# Metal Improvement Company, Inc.

## Review of Shot Peening Technology

# impact

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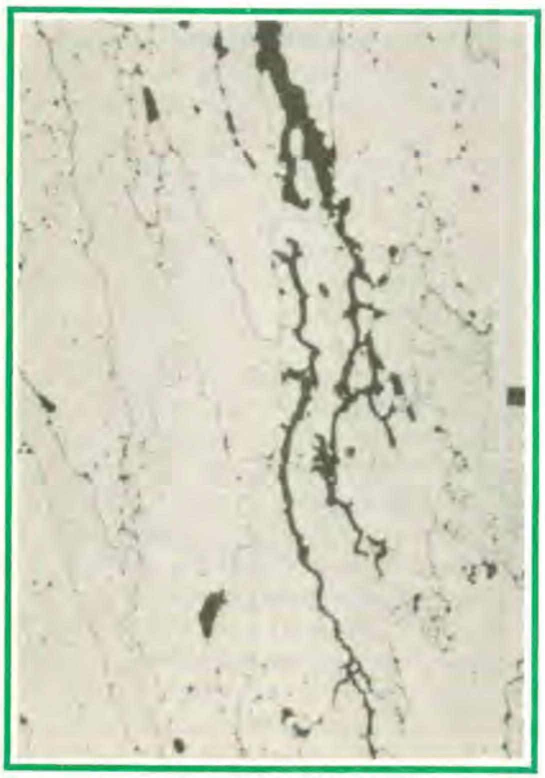
## *In This Issue:*



# Stress Corrosion Cracking: Prevention and Cure

Dale R. McIntyre, formerly with Battelle-Houston, wrote: "Stainless steels as a class offer the chemical engineer many attractive features: good corrosion resistance, weldability, fabricability and reasonable cost. However, any engineer hoping to take advantage of these benefits must consider the possibility of stress-corrosion cracking.

Stress-corrosion cracking (SCC) is an interaction between tensile stress and corrosion, which results in localized cracking. The cracking can take place at very low stresses and in environments where general corrosion, as measured by reduction in wall thickness, is negligible.



**Photomicrograph of cracked reactor tube, showing branching transgranular cracking caused by stress corrosion.**

Stress-cracking agents in process streams are not the only cause of SCC; many failures take place due to traces of SCC agents in the air.

TENSILE STRESSES are necessary for the propagation of stress-corrosion cracks. However, these stresses need not be applied ones; residual tensile from forming, welding and heat-treating have the same effect. This is important to remember in pressure vessels and piping. Applied stresses are usually quite low, but welding and fabrication stresses are often at or beyond the yield point.

Stress level plays an important role in the initiation time for SCC; the higher the stress, the shorter the initiation time.

### ELIMINATING TENSILE STRESSES

"This is a very effective method for preventing stress-corrosion cracking. In process vessels and piping, stresses due to internal pressure are usually quite low, typically only 25% of the ultimate tensile strength. Most SCC failures are due to residual stresses from welding and fabrication.

Shot peening is one of the most promising methods for prevention of SCC. During shot peening, the wetted surfaces of the item are cold-worked with steel shot under carefully controlled conditions to produce a thin layer of metal with a net residule compressive stress. Stress-corrosion cracks cannot propagate through compressive stresses; therefore, the SCC problem is eliminated.

### SHOT PEENING CAN ELIMINATE SCC

Done properly, shot peening produces a layer of material about 0.02 in. thick that has residual compressive stresses of yield-point magnitude. Not only are welding stresses cancelled out, but subsequent application of service stresses should still leave the surface with net compressive stresses. This is an important advantage over stress relieving, which may delay but not necessarily eliminate SCC. Theoretically, shot peening should eliminate SCC entirely.

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# Henry Fuchs (1907-1989) Philosopher, Engineer, Entrepreneur and Educator

The following announcement was issued by Gerald Nachman, President, Metal Improvement Company, Inc.:

"It is with deep regret that I advise you of the death of Henry Fuchs. Dr. Fuchs passed away on January 17. As you know, Dr. Fuchs was the founder of Metal Improvement Company and a consultant to the company for many years." The influence of Dr. Henry Fuchs; the process of shot peening; and Metal Improvement Company have been so intertwined that they have become almost synonymous in the art and science of preventing failures of metal parts. His death prompted a document review and several interviews from which was extracted an interesting history of all three: the person, the process and the company and we offer it here in his memory.

**PROFESSOR HENRY FUCHS 1907-1989**

Henry O. Fuchs was born on May 27, 1907 and though his life's work was devoted to the science of engineering, his first diplomas were in Languages and Philosophy, from the University of Strasbourgh, France. No doubt, this early training made Henry the excellent teacher that he was: he had a unique gift to simplify complex phenomena and communicate the idea. Henry believed, for instance, that "residual stresses" were difficult to visualize and so coined the term "self stresses". His many books and articles display an appreciation for the nuances of language that is rarely found in engineering texts. His philosophy transcended the technical and Dr. Ralph I. Stevens, Professor of Mechanical Engineering, University of Iowa was to say of him "After my father, Henry was the most influential person in my life." Together, they published "Metal Fatigue in Engineering".[1] The titles of his many technical papers reveal the depth of his engineering, e.g., "Analysis of Nonpropagating Fatigue Cracks in Notched Parts with Compressive Mean Stresses",[2] and also his sharp sense of humor: "Teaching Design by Precept, Practice and Post Mortem."[3] Dr. Fuchs received his training in engineering from the Technical University of Karlsrule, Germany, where his thesis on "The Effect of Shock Absorbers on Ride" earned him a doctorate in 1932. It also secured him a job as Junior Engineer at General Motors in Detroit the very next year, where he remained until 1945.

At G.M., he was exposed to Shot Peening. At the First International Conference on Shot Peening in 1981, Henry related that although the earliest publication and patent were found in the German literature, it seems that the process was first applied in production and developed in the United States. [4] About 1928, the service life of valve springs was a subject of concern. Danse at Cadillac and Heiss at Buick observed that springs cleaned by shot blasting were clearly superior. The process was used in production, but the reasons for its success were not understood. Zimmerli stated in 1940, "Shot blasting has done more to increase fatigue life of our small springs than any of the alloy steels ever used."[5] J. O. Almen began to devote himself to the investigation of shot peening and soon proclaimed that residual stresses (self stresses) were the cause of the improvement; that stresses could not be calculated from loads and geometry alone; and that fatigue cracks would not propagate unless tensile stresses were present.[6] His views were unorthodox at the time and strongly resisted by some academics but were eventually legitimized through the development of fracture mechanics.

**First peen formed integrally stiffened wing skins, for Lockheed Super-Constallation.**

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During World War II, shot peening spread in the U.S. from the automobile industry to the aircraft and other industries, largely through the efforts of Almen, supported by a government grant. Almen started the SAE committee on shot peening and was its guiding spirit.

In 1946, Henry Fuchs and Fred Landecker (his son-in-law), started Metal Improvement Company, a shot peening service business, in Los Angeles, to take the relatively new technology to the aircraft industry. Western Gear was their first customer. Henry Fuchs, meanwhile, though officially President of MIC, was only able to serve as a consultant: he had a full time job as Assistant Chief Designer and later Chief Research Engineer at Preco, Inc. It was 1954 before their business had grown enough to support two executives and Henry was able to join his own company full-time.

As early as 1943, at the University of Detroit, Dr. Fuchs taught part-time evening courses and again in 1948 through 1954 at the University of California, Los Angeles. In 1958, he taught at USC and was visiting lecturer at Berkley and also at UCLA. Teaching was always Henry's avocation but, during those early days, one suspects it was also a necessity.

**Starting in 1951, Henry worked to develop the process of peen forming**

Starting in 1951, Henry worked in conjunction with Jim Borger[8], an engineer from Lockheed, to develop the process of peen forming, applied in production to 32 foot long wing panels for the Lockheed Super Constellation. These were the first wing skins where stiffening stringers were integral to the skin, machined from a thick plate of aluminum. Metal Improvement Company designed the equipment and soon afterwards, four peen forming machines were built for Boeing and one, at least, is still in operation at Boeing Military Airplane in Wichita. Patents for a "Gantry Type Peen Forming Machine" and "Panel Forming Equipment" were granted to H. O. Fuchs, just two of over twenty patents for which he is credited.

By 1962 Henry again functioned as a consultant, having left Metal Improvement Company to pursue his first love, teaching. He became Senior Lecturer at UCLA and then Professor of Mechanical Engineering at Stanford where he was elected to Emeritus Professor in 1972. Always the philosopher-engineer, in 1974 Professor Fuchs was named co-recipient of the Chester F. Carlson award for "applying his creative talents in the design and implementation of a new instructional technique, methodology or concept," specifically by the development of "engineering case studies that are a superior way of building bridges between classroom education and engineering practice".[9] In 1980 Prof. Fuchs receive the third annual Leonardo da Vinci award of the Design Engineering Division, American Society of Mechanical Engineers.


**Over 1000 AirBus Series wing panels have been peen formed by MIC-Chester, England Division.**

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### Stress-Corrosion Cracking

For maximum effectiveness, shot peening should be the last manufacturing operation before the item is placed in service. No welding or torch heating should be performed on an item that has been shot-peened unless the heat-affected area is re-peened after heating. On process vessels, shot peening should be performed after the final hydrostatic test. The deliberately severe hydrotest stresses would reduce the magnitude of compressive stresses on a previously shot-peened surface.

*For full text of Dale McIntyre's articles, please check reply card.*

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### Henry Fuchs (1907-1989)

The passing of Henry O. Fuchs on January 17, 1989 closes a chapter but the story is far from over. Students all over the world study from his texts and though few understand the role of stresses in metals as he did, many have picked up his torch. The process of shot peening to extend fatigue life that he pioneered at General Motors is again commanding the attention of the automobile engineers as they struggle to combine lighter, more efficient designs with extended warranties. All commercial and most military aircraft flying today have parts that were shot peened for life enhancement or contour forming. The company that he started with so much vision and little else has grown to be one of the largest contract processors of metal parts, with facilities in North America, Europe and Asia. Few people have the opportunity to leave a legacy that daily touches for good the lives of countless numbers of people. Henry Fuchs made that opportunity for himself but with no thoughts of grandeur. His influence at a technical meeting or in classroom was subtle but incisive for his strength came from a depth of knowledge and understanding that all recognized but few could match. He leaves with the respect of all who knew him.

**METAL IMPROVEMENT COMPANY, INC., Subsidiary of CURTISS-WRIGHT CORPORATION**
**Shot Peening and/or Heat Treating Facilities in the following cities: NORTH AMERICA: Boston, MA; Carlstadt, NJ; Charlotte, NC; Chicago, IL; Cincinnati, OH; Cleveland, OH; Columbus, OH; Dallas, TX; Detroit, MI; Hartford, CT; Houston, TX; Lafayette, LA; Long Island, NY; Los Angeles, CA (3); Miami, FL; Milwaukee, WI; Minneapolis, MN; Murphy, NC; Orangeburg, NY; Phoenix, AZ; Toronto, ONT; Wichita, KS (2).**
**EUROPE: Chester, Derby and Newbury, England; Bayonne and Montargis, France; Unna, Germany**