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SHOT PEENING – PAST, PRESENT AND FUTURE

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Mr. Nakonieczny, Members of the International Scientific Committee, Ladies and Gentlemen:

Thank you for the opportunity of speaking to you today. It is truly an honor to be the keynote speaker at the Seventh Congress on Shot Peening.

Before going into detail, let me first introduce myself as president of Metal Improvement Company and one of its original owners. Metal Improvement Company started in southern California over 50 years ago and was the brainchild of a gentleman by the name of Dr. Henry Fuchs. Dr. Fuchs had been at the Research Laboratory of General Motors Corporation, working hand in hand with John Almen. They worked on new applications for shot peening of various components for automobiles and military hardware produced before and during World War II.

My exposure to John Almen and the automotive industry came in the early 1950's when I visited with John Almen in Detroit. I became familiar with the various highly stressed automotive components such as valve springs, transmission gears, crankshafts and connecting rods. However, with the exception of the valve springs, these early applications faded in a short time. The automotive industry in America was not concerned about metal fatigue, as most components were made of low grade steels. If a failure occurred, they simply made the parts heavier, since fuel economy or vehicle weight were not problems to be considered. If shot peening was used at all, it was only as a temporary means to fix the situation until a new part design could be substituted.

I have always been amazed at the number of instances that I have experienced over the years of the misuse of the Almen strip. Many people with whom I have come in contact, both in academia and industry, have tried to find substitutes for the Almen strip. In my opinion, the Almen system developed by John Almen, is one of the finest, most flexible and least expensive tools for duplicating the shot peening process once the process has been developed, tested and locked in place. The Almen strip was never meant to be used as a method of measuring residual stress nor, of itself, does it have any relationship to the depth of compressive stress.

Shot peening is a very forgiving process and, unfortunately, this has led to too many instances where the process has either been misused or misapplied. There are still many specifications that have call-outs that are absolutely absurd, such as requiring very high coverage rates and very high intensities for applications where normal shot peening processes would reduce the costs and create less surface damage and a better surface finish. Because there is no nondestructive method of measuring the uniformity of compressive stress subsurface, this has led to uncertainties on the part of the engineering community as a whole. There have been good reasons for concern due to the fact that after the process has been applied, there is no way of telling whether or not it has been properly applied. Example: There are numerous specifications that exempt manual peening, yet it is being done all over the world in violation of proper shot peening specifications.

Many of you assembled here today had the privilege of knowing John Almen and Dr. Fuchs, who were such pioneers in our industry. At the very First Congress on Shot Peening in 1981, Henry Fuchs presented an excellent history of shot peening, so I am going to only touch on some more interesting historical highlights and then will spend time on some of the more exciting recent developments and especially where I see the industry going in the near future. In a nutshell, the time frame starts with the early use of cast iron shot, then passes on to cast steel shot, then to glass and ceramic beads and, finally, would you believe, peening with no shot at all!

Dr. Fuchs saw opportunities in the aircraft industry where weight and size should have been major design constraints, but even here the acceptance of shot peening was slow. Remember, this was just after World War II and the Douglas DC-3 aircraft was the airliner of choice. It was so over-designed that many are still flying today in commercial service in far corners of the globe. The emerging Metal Improvement Company also found applications for its process in the oil tool industry. The very first real parts that we peened were some highly stressed pinions for the Western Gear Company, but selling the idea of shot peening was not easy.

More than anything else, what really made the engineering community sit up and take notice of the shot peening process was the development of peen forming of the wing skins for the Lockheed Super Constellation in the mid-1950's. I don't think there is a mechanical engineer in the world, even if his product is dental picks, who is not fascinated by the use of shot peening for inducing the very precise aerodynamic curvatures in wing skins. Today those wing skins surpass 30 meters in length! Peen forming established the credibility that the shot peening process so desperately needed. From that time on, engineers would listen, even though very few had any need for peen forming, per se.

New applications now came much more quickly and MIC opened a second plant on the East Coast. Perhaps a good method to measure the acceptance of the shot peening process would be to look at the expansion of Metal Improvement Company since, if you will pardon me for this observation, as MIC went, so went the shot peening industry. Over the last 50 or so years, MIC expanded from the small, shared space in Los Angeles to 31 shot peening service facilities in North America and Europe. Worldwide interest in shot peening is at an all-time high and continues to grow; and here we are, delegates from a great variety of countries and backgrounds meeting in Poland!

Applications for shot peening now cover almost all aspects of the metalworking industries. Ironically, the automobile industry, which initially paid little attention to the process that was developed within its own laboratories, today has become a major user. Cars and trucks now must be designed to meet the stringent double requirements of fuel economy and long life. At the same time as applications expanded, so did the process variations and techniques. I don't have enough time to go into details here, so I invite you to review Metal Improvement Company's recently published 8th Edition of "Shot Peening Applications, an Engineering Manual." I will, though, just highlight some of the innovations.

- Peenscan ® : A process that used fluorescent dyes for better coverage determination
- CMSP: Computer Monitored Shot Peening - to ensure consistent repeatability
- X-Ray Diffraction: An accurate means of determining in-depth residual stress
- MILAM_: A system, using coupons, that permits X-Ray diffraction readings without destroying the part
- Peenstress_: A computer program that plots simulated residual stress curves for a whole library of metals and alloys to aid in development of shot peening parameters.
- C.A.S.E._: A process for superfinishing shot peened surfaces for, as an example, increasing pitting fatigue resistance of gears.

- LaserShot_ Peening: (This is the "no shot at all" peening process!) LaserShot_ Peening employs a beam of coherent light pulses to actually indent metal surfaces and produce greater and deeper compressive stress than can be obtained by conventional shot peening.

These are all existing processes and practices that are in use now. What of the near future? I suspect that we will know much more about the future of shot peening as this Congress progresses, but let me touch on two items that I believe have enormous potential.

An obvious one is the process of peening with light. The idea has been around since the 1970's and some proof of concept had been accomplished. However, it was only recently that the Lawrence Livermore Laboratories, working on a government contract for a laser to illuminate passing satellites, synergistically developed a laser with sufficient power and pulse frequency to make laser peening commercially viable. Right now, under a joint agreement between MIC and Lawrence Livermore, the process is being applied successfully in production; but we are witnessing just its infancy. It is being used primarily for parts such as turbomachinery components that are highly stressed and very expensive to replace. As development proceeds with LaserShot_ Peening, the lasers will become even more efficient and costs will come down. Applications, as a consequence, will proliferate and we will find ourselves LaserShot_ Peening types of parts that never were shot peened before. Oddly enough, one of the very first applications for shot peening, rock drills and other oil industry tools, become candidates for LaserShot_ Peening because of the inherently high rates of service wear and the consequent need for very deep depths of compression, minimum of 1 mm (0.040")

I have always considered that one of the most important criteria, if not the most important, in developing a shot peening specificiation is to determine the required depth of compression. Too deep a depth in a thin section, in addition to causing distortion, can create subsurface cracking caused by too high a tensile stress in the core, whereas in other applications an insufficient depth of compression will not produce the required fatigue life for that particular component. <u>For example</u>: When a part is subjected to corrosion, pitting corrosion, mechanical damage, abrasion and wear, a deeper depth is required to overcome all such mechanical surface damage. A good example is the shot peening of the propeller blades on the old reciprocating aircraft engines where experience showed that as the aircraft was warming up on the runway, gravel would cause mechanical damage by nicking the propeller blade. Shot peening was used as a method of overcoming the harmful effect of such mechanical damage.

The other area that I think will become very significant in the near future is in the aircraft industry, particularly the military sector. If that sounds strange (after all, aren't all airframe parts shot peened?), let me give you a little more history. Shot peening gained rapid acceptance on airframe components for the prevention of stress corrosion cracking (SCC) of high strength aluminum alloys. Then along came the development of SCC resistant alloys and shot peening began to disappear off the drawings for new aircraft. Well, you might ask, if there was no more danger from SCC, there was still metal fatigue, wasn't there? Oh yes, but a new design criterion emerged, known as "Damage Tolerance!" Essentially, "damage tolerance" stipulates that an airframe part must be able to sustain a crack or fault or even foreign object damage that is fifty thousandths of an inch deep, about 1.25 mm! Since this kind of depth is well below the depth of compression that can practically be reached by shot peening, why shot peen?

Well, the damage tolerant designs have not proven in service to be quite as damage tolerant as their proponents expected. In addition, recent research has shown that normal surface shot peening can contribute much to limiting the progress of a crack in aluminum alloys, even if it is fifty thousandths (1.25 mm) deep! Of course, the shot peened surface will prevent many cracks from initiating in the first place, long before fatigue cracks can progress to 50 thousandths (1.25 mm) depth! I think we are going to see a return of shot peening to airframe component designs. This area of airframe component design is one where we, collectively as the shot peening industry, can have a very significant impact if we strive to educate the aircraft industry as a whole.

A number of years ago, Metal Improvement Company expanded its facilities and entered the heat treating field, giving the company direct exposure to two industries, shot peening and heat treating. I was amazed at the maturity of the heat treating industry as compared to the shot peening industry. Granted, heat treating has been around a lot longer than shot peening, but I believe that it is time that the shot peening industry attained a certain level of maturity. By this I mean that when advising industry of the value of the process and assisting in establishing proper specifications, more knowledge needs to be communicated to relieve any anxiety on the part of engineering and metallurgy and to give assurance that what is recommended is best, avoiding a great deal of testing under different conditions. Unfortunately, I have seen a trend within the last five to eight years whereby industry is tending to put greater emphasis on the commercial aspect of the process, namely - cost, rather than on the technical importance of proper specifications and best usage of the process.

Although shot peening is coming to be regarded by some as a commodity item, I submit that we still should be very much in the education mode. Even at the university level, while there are many courses that teach failure analysis, there are very few that actually address failure prevention. Ultimately, it is failure prevention that any engineer has to be concerned with. Yes, shot peening has always been a handy fix if your parts are breaking, but is it not preferable to design-in the failure prevention before the parts begin to break? Is it not better to use shot peening to allow an upgrade in a device rather than go into a complete and expensive redesign?

Let me give you a good example of just that. Some years ago, one of the major car companies in Detroit designed and built an automatic transmission for a 125 horsepower engine. Today, that same basic transmission is coupled to a 250 horsepower engine! Yes, there have been many improvements, but the gears are unchanged – except for the addition of shot peening! But it is not going to happen very often if we regard shot peening as a commodity and just go to Purchasing and ask, "Do you need any shot peening today?" and "Our prices are the lowest."

Our challenge as an industry is still education, first of ourselves and then of our customers, be they in-house customers or at other companies. That is the challenge I want to leave with all of us, not only those of us here at this Congress, but all of us in this still very exciting industry.