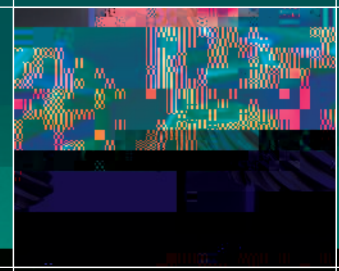

SHOT PEENING APPLICATIONS

METAL IMPROVEMENT COMPANY

A Subsidiary of Curtiss-Wright Corporation

NINTH EDITION

TABLE OF CONTENT

NOTE

etal Improvement Company (MIC) is a world leader in providing specialized metal treatment services that enhance the performance and extend the life of components operating in a wide range of applications. Our services are an integral part of the manufacturing process for producing

THE SHOT PEENING PROCESS

Shot peening is a cold working process in which the surface of a part is bombarded with small spherical media called shot. Each piece of shot striking the metal acts as a tiny peening hammer imparting a small indentation or dimple on the surface. In order for the dimple to be created, the surface layer of the metal must yield in tension (F

Shot peening is primarily used to combat metal fatigue. The following points pertain to metal fatigue and its application to the Typical Stress versus Load Cycles graph shown in **Figure 1-4**.

- Fatigue loading consists of tens of

SUMMATION OF APPLIED AND RESIDUAL STRESS

When a component is shot peened and subjected to an applied load, the surface of the component experiences the net stress from the applied load and shot peening residual stress. Figure 1-6 depicts a bar with a three-point load that creates a bending stress at the surface.

The diagonal dashed line is the tensile stress created from the bending load. The curved dashed line is the (residual) compressive stress from shot peening. The solid line is the summation of the two showing a significant reduction of tensile stress at the surface.

Shot peening is highly advantageous for the following two conditions:

- Stress risers
- High strength materials

Stress risers may consist of radii, notches, cross holes, grooves, keyways, etc. Shot peening induces a high magnitude, localized compressive stress to offset the stress concentration factor created from these geometric changes.

Shot peening is ideal for high strength materials. Compressive stress is directly correlated to a material'o ikent54 17e,actor cro

DEPTH OF RESIDUAL STRESS

The depth of the compressive layer is influenced by variations in peening parameters and material hardness [Ref 1.2]. **Figure 1-7** shows the relationship between the depth of the compressive layer and the shot peening intensity for five materials: steel 30 HRC, steel 50 HRC, steel 60 HRC, 2024 aluminum and titanium 6Al-4V. Depths for materials with other hardness values can be interpolated.

SHOT PEENING MEDIA

Media used for shot peening (also see Chapter 11) consists of small spheres of cast steel, conditioned cut wire (both carbon and stainless steel), ceramic or glass materials. Most often cast or wrought carbon steel is employed. Stainless steel media is used in applications where iron contamination on the part surface is of concern.

Carbon steel cut wire, conditioned into near round shapes, is being specified more frequently due to its uniform, wrought consistency and great durability. It is available in various grades of hardness and in much tighter size ranges than cast steel shot.

Glass beads are also used where iron contamination is of concern. They are generally smaller and lighter than other media and can be used to peen into sharp radii of threads and delicate parts where very low intensities are required.

EFFECT OF SHOT HARDNESS

It has been found that the hardness of the shot will

Shot peening has proven to be effective in restoring most of the fatigue strength lost due to decarburization [Ref 2.7]. Because the decarburized layer is not easily detectable on quantities of parts, peening can insure the integrity of the parts if decarburization is suspected. If a gear that is intended to have a high surface hardness (58+ HRC) exhibits unusually heavy dimpling after peening, decarburization should be suspected.

Decarburization is often accompanied with the undesirable metallurgical condition of retained austenite. By cold working the surface, shot peening reduces the percentage of retained austenite.

APPLICATION CASE STUDY

[illegible]

Depth (inches)	Depth (mm)	Retained Austenite Volume (%) Unpeened	Retained Austenite Volume (%) Peened
0.0000	0.00	5	3
0.0004	0.01	7	4
0.0008	0.02	14	5
0.0012	0.03	13	6
0.0016	0.04	14	7
0.0020	0.05	14	7
0.0024	0.06	15	8
0.0028	0.07	15	9
0.0039	0.10	15	10
0.0055	0.14	12	10

[illegible]

AUSTEMPERED DUCTILE IRON

Improvements in austempered ductile iron (ADI) have allowed it to replace steel forgings, castings, and weldments in some engineering applications. ADI has a high strength-to-weight ratio and the benefit of excellent wear capabilities. ADI has also replaced aluminum in certain high strength applications as it is at least 3 times stronger and only 2.5 times more dense. With the addition of shot peening, the allowable bending fatigue strength of ADI can be increased up to 75%. This makes certain grades of ADI with shot peening comparable to case-carburized steels for gearing applications [Ref 2.9].

CAST IRON

There has been an increased demand in recent years for nodular cast iron components that are capable of withstanding relatively high fatigue loading. Cast iron components are often used without machining in applications where the cast surface is subject to load stresses. The presence of imperfections at casting surfaces in the form of pinholes, dross or flake graphite can considerably reduce the fatigue properties of unmachined pearlitic nodular irons. The unnotched fatigue limit may be reduced by as much as 40%, depending on the severity of the imperfections at the casting surface.

Shot peening can significantly improve properties when small cast-surface imperfections are present. One application is diesel engine cylinder liners. At the highest shot peening intensity used in the tests, the fatigue limit was 6% below that of fully machined fatigue specimens. This compares to a reduction of 20% for specimens in the as-cast unpeened condition. Visually, the peening on the as-cast surface has a polishing effect leaving the appearance of smoothing the rougher as-cast surface [Ref 2.10].

ALUMINUM ALLOYS

Traditional high strength aluminum alloys (series 2000 and 7000) have been used for decades in the aircraft industry because of their high strength-to-weight ratio. The following aluminum alloys have emerged with increasing use in critical aircraft/aerospace applications and respond equally well to shot peening:

- Aluminum Lithium Alloys (Al-Li)
- Isotropic Metal Matrix Composites (MMC)
- Cast Aluminum (Al-Si)

RESPONSE OF METALS

TITANIUM

. . . C, ι F ι, , ι . CF, - HCF of titanium is illustrated by Figure 2-4,BT/F1 1 Tf0 24 -24 0 47.299Mich compaS2 gses theBT/F-91.0739 d by

C. A TE T. O

RESPONSE OF METALS

MANUFACTURING NG NG NG N

If the weld is shot peened (rather than stress relieved) there is a significant reversal of residual stress from tensile to compressive. This will offer significant resistance to fatigue crack initiation and propagation.

Figure 3-1 shows the optimal manufacturing sequence for welding is to stress relieve and then shot peen. The stress relieving process softens the weld such that inducing a deeper layer of compressive stress becomes possible.

The American Welding Society (AWS) Handbook cautions readers to consider residual tensile stresses from welding if the fabrication is subject to fatigue loading as described in the following statement: "Localized stresses within a structure may result entirely from external loading, or there may be a combination of applied and residual stresses. Residual stresses are not cyclic, but they may augment or detract from applied stresses depending on their respective sign. For this reason, it may be advantageous to induce compressive residual stress in critical areas of the weldment where cyclic applied stresses are expected".

The use of the shot peening process to improve resistance to fatigue as well as stress corrosion cracking in welded components is recognized by such organizations as:

- American Society of Mechanical Engineers [Ref. 3.4]
- American Bureau of Shipping [Ref. 3.5]
- American Petroleum Institute [Ref. 3.6]
- National Association of Corrosion Engineers [Ref. 3.7]

ANODIZING

Hard anodizing is another application in which shot peening improves fatigue resistance of coated materials. Benefits are similar to those for plating providing the peening is performed to the base material before anodizing.

APPLICATION CASE STUDY

AN , , AL N , NGS

Aluminum (AlZnMgCu 0.5) rings with external teeth were tested for comparison purposes with anodizing and shot peening. The rings had an outside diameter of ~ 24" (612 mm) and a tensile

PLASMA SPRAY

Plasma spray coatings are primarily used in applications that require excellent wear resistance. Shot peening has proven effective as a base material preparation prior to plasma spray applications that are used in cyclic fatigue applications. Shot peening has also been used after the plasma spray application to improve surface finish and close surface porosity.

ELECTRO-DISCHARGE MACHINING (EDM)

EDM is essentially a "force-free" spark erosion process. The heat generated to discharge molten metal results in a solidified recast layer on the base material. This layer can be brittle and exhibit tensile stresses similar to those generated during the welding process. Shot peening is beneficial in restoring the fatigue debits created by this process. In **Figure 3-5** the effect of shot peening on electro-chemical machined (ECM), electro-discharge machined (EDM) and electro-polished (ELP) surfaces is shown [Ref 3.12]. **Figure 3-5** should be viewed in a clockwise format. ECM, EDM and ELP fatigue strengths are compared with and without shot peening.

ELECTRO-CHEMICAL MACHINING (ECM)

Electro-chemical machining is the controlled dissolution of material by contact with a strong chemical reagent in the presence of an electric current. A reduction in fatigue properties is attributed to surface softening (the rebinder effect) and surface imperfections left by preferential attack on grain boundaries. A shot peening post treatment more than restores fatigue properties as shown in **Figure 3-5** [Ref 3.12].

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BENDING FATIGUE

The optimal way to induce resistance to pitting fatigue near the gear tooth pitch line is to induce a compressive stress followed by a lapping, honing or isotropic finishing process. Care must be taken to not remove more than 10% of the shot peening layer. Processes that refine the surface finish of shot peening dimples allow the contact load to be distributed over a larger surface area reducing contact stresses.

Metal Improvement Company (MIC) offers a shot peening and superfinishing process called C.A.S.E.[SM] that has increased pitting fatigue resistance of gears by 500%. Please see Chapter 10 for additional information and photomicrographs on this process.

Increases in fatigue strength of 30% or more at 1,000,000 cycles are common in certain gearing applications. The following organizations/specifications allow for increases in tooth bending loads when controlled shot peening is implemented:

- Lloyds Register of Shipping: 20% increase [Ref 4.2]
-

CRANKSHAFTS

In most cases, all radii on a crankshaft are shot peened. These include the main bearing journals and crankpin radii as shown in Figure 4-6. The most highly stressed area of a crankshaft is the crank pin bearing fillet. The maximum stress area is the bottom side of the pin fillet when the engine fires as the pin is in the top dead center position (Figure 4-6). It is common for fatigue cracks to initiate in this pin fillet and propagate through the web of the crankshaft to the adjacent main bearing fillet causing catastrophic failure.

Experience has shown shot peening to be effective on forged steel, cast steel, nodular iron, and austempered ductile iron crankshafts. Fatigue strength increases of 10 to 30% are allowed by Norway's Det Norske Veritas providing fillets are shot peened under controlled conditions [Ref 4.5].

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TORSIONAL FATIGUE

Torsional fatigue is a failure mode that responds well to shot peening because the greatest (tensile) stress occurs at the surface. Torsional loading creates stresses in both the longitudinal and perpendicular directions such that the maximum tensile stress is 45° to longitudinal axis of the component. Figure 5-1 depicts a solid bar loaded in pure torsion with a crack depicting reversed torsional loading.

Lower strength materials tend to fail from torsional fatigue in the shear plane perpendicular to the longitudinal axis. This is because they are weaker in shear than in tension. Higher strength materials tend to fail at 45° to the longitudinal axis because they are weaker in tension than in shear.

COMPRESSION SPRINGS

Compr

It is quite common to perform a baking operation after shot peening of springs. The baking operation is used as a stabilizing process in the manufacture of springs and is used to offset a potential setting problem that may occur with some shot peened spring designs. The baking is approximately 400 °F (205 °C) for 30 minutes for carbon steel springs and is below the stress relief temperature of the wire. Temperatures above 450 °F (230 °C) will begin to relieve the beneficial residual stress from shot peening.

Other spring designs respond equally well to shot peening. The fatigue failure will occur at the location of the highest combination of residual and applied tensile stress. Torsion springs will generally fail at the OD near the tangent of the tang. Extension springs will generally fail at the inner radius of the hook. Other potential spring designs that can benefit from shot peening are leaf springs, cantilever springs, flat springs, etc.

DRIVE SHAFTS

Shaft applications are used to transmit power from one location to another through the use of rotation. This creates a torsional load on the rotating member. Because most drive shafts are primary load bearing members, they make excellent shot peening applications. As shown in

CONTACT FAILURE

Pitting failures initiate due to Hertzian and sliding contact stresses near the pitch line. When asperities from mating surfaces make contact, the loading is a complex combination of Herzian and tensile stresses. With continued operation, a micro-crack may initiate. Crack growth will continue until the asperity separates itself leaving a "pit".

A condition of mixed lubrication is very susceptible to pitting failure. This occurs when the lubricant film is not quite thick enough to separate the surfaces and actual contact occurs between the asperities. Figure 7-3 shows a gear flank and the mechanisms that cause pitting [Ref 7.2].

Shot peening has been proven to be highly beneficial in combating pitting fatigue when followed by a surface finish improvement process. By removing the asperities left from shot peening, the contact area is distributed over a larger surface area. It is important when finishing the shot peened surface to not remove more than 10% of the compressive layer. Please see Chapter 10 for photomicrographs of a shot peened and isotropically finished surface using the C.A.S.E.SM process.

GALLING

Galling is an advanced form of adhesive wear that can occur on materials in/F2 1 Tf9.5 0 0Ref e8T thaE0 0GALLING

CORROSION FAILURE

Tensile related corrosion failures can be derived from either static or cyclic tensile stresses. In both types of failures, environmental influences contribute to failure. Environments such as salt water and sour gas wells create metallurgical challenges. In most cases, these environments become more aggressive with increasing temperature.

STRESS CORROSION CRACKING

Stress corrosion cracking (SCC) failure is most often associated with static tensile stress. The static stress can be from applied stress (such as a bolted flange) or residual stress from manufacturing processes (such as welding). For SCC to occur three factors must be present:

- Tensile stress
- Susceptible material
- Corrosive environment

Figure 8-1 shows the stress corrosion triangle in which each leg must be present for SCC to occur.

The compressive layer from shot peening removes the tensile stress leg of the SCC triangle. Without tensile stress, SCC failure is significantly retarded or prevented from ever occurring. The following is a partial list of

APPLICATION CASE STUDY

A CA N C CAL AN L NG N

Shot peening has been utilized as a cost savings measure for construction of chemical handling equipment. In cases where ammonia or chloride based solutions were to be contained, a lower cost SCC susceptible material was selected with shot peening rather than a more expensive non-susceptible material. Even with the additional shot peening operation, construction costs were less than using the more expensive alloy.

The following table demonstrates the effectiveness of shot peening in combating stress corrosion cracking for the following stainless steel alloys. A load stress equivalent to 70% of the materials yield strength was applied [Ref 8.2].

ater al	eene ye no	e t L fe o r
316 SS	no	11.3
316 SS	yes	1000 N.F.
318 SS	no	3.3
318 SS	yes	1000 N.F.
321 SS	no	5.0
321 SS	yes	1000 N.F.

N No a l re

CORROSION FATIGUE

Corrosion fatigue is failure of components in corrosive environments associated with cyclic loading. Fatigue strength can be reduced by 50% or more when susceptible alloys are used in corrosive environments.

APPLICATION CASE STUDY

S L S SS C AC NG

Hydrogen sulfide (H_2S) is commonly encountered in sour gas wells. Certain metal alloys when exposed to H_2S will experience a significant decrease in fatigue strength. The following test results illustrate the response of precipitation hardened 17-4 stainless steel exposed to H_2S with and without shot peening [Ref 8.3].

of el Strengt	A ac ne to fa l	A ac ne an ot eene r to fa l
30	29.8	720 N.F.
40	37.9	561
50	15.4	538
60	15.2	219

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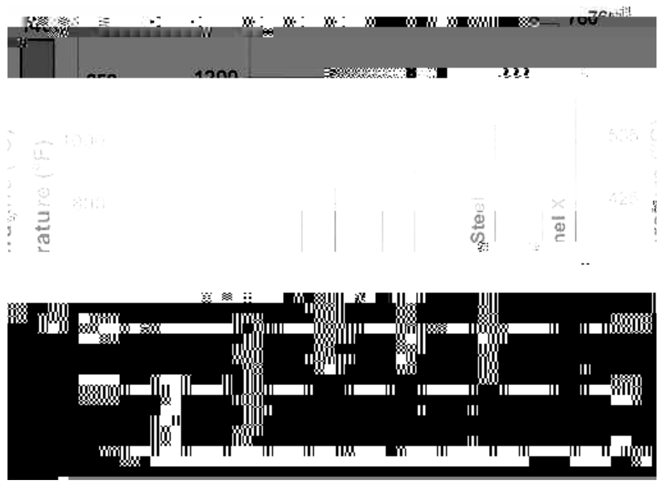

THERMAL FATIGUE

Thermal fatigue refers to metal failures brought on by uneven heating and cooling during cyclic thermal loading. Rapid heating and cooling of metal induces large thermal gradients throughout the cross section, resulting in uneven expansion and contraction. Enough stress can be generated to yield the metal when one location attempts to expand and is resisted by a thicker, cooler section of the part.

CHAPTER TEN

OTHER APPLICATIONS

PEENTEX[SM]

Controlled shot peening also can be used to deliver a number of different, aesthetically pleasing surface finishes. MIC stocks a great variety of media types and sizes. These media range from fine glass to large steel (and stainless steel) balls. Using a carefully controlled process, MIC is able to provide architectural finishes that are consistent, repeatable and more resistant to mechanical damage through work hardening.

Shot peening finishes have been used to texture statues, handrails, gateway entrances, building facades, decorative ironwork and numerous other applications for visual appeal. When selecting a decorative finish, MIC recommends sampling several finishes for visual comparison. Figure 10-5 is a hand rail utilizing a chosen Peentex[sm] finish (left side of Figure 10-5) to dull the glare from the untextured finish (right side).

Figure 10-5 efore r g t an After left Co ar on of eente

A textured surface is able to hide surface scratches and flaws that would otherwise be highly visible in a machined or ground surface. It is common to texture molds used for making plastics to hide surface defects. The texture on the mold surface will become a mirror image on the plastic part's surface.

ENGINEERED SURFACES

Engineered surfaces are those that are textured to enhance surface performance. The following are potential surface applications achieved through shot peening:

- In most cases, a textured surface has a lower coefficient of (sliding) friction than a non-textured surface. This is because the surface contact area is reduced to the "peaks" of the shot peening dimples.
- In some applications, the "valleys" of the peening dimples offer lubricant retention that are not present in a smooth surface.
- In some instances, a non-directional textured surface is desired over a uni-directional machined/ground surface. This has proven effective in certain sealing applications.
- In certain mold applications, a textured surface has less vacuum effect resulting in desirable "release" properties.

EXFOLIATION CORROSION

A large number of commercial aircraft are over 20 years old. Ultimately, the safety of older aircraft depends on the quality of the maintenance performed. An aged Boeing 737 explosively depressurized at 24,000 feet (7300 m) when 18 feet (6 m) of the fuselage skin ripped away. The cause of the failure was corrosion and metal fatigue [Ref 10.3].

MIC has developed a process called Search Peening[sm] to locate surface and slightly sub-surface corrosion. Exfoliation corrosion is a form of intergranular corrosion that occurs along aluminum grain boundaries. It is characterized by delamination of thin layers of aluminum with corrosion products between the layers. It is commonly found adjacent to fasteners due to galvanic action between dissimilar metals.

In exfoliation corrosion, the surface bulges outward as shown in **Figure 10-8**. In severe cases, the corrosion is subsurface.

Once corrosion is present repairmen can manually remove it with sanding or other means. Shot peening is then applied to compensate for lost fatigue strength as a result of material removal. Additional sub surface corrosion will appear as "blisters" exposed from the shot peening process. If additional corrosion is found, it is then removed and the Search Peening[sm] process repeated until no more "blistering" occurs.

MIC is capable of performing the Search Peening[sm] on site at aircraft repair hangers. Critical areas of the aircraft are masked off by experienced shot peening technicians before beginning the process.

POROSITY SEALING

Surface porosity has long been a problem that has plagued the casting and powder metal industries. Irregularities in the material consistency at the surface may be improved by impacting the surface with shot peening media. By increasing the intensity (impact energy), peening can also be used to identify large, near-surface voids and delaminations.

INTERNAL SURFACES AND BORES

When the depth of an internal bore is greater than the diameter of the hole it cannot be effectively shot peened by an external method. An internal shot peening lance or internal shot deflector (ISD) method must be used under closely controlled conditions **(Figure 10-9)**. Holes as small as 0.096 inch (2.4 mm) in jet engine disks have been peened on a production basis using the I

MIC developed an intensity verification technique for small holes. Figure 10-10 shows the results of a study to a jet engine disk comparing the residual stress on the external surface (peened with conventional nozzles) to that on internal surfaces of a small bore peened with internal shot deflector methods. Using the same shot size and intensity, the two residual stress profiles from these controlled processes were essentially the same [Ref 10-4].

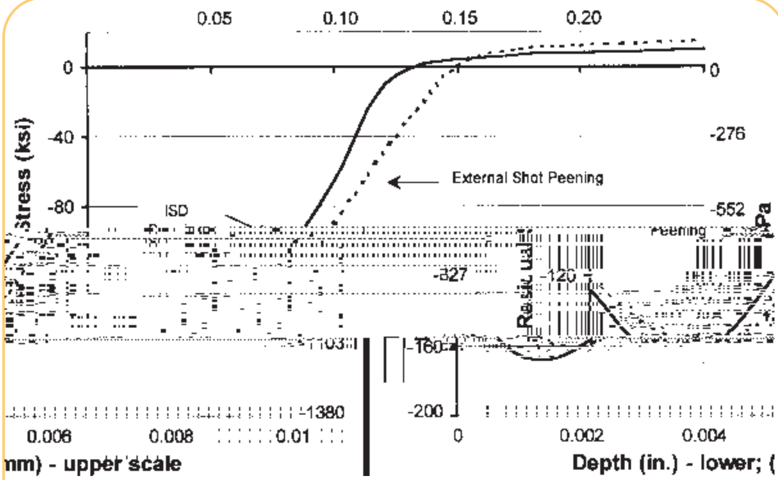

Figure 10-10 nternal S rface, eflector ternal S ot een ng

DUAL (INTENSITY) PEENING

Dual peening (or Dura Peen[sm]) is used to further enhance the fatigue performance from a single shot peen operation. Fatigue life improvements from shot peening typically exceed 300%, 500%, or more. When dual peened, (single) shot peen results can often be doubled, tripled or even more.

The purpose of dual peening is to improve the compressive stress at the outermost surface layer. This is where fatigue crack initiation begins. By further compressing the surface layer, additional fatigue crack resistance is imparted to the surface. Figure 10-11 shows approximately 30 ksi of additional compression at the surface when performing dual peening for a chrome silicon spring wire [Ref 10.5].

Dual peening is usually performed by shot peening the same surface a second time with a smaller media at a reduced intensity. The second peening operation is able to hammer down the asperities from the first peening resulting in an improved surface finish. The effect of driving the asperities into the surface results in additional compressive stress at the surface. Figures 10-12 and 10-13 show the surface finishes from the single and dual peen at 30x magnification recorded in the graph shown in Figure 10-11 [Ref 10.5].

THE C.A.S.E.^{SM} PROCESS

The C.A.S.E.^{sm} process consists of shot peening followed by isotropic finishing. The isotropic finishing removes the asperities left from shot peening via vibratory polishing techniques while maintaining the integrity of the residual compressive layer. The process is performed in a specially formulated chemical solution to reduce processing time making it feasible for high production components.

C.A.S.E.^{sm} was designed for surfaces that require both excellent fatigue strength and surface finish due to contact loading. C.A.S.E.^{sm} h

CONTROLLING THE PROCESS

CON

EEN CAN C – Determination of shot peening coverage can be fairly easy when softer materials have been peened because the dimples are quite visible. A 10-power (10x) magnifying glass is more than adequate for these conditions. In many applications determination of coverage is more difficult. Internal bores, tight radii, extremely hard materials and large surface areas present additional challenges in determining coverage.

MIC has developed the PEENSCAN® process using DYESCAN® fluorescent tracer dyes for this reason. PEENSCAN

MIC has developed CMSP equipment that has the capability to monitor, control and document the following parameters of the peening process:

- Air pressure and shot flow (energy) at each nozzle
- Wheel speed and shot flow (energy) of each wheel
- Part rotation and/or translation
- Nozzle reciprocation
- Cycle time

These parameters are continuously monitored and compared to acceptable limits programmed into the computer. If an unacceptable deviation is found, the machine will automatically shut down within one second and report the nature and extent of deviation. The machine will not restart processing until machine parameters have been corrected.

A printout is available upon completion of the CMSP. Any process interruptions are noted on the printout. The process is maintained in MIC quality records and is available for review. **Figure 11-10a** is a CMSP machine used for peening internal bores of aerospace components. **Figure 11-10b** is a multi-nozzle CMSP machine. Both figures show the central processing unit on the side of the machine.

Figure 11-10a *Co ter on tore Lance S ot een ng ac ne for roce ng nternal ore*

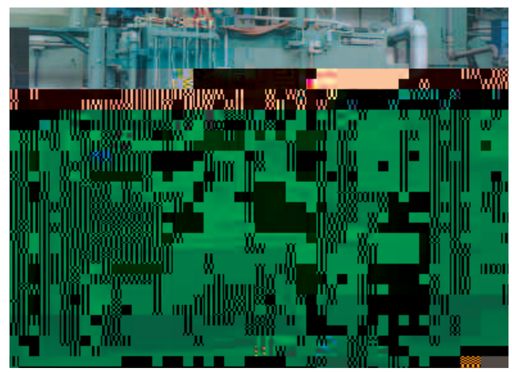

Figure 11-10b *lt No le Co ter on tore S ot een ng ac ne*

APPLICATION CASE STUDY

C S NC AS S N NG N S C L

CMSP registered significant interest when the FAA allowed a rating increase on a turbine engine from 700 to 1,500 cycles between overhauls. This increase made it possible for the engine, which was designed for military use, to enter the commercial market.

There was minimal space for design modifications so the engine manufacturer chose to use shot peening to improve life limited turbine disks and cooling plates. CMSP ensured that the peening parameters of the critical components were documented and repeated precisely [Ref 11.1].

SPECIFYING SHOT PEENING

Figure 11-11 shows a splined shaft (shaded) installed with two bearings supporting the shaft inside an assembly. The outboard spline and adjacent radius would be likely fatigue failure locations from bending and/or torsional fatigue. In this case, engineering would specify shot peening (of the shaft) on the drawing as follows:

- Area "A": Shot peen
- Area "B": Overspray allowed
- Area "C": Masking required

The details on the print should read:

- Shot peen splined areas and adjacent radius using MI-110H shot; 0.006"-0.009" A intensity.
- Minimum 100% coverage in splined areas to be verified by PEENSCAN®.
- Overspray acceptable on adjacent larger diameter.
- Mask both bearing surfaces and center shaft area.
-

PEENSTRESS℠ – RESIDUAL STRESS MODELING

When engineering a proper callout for shot peening, Metal Improvement Company (MIC) considers many

The primary benefit of laser peening is a very deep compressive layer with minimal cold working, which increases the component's resistance to failure mechanisms such as fatigue, fretting fatigue and stress corrosion. Compressive stress layer depths of up to 0.040 inches (1.0 mm) on carburized steels and 0.100 inches (2.54 mm) on aluminum and titanium alloys have been achieved. A secondary benefit is that thermal relaxation of the residual stresses of a laser peened surface is less than a shot peened surface due to the reduced cold work that is involved with the process. (Ref 12.1).

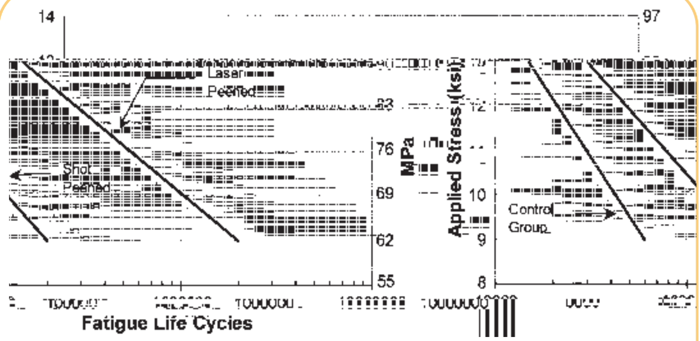

Figure 12-3 La er een ng of Al ~

The benefits of an exceptionally deep residual compressive layer are shown in Figure 12-3. The S-N curve shows fatigue test results of a 6061-T6 aluminum. The testing consisted of unpeened, mechanically shot peened and laser peened specimens (Ref 12.2).

MIC currently operates laser peening facilities in the United States and United Kingdom, and offers a mobile laser peening system in order to bring this unique technology directly to customers on site.

COATING SERVICES

Our E/M Coating Services Division has over 40 years of experience in applying critical tolerance coatings and is a pioneer in the development and application of solid film lubricant (SFL) coatings. These coatings are effective in a broad range of applications, whenever conventional wet lubricants provide insufficient protection due to high temperatures, extreme loads, corrosion, wear, chemical corrosion and other adverse operating conditions.

E/M Coating Services can assist you in selecting the right coating to meet your design challenge, lower the cost of ownership or enhance the performance and longevity of your products. Selection of the proper coating can facilitate the use of less expensive metals, improve part wear life and reduce maintenance costs.

Among the different categories of coatings E/M Coating Services applies are:

- Solid Film Lubricants – that protect against adverse operating conditions such as high temperatures, extreme loads, corrosion, wear, galling, seizing, friction, abrasion and chemical corrosion.
- Impingement Coatings – that provide an ultra thin, firmly adherent solid film lubricant.
- Conformal Coatings – for sealing more delicate objects — such as medical devices, satellite components and circuit assemblies — that operate in hostile environments.
- Shielding Coatings – that protect electronic devices from Electro-Magnetic Interference (EMI), Radio Frequency Interference (RFI) and Electro-Static Discharge (ESD).

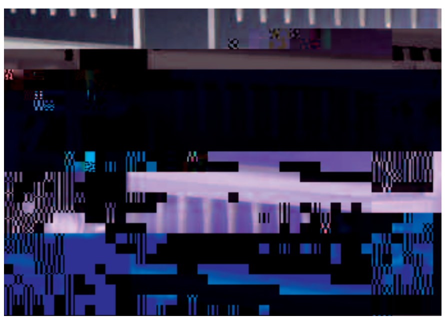

Figure 12-4 Coat ng Ser ce

E/M Coating Services applies all coatings using controlled processes to achieve the highest levels of quality and consistency. Coating engineers and technical service personnel also can help customers determine the right coating process for their application.

HEAT TREATING

Thermal processing relieves stresses within fabricated metal parts and improves their overall strength, ductility and hardness.

MIC specializes in the thermal processing of metal components used in a wide range of industries. Among the numerous thermal processes available through our network of facilities are vacuum heat treating, induction hardening, isothermal annealing and atmosphere normalizing.

MIC's heat treating facilities are located in the Midwest and Eastern U.S. and have capabilities and quality approvals specific to their local customer base. We have the expertise and equipment to handle demanding project requirements and materials that include, but are not limited to:

- Aluminum
- Titanium
- Carbon steels
- Alloy steels
- Cast irons
- Tool steels
- Corrosion resistant steels

Each of our facilities uses programmable controllers that set temperatures and cycle times and monitor the heat treating process to assure a homogenous correctly treated product. Our attention to detail includes an on-going engineering review of the process that assures you the most economical

Common Conversions Associated with Shot Peening

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TECHNICAL ARTICLE REPRINTS

Metal Improvement Company has on file a large collection of technical resources pertaining to metal fatigue, corrosion and shot peening. Many of the reprints that are available are listed below. Please contact your local service center or visit our website www.metalimprovement.com for other specific information on shot peening and our other metal treatment services.

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23. “Effect of Shot Peening Parameters on Fatigue Influencing Factors”; A. Niku-Lari, IITT, France.

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52. “Stress Corrosion Cracking: Prevention and Cure”; Impact - Review of Shot Peening Technology, Metal Improvement Company, 1989.

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54. “The Use of Shot Peening to Delay Stress Corrosion Crack Initiation on Austenitic 8Mn8Ni4Cr Generator End Ring Steel”; G. Wigmore and L. Miles, Central Electricity Generating Board, Bristol, England.

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TECHNICAL ARTICLE REPRINTS

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