fatigue strength closely approximating original unpeened surfaces.[4]

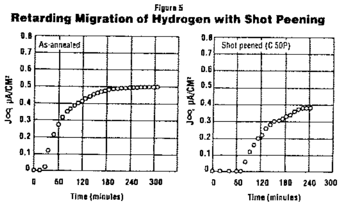
•Contour correction. Just as it is possible to create a desired curvature and shape to components by shot peening, it is possible to correct the shape and form of parts as well. The shot peening process avoids the unfavorable (tensile) residual stresses produced by other straightening methods and instead produces favorable (compressive) residual stresses.

•Increased wear due to work hardening. If a material's ability to readily work-harden is a major consideration for a company, then it should be addressed in the specification. For materials that cannot be heat treated but require wear resistance, shot peening should be considered.

•Porosity. When porosity is a concern, it should be reviewed as a specification option. Typically, shot peening is not utilized for the compressed stress benefits, but rather to compact the surface[7] or reveal some subsurface porosity prior to machining. Therefore, it can be used as an inspection tool before machining of questionable castings.

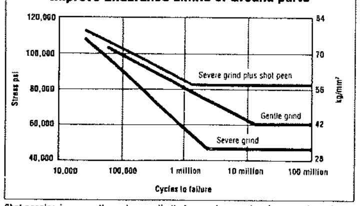
•Salvage/grinding before and after shot peening. When severe grinding has developed a resultant residual tensile stress and surface brittleness, consider shot peening the surface after grinding. Figure 6 shows S-N curves for a part originally designed for an endurance limit with a gentle grind, the resultant lowered endurance limit after grinding, and the improved endurance limit of the severely ground surface followed by shot peening.

Figure 5
Retarding Migration of Hydrogen with Shot Peening



Peening can retard the migration of hydrogen through metal, as shown in the diagram non-treated and shot peened surfaces.[5]

Figure 6
Improve Endurance Limits of Ground parts



Shot peening improves the endurance limit of severely ground surface, as shown in this diagram of reversed bending fatigue of RC 45 flat bars.[1]

Another technique that can be used especially on particularly difficult grinding operations or materials is to shot peen prior to grinding to prevent grinding cracks. Grinding of carburized gears can produce high residual tensile stresses, which can initiate cracks in the tooth surface. Shot peening prior to grinding greatly reduces this tendency. Used here, peening can prevent crack propagation from the grinding but is not intended to increase bending fatigue strength.

•Stress corrosion cracking. In particularly hostile environments in which a material may be affected adversely by general corrosion coupled with residual or applied tensile stresses, shot peening may be a consideration. Peening changes the surface residual tensile stresses to compressive stresses, which eliminates the conditions that promote stress corrosion cracking.

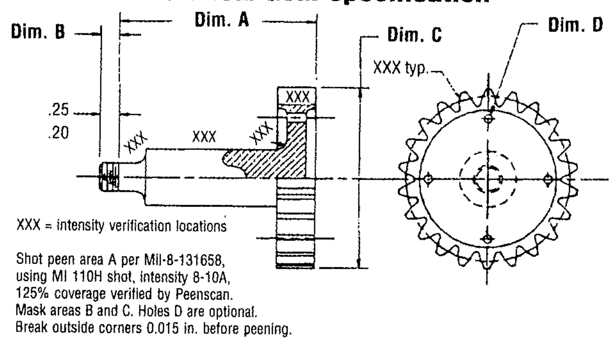
Specifications on Part Drawings

Once a satisfactory in-house specification has been established that addresses the particular needs of a company, it is still necessary to translate the information to particular gears. The general specification should assist the design professional regarding the necessary steps to properly select an optimum drawing specification. The information then must be transferred to the manufacturing drawing. Now you have arrived at specifying shot peening.

In specifying shot peening requirements on part drawings, the following parameters should be identified:

- areas to be shot peened
- areas to be masked
- optional areas
- areas where shot peening fades out (if necessary)
- shot size, hardness and material
- locations for intensity verification and intensity range
- coverage requirements for all areas to be peened, including the method used for coverage determination
- applicable shot peening specification

Figure 7
Theoretical Gear Specification



This part drawing of a gear provides a theoretical example of a suggested specification.

Figure 7 provides a theoretical example of a gear with a suggested specification. Using the points listed above, the analysis of this specification is as follows:

•Areas to be shot peened. These are noted by DIM **A**, and further critical areas are identified by **XXX**. There are five primary areas requiring the proper intensity: at the tooth root fillet, the gear pitch line, two shaft fillet transition areas and the main shaft body.

The shot selection indicates, because only one peening operation is to be performed, that the apparent geometric limiting factor of the shot is the fillet radii of the gear teeth. Most likely, the main shaft is being peened because the shaft also may experience problems with fatigue. It is possible that some machining may occur on the shaft body after shot peening, so rather than mask this area, peening is being allowed. The gear pitch line area is noted because pitting of the gear tooth may occur.

•Areas to be masked. These are noted by DIM **B** and DIM **C**. Most likely the O.D. of the gear has limitations on the potential of burring at the top land. This is costly and should be avoided unless other alternate ways are not available. A potential alternate solution may be to break or radius all sharp edges in the areas to be peened prior to peening. This can minimize or eliminate the potential to burr. The threads at the shaft end do not require peening and must be masked because peening could damage them.

•Optional areas. Noted by DIM **D**. These are the holes in the gear body.
•Areas where shot peening fades out. This is not applicable here.

• Shot size, hardness and material. MI 110 shot, intensity 6-10A. The MI 110 designation defines a cast steel shot.

• Location for intensity verification and intensity range at each location. Only one intensity is specified. It is marked by **XXX**. If other intensities or shot sizes are to be used, additional callouts and symbols are necessary.

• Coverage requirements for all areas to be peened, including the method used for coverage determination; 125 percent coverage, verified by Peenscan.

• Applicable shot peening specification; MIL-S-13165B.

The above sample drawing specification clearly denotes the proper shot peening requirement, which should be easily accomplished by the manufacturing group or vendor. The drawing specification should readily coincide with the company in-house peening specification. However, the above sample specification most likely will not work on parts similar to the gear for which it was developed. It is best that each gear requiring shot peening first be evaluated based on the general in-house specification prior to placing shot peening callouts on a manufacturing drawing.

Confusion and some misunderstanding in properly specifying shot peening can cause difficulties in the manufacturing process. Concise in-house specifications covering considerations, coupled with accurate manufacturing drawing callouts can make the most of shot peening.

With the in-house specification addressing the particular needs of the manufacturing company's gearing requirements and the correct specification on the manufacturing drawing conveying this to the vendor, shot peening can be used to its fullest advantage.

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