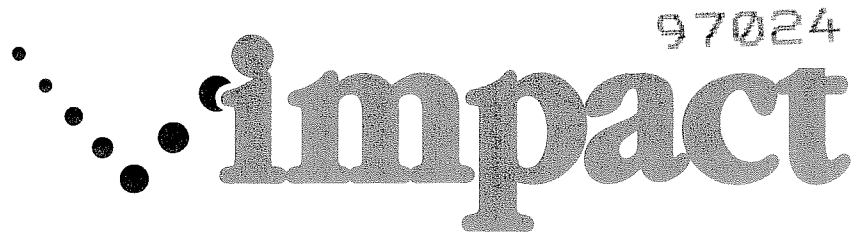


METAL IMPROVEMENT COMPANY

SUBSIDIARY OF CURTISS-WRIGHT CORPORATION

Non-Destructive
XRD:
NEW INDUSTRY
BREAKTHROUGH



Review of Shot Peening Technology

Economical XRD Stress Profiles Now Available in Days

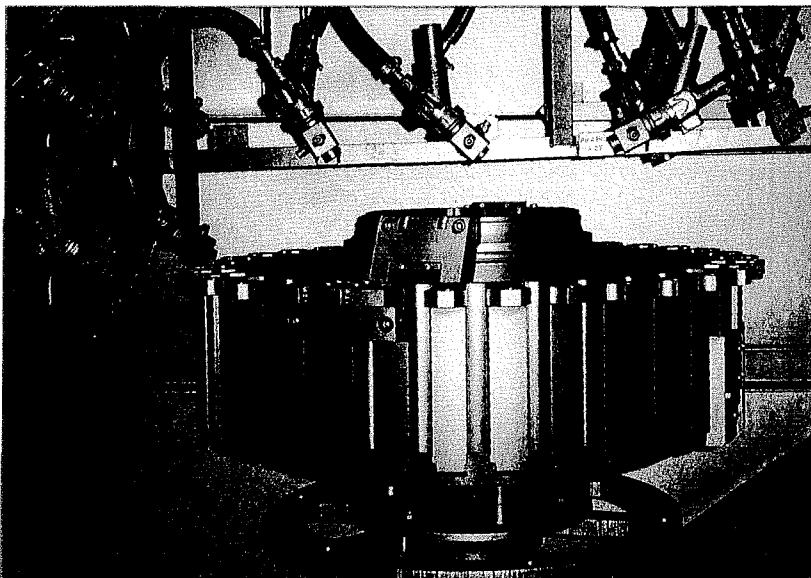
Introduction

Metal Improvement Company, Inc. (MIC) has engaged the services of Lambda Research to bring to the shot peening industry a significant breakthrough in the control of the shot peening process. The new method, exclusively offered by MIC, is called the MILAMsm System and makes X-Ray Diffraction (XRD) readings of residual stress profiles much more economical and available in days rather than weeks. The new method permits the use of XRD profiles as quality control measurements that can be recorded for Statistical Process Control data. The practical MILAMsm System has wide application: for instance, low volume aircraft components; high volume automotive transmission gears and even in-the-field

shot peening of chemical processing vessels. It can also be used to predetermine with high accuracy the shot peening parameters for process development. A distinct advantage of the MILAMsm System is that it can be used to determine the effects of the shot peening on, for instance, the adverse effects of products of transformation on heat treated surfaces.

*Parts remain intact
with Milamsm System.*

MIC and Lambda Research have been working together for some time on a method to bring to engineers and metallurgists, involved with controlled shot peening, a simplified and economical method to obtain accurate residual stress profiles, without the necessity of destroying the part. X-Ray diffraction is still the method of choice. That has not changed so you can count on the results. What we have done is to speed up the entire process to make it much more affordable with results in 2 to 5 days.



Paul Prevey, the President of Lambda Research, is recognized as one of the best (Paul is too modest to let us say "the very best"!) practitioners in the science of measuring stresses by X-Ray Diffraction (XRD). If you want the technical details, please read Paul's article entitled "Residual Stress Measurement for Quality Control of Shot Peening", reproduced by permission in this publication. We want to address the "how to's" of this exciting program that brings a whole new dimension to monitoring the shot peening process.

The Summary

The new MILAMsm System actually offers three alternatives for its use: The first employs coupons that are essentially the same size as a standard Almen strip, 3/4 by 3 inches, but that are 1/4 inch thick. The coupons are designed to fit on a standard Almen block and can therefore be used on an existing Almen fixture. In this way, the MILAMsm coupons are placed to represent the critical areas of the part to be peened. The MILAMsm coupons are made from the same material (even the same heat of material, if you, the customer, prefer) as the parts and heat treated along with the parts. They are shot peened after the Almen strip verification and just before the parts are processed and periodically thereafter per the customer's request.

The second is an alternative to the MILAMsm coupons but still part of the MILAMsm System. MIC and Lambda can handle small parts directly as long as they fit within a 2 x 2 x 1.5 inch envelope. With the third, larger parts can be cut up so that the critical areas for XRD reading can fit within the above envelope but you must let Lambda do the cutting. Both these last two alternatives work well if you prefer to use actual parts rather than the coupons. Please request a quotation for either of these two cases.

After shot peening, Metal Improvement Company then sends the coupons or the parts to Lambda where, because of their standard size, the coupons or the small parts can be etched and x-rayed at successive depth levels for residual stress readings in a very expeditious manner. This accounts for the quick processing and the economical pricing. Lambda, in turn, electronically transmits their resulting stress gradient curves back to the MIC division that sent them, for delivery to the customer. Please note that you receive only the curves: there is no detailed report so it is presumed that you understand what the curves represent. (If you don't, please ask the MIC Technical Services Manager for an explanation.)

The details:

When you are considering the use of the MILAMsm System, we would like you to please be aware of the following:

1. MILAMsm coupons are to be furnished by you, the customer, so that they are representative of the material and the metallurgical qualities of your parts, including heat treating and surface finish.
2. MILAMsm coupons are the same size as the Almen strip: 3 inches long by 3/4 inch wide, however they are 1/4" thick, so that they will fit the standard Almen block, except with the possible substitution of longer screws to accommodate the 1/4 inch thickness.
3. MILAMsm coupons are best cut from the same raw material (e.g., bar stock, extrusions, forgings, castings, etc.) from which the parts are made and then heat treated along with the parts. The surface to be peened must not be grit blasted, for instance, and if the coupons are cut by wireEDM, the recast layer should be removed. A good way to do this would be to wet lap the coupons in a surface preparation machine for metallurgical samples, using a 400 grit paper. Care must be taken not to induce high residual stresses during preparation of the coupons.
4. Your MILAMsm coupons will be identified by MIC with sufficient information so that they can be linked to a specific part and lot and even to a specific location on the Almen fixture. Please be sure to advise us of the part number that the coupons represent. Do not use stick-on labels anywhere on the MILAMsm coupons.
5. How many MILAMsm coupons should be supplied? At least one for each Almen strip location on the Almen test fixture for your particular parts. Beyond that, you need to decide if you want to monitor the residual stress only at the development of the process and/or at the start of a production run. You might want to consider periodic monitoring, particularly if you want to use the XRD results for Statistical Process Control.

RESIDUAL STRESS MEASUREMENT FOR QUALITY CONTROL OF SHOT PEENING

The magnitude and depth of the layer of compressive residual stress produced by shot peening is critical to achieving increased component fatigue strength. Although the Almen strip provides a practical means of monitoring the intensity of shot peening, the Almen strip arc height depends upon the area under the stress-depth plot, and is not sufficient to guarantee both the magnitude and depth of the residual stress distribution produced. The subsurface stress distribution must be measured for reliable quality control of shot peening.

The best developed and most accurate means of measuring shot peening residual stress distributions with depth is by x-ray diffraction (XRD).⁽¹⁾ XRD procedures have been established by the SAE,⁽²⁾ and have been widely used since the 1970's for the determination of subsurface stress distributions in automotive and aerospace applications.

Non-destructive surface residual stress measurements alone are not adequate to determine whether a part has been shot peened properly.⁽³⁾ Surface residual stresses simply are not indicative of the processing history. Similar surface residual stresses do not insure similar processing, as demonstrated in Figure 1. To adequately determine both the magnitude and depth of the compressive layer produced by shot peening, measurements must be made as a function of depth.

Lambda Research has developed novel automation technology⁽⁴⁾ which allows subsurface residual stress profiles to be obtained automatically, accurately, and cost effectively. It is now possible to determine full stress distributions for quality control and process development in routine applications of shot peening to a wide range of materials, including martensitic steels, austenitic stainless steels, nickel, and aluminum alloys.

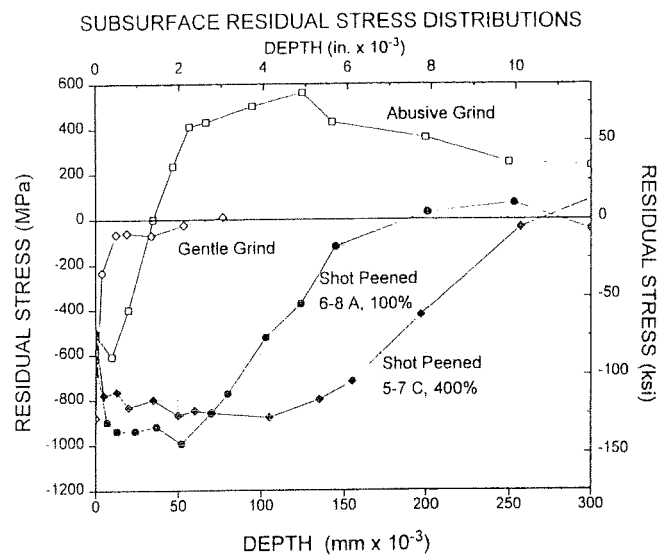


Fig. 1 - Comparable surface stresses produced by radically different processing showing the need for subsurface measurement.

• BENEFITS

The availability of residual stress measurement for quality control of shot peening offers numerous benefits:

Manufacturing Consistency

Uniform residual stress distributions produced by shot peening can be achieved, improving production efficiency, reducing rejection rates, and lowering overall manufacturing costs.

Improved Component Life

Quality control testing can virtually eliminate field failures, reduce warranty costs, and assure customer satisfaction.

Process Optimization

Residual stress testing allows informed engineering decisions for the optimization of the peening process. Peening parameters can be chosen to produce the depth and magnitude of compression giving the best fatigue life at minimum time and cost.

Objectivity

With the use of an accredited independent laboratory, results are accurate, timely, and accepted world-wide.

• **QUALITY ASSURANCE**

Lambda Research is the leading independent laboratory providing x-ray diffraction testing services for over twenty years. Thousands of individual residual stress studies have been performed for virtually every major automotive, aerospace, and nuclear manufacturer. All of the apparatus, software and procedures employed, conform to SAE and ASTM standards, where applicable. All calibrations are performed to ASTM E1426 for the determination of x-ray elastic constants and instrument alignment is verified to ASTM E915. Residual stress measurement methods conform to SAE J784a.

Lambda Research is accredited by the American Association of Laboratory Accreditation, and is certified by the principal automotive, aerospace and nuclear manufacturers. Results are provided directly to the client, and all data are archived indefinitely. The Quality Assurance program at Lambda Research is registered to ISO 9002, insuring international recognition and acceptance.

• **SAMPLE REQUIREMENTS**

The samples submitted for residual stress analysis may be either shot peened coupons, or actual components. The coupon, or portion of the sample tested, must fit in an envelope of approximately 2 in. x 2 in. x 1.5 in. Residual stress measurements are made at a single position and direction on the face of the component as a function of depth. The direction and location of measurement must be specified when the samples are submitted. Contact the laboratory for detailed requirements.

Full components such as gears will be sectioned to reduce them to the required coupon dimensions dictated by the automation apparatus. Strain gage monitoring of, and correction for, sectioning stress relaxation is available. For non-automated measurements on any sample geometry, either in the lab or field, contact Lambda Research.

References:

- (1) Paul S. Prevey, "X-Ray Diffraction Residual Techniques," Metals Handbook: 9th ed., Vol. 10, Metals Park, OH: ASM, 1986, pp. 380-392.
- (2) Residual Stress Measurement by X-Ray Diffraction, SAE J784a, 2nd ed., SAE, Warrendale, PA, 1971.
- (3) Paul S. Prevey, "Problems with Non-Destructive Surface X-Ray Diffraction Residual Stress Measurement," Practical Applications of Residual Stress Technology, Materials Park, OH: ASM, 1991, pp. 47-54.
- (4) Patent Pending.

LAMBDA RESEARCH

5521 FAIR LANE
CINCINNATI, OH 45227-3465
U.S.A.

PHONE: (513) 561-0883
FAX: (513) 561-0886
E-MAIL: lamresch@iac.net



Lambda Research is an independent testing laboratory founded in 1977, providing x-ray diffraction and related testing services. Lambda Research is accredited by the American Association for Laboratory Accreditation in accordance with ISO/IEC Guide 25. The laboratory quality assurance system is registered to ISO 9002 (ANSI/ASQC Q92).



6. The MILAMsm coupons will be run right after the initial Almen test of the set up and on the test fixture that has been prepared for that purpose, so that no additional fixturing is necessary in most cases. Please be sure to advise us if you wish us to follow a different routine for your parts.

THE MILAMsm SYSTEM

Now let's see how the MILAMsm system works in every day situations. We strongly recommend that you read all the different scenarios listed below so as to familiarize yourself with the requirements and possible applications. Parts need not be peened by MIC: they can be peened by the customer or any other source.

SCENARIO 1: Aircraft Structural Components

You have limited quantities, say 20 piece lots, once a month, of a flight critical component that is controlled shot peened by one of Metal Improvement Company's three Los Angeles area facilities. You conclude that it would be a good idea to monitor the residual stress distribution. You call the local MIC facility and request a visit from the Technical Services Manager (TSM) in Southern California. Together, you determine that you will supply the aluminum MILAMsm coupons and will use, for the coupons, the drop-offs from machining the actual components. No subsequent heat treating is involved since the aluminum is already heat treated before machining. The TSM will arrange for the change order for the process sheet to include the peening of the MILAMsm coupons with these particular components in the future. When your parts come in to MIC with the MILAMsm coupons, the coupons will be peened to production procedure requirements.

The MILAMsm coupons will now be expressed to Lambda Research for X-Ray Diffraction Readings. Upon completion of their work on your coupons, Lambda transmits, electronically, the XRD curves back to the originating MIC Division, identifying them to the specific coupon location. The TSM or the Quality Manager at the MIC Division will review the charts received from Lambda and then passes them on to you, the customer. Please note that with the MILAMsm system you receive only the curves: Lambda does not supply a report. You will be invoiced by MIC.

***Milamsm System can
be used with most
engineering metals.***

SCENARIO 2: Automotive Transmission Sun Gears

You have sun gears that go in the transmissions of some models of popular cars. They are carburized and hardened and, at several thousand per day, keep a dedicated shot peening machine busy around the clock at another of MIC's divisions. You would like to monitor the residual stress on a regular basis, say every Monday and Thursday morning so that you can use the results to plot SPC charts. You need to arrange for cutting of MILAMsm coupons from your material and have them carburized along with the gears, in quantities sufficient to meet your requirements. These can be cut at your company or by an outside contractor, who could also arrange for the carburizing, if you are not able to get this done internally. Once all is in place at the MIC Division, a set of MILAMsm coupons are shot peened just the same as the sun gears every Monday and Thursday mornings. If cutting of coupons is impractical, MIC can arrange for cutting of actual gear teeth on automotive sized gears at an extra charge. Alternately, if the gears are small enough to fit within the 2 x 2 x 1.5 inch envelope, then MIC can randomly select sun gears from production after shot peening. The coupons or the test gears are sent to Lambda (overnight, if you want) and 2 to 5 days later, the results are transmitted back to the originating MIC Division. After review, the XRD results are added to our SPC records and the charts can be delivered to you on a regular basis.

Scenario 3: Jet Engine Compressor Disks

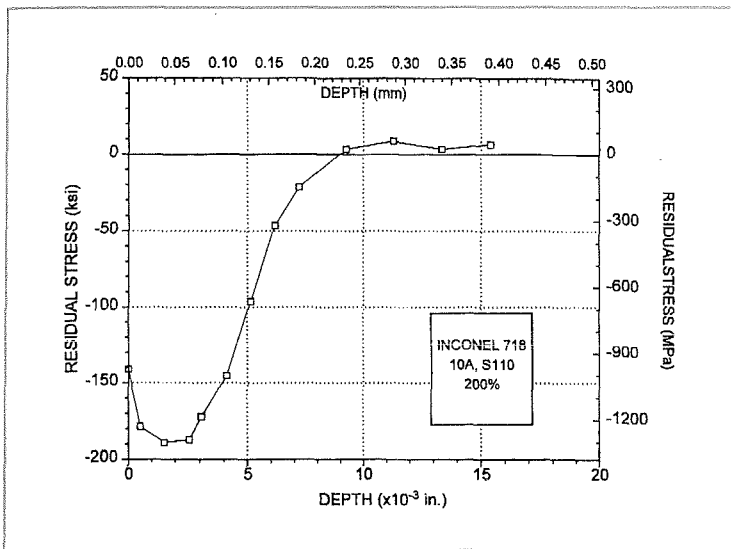
Superalloy jet engine turbine discs are worth a small fortune and are regularly shot peened to retard bending and fretting fatigue. Yours are about 24 inches in diameter and the Almen test fixture, made out of a scrap part, has Almen blocks all over it. This is a brand new part number and you are working with MIC to develop the correct procedure,

which will be “frozen” for use with all subsequent parts of the same number. The MILAMsm system is ideal for process development since you can get preliminary stress readings quickly and economically before you commit an actual part. You would like to have residual stress measurements from all the Almen locations. You undertake to provide enough finished MILAMsm coupons. A coupon is placed in each Almen block, after the Almen strips have been peened to check the parameters, and the Almen test fixture is again loaded into the machine, to be peened for the time necessary to achieve the required coverage. The coupons are then removed from the fixture and sent to Lambda for evaluation. As before, you will receive the results for each MILAMsm coupon and for each location on the Almen test fixture.

Scenario 4: On-Site Peening of a Process Reactor Vessel

You contract with MIC to send a field crew to your work site to peen the weldments, for prevention of Stress Corrosion Cracking, in a chemical process reactor. The material is 316 grade stainless steel. You provide the MILAMsm coupons of this material, 1/4 inch thick. The shot peening of some test coupons can be performed in our plant a few days prior to the field work, so that the shot peening parameters can be precisely determined before hand. Then, in the field, more coupons can be peened, for comparison.

Some Answers



Typical MILAM XRD curve for shot peened Inconel 718.

Question: Can I still send actual parts directly to Lambda or do I have to send them through MIC? Yes, of course, but MIC has a volume discount arrangement with Lambda and the savings will be passed on to you, if you send them through MIC.

Question: We send some parts to MIC but we also shot peen some parts in house. Can I use the MILAMsm coupons for the parts we peen ourselves? Sure you can, but you will have to pass the coupons through Metal Improvement Company. Lambda will accept MILAMsm coupons only from MIC and will only send the results back to MIC.

Question: We are using a shot peening job shop in competition with MIC. We have found the MILAMsm system specified on drawings from a prime aircraft manufacturer. Can we use the MILAMsm coupons? Yes, but the same condition applies as in the question above: you have to send them through MIC.

Question: We have MIC shot peen very small jet engine blades that fit the 2 x 2 x 1.5 inch envelope. Can we use some blades for XRD instead of the MILAMsm coupons? Yes, of course, but you may want to consider the cost of the blades since they will be scrap after the etching required for the XRD evaluation. The MILAMsm coupons are not that expensive if you can make them in reasonable quantities.

Question: How many depth points do I get on the residual stress curves? It depends somewhat on the depth of compression on the coupon itself but, in any case, you will get a curve with about 8 points on it, more if the compression is deep.

Question: Which metals respond well to the MILAMsm System? The system works very well with fine grain steels such as used for gearing, bearings, etc.; with nickel based alloys such 718 and similar superalloys; with 300 and 400 series stainless steels; and with aluminum alloys.

CONCLUSION

The MILAMsm system brings a new and added dimension to the monitoring of the shot peening process. Please contact the Technical Services Manager of your nearest Metal Improvement Company, Inc. facility. Your local Technical Services Manager can guide you in utilizing the MILAMsm system to best suit your particular parts and conditions.

Below is a list of the Metal Improvement Company major locations in North America, together with the telephone and fax numbers. Please contact the one nearest to you or you may address us at our Corporate Offices in New Jersey, USA.

— John S. Eckersley, *Editor*

Arizona	103 S. 41st. Avenue, Phoenix, AZ 85009 Tel: 602-278-2811 Fax: 602-278-3911
California	3239 East 46th. Street, Vernon, CA 90058 (Los Angeles) Tel: 213-585-2168 Fax: 213-585-0157 2151 South Hathaway, Santa Ana, CA 92705 Tel: 714-546-4160 Fax: 714-546-8643 2588-A Industry Way, Lynwood, CA 90262 Tel: 213-563-1533 Fax: 213-563-2105
Connecticut	145 Addison Road, Windsor, CT 06095 (Hartford) Tel: 860-688-6201 Fax: 860-285-8809
Florida	1940 N.W. 70th Avenue, Miami, FL 33126 Tel: 305-592-5960 Fax: 305-477-9648
Illinois	678 Winthrop Avenue, Addison, IL 60101 (Chicago) Tel: 630-543-4950 Fax: 630-543-3982
Kansas	1019 S. McLean Blvd., Wichita, KS 67213 Tel: 316-267-0239 Fax: 316-267-7904 1618 Ida Street, Wichita, KS 67211 Tel: 316-267-8201 Fax: 316-267-5735
Louisiana	116 Southpark Road, Lafayette, LA 70508 Tel: 318-837-9273 Fax: 318-837-2505
Massachusetts	26 Alley Street, Lynn, MA 01902 (Boston) Tel: 617-599-4165 Fax: 617-599-3350
Michigan	41200 Coca Cola Drive, Belleville, MI 48111 (Detroit) Tel: 313-397-8400 Fax: 313-397-2650
Minnesota	8630-A Monticello Lane, Maple Grove, MN 55369 (Minneapolis) Tel: 612-425-2400 Fax: 612-425-4669
New Jersey	472 Barell Avenue, Carlstadt, NJ 07072 Tel: 201-935-1800 Fax: 201-935-8670
New York	195 Field Street, W. Babylon, NY 11704-1499 (Long Island) Tel: 516-694-8770 Fax: 516-694-8775
North Carolina	500 Spring Brook Road, Charlotte, NC 28217 Tel: 704-525-3818 Fax: 516-525-3118

Reply Card – MILAMsm

Please:

- Add me to your mailing list.
- Keep me on your mailing list.
- Remove me from your mailing list.
- Correct my address, etc., as below.
- Send *Impact* to person listed below:

Please send me a complimentary copy of:

1. "Shot Peening Applications" – Seventh Edition.
2. "Are You Prepared for the New Shot Peening Specifications?"
3. "The Application of Controlled Shot Peening for the Prevention of Stress Corrosion Cracking"

Please contact me ASAP; I would like:

- A discussion on the new MILAMsm System.
- To see "Shot Peening Applications" – The Video.

Name _____

Title _____

Company _____

Address _____

City _____

State/Country _____ Code _____

Tel.: _____ Fax: _____

Ohio	11131 Luscek Drive, Blue Ash, OH 45241 (Cincinnati) Tel: 513-489-6484 Fax: 513-489-6499 1652 E. Highland Road, Twinsburg, OH 44087 (Cleveland) Tel: 216-425-1490 Fax: 513-489-6499
Texas	1450 Avenue S, Grand Prairie, TX 75050 (Dallas) Tel: 972-642-8011 Fax: 972-660-3692 9410 East Hardy, Houston, TX 77093 Tel: 713-691-0257 Fax: 713-691-4744
Wisconsin	8201 North 87th St., Milwaukee, WI 53224 Tel: 414-355-6119 Fax: 414-355-9114
Canada	105 Alfred Kuehne Blvd., Brampton, Ont. L6T 4K3 (Toronto) Tel: 905-791-8002 Fax: 905-791-4490

CORPORATE OFFICES

10 Forest Avenue, Paramus, NJ 07652

Tel: 201-843-7800 Fax: 201-843-3460

E-mail: METALIMP@ix.netcom.com

Internet: www.METALIMPROVEMENT.com