The Metalock Process with Case Studies

An Online Continuing Education Course for Engineers

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Introduction

The Metalock process was developed to repair cracked and broken industrial equipment. The process was developed primarily to repair cast iron components, but it can also be used to repair steel, bronze, and aluminum equipment, to name a few. This process is performed cold, without the heat input processes such as welding required. This results in a distortion-free repair. This also eliminates metallurgical issues that result from welding. The process also lends itself to in-situ repairs and is relatively fast compared to other repair processes, which results in short equipment downtime.

The Metalock process uses specialty components that are inserted into the fractured equipment at right angles to the fracture plane. These components return tensile strength to the material. Additional components are installed parallel to the crack in order to lock the first components into the material and return its shear strength. If the fracture is extensive, entire sections can be removed, and matching unfractured sections can be Metalocked into the equipment. The Metalock process can also be used to install reinforcements into the equipment such as gussets.

The Metalock process is extensively used in multiple industries to this day. Primarily, it is employed in the maritime and mining industries but is effective where welding is not advised, the repair is in a remote location, and extensive downtime is prohibitive.

The History of Metalock

During the late 1930s in Texas, a novel technique for repairing cast iron components in oil fields emerged. This method resulted in permanent repairs without using heat or open flame, making it suitable for environments where such methods were restricted. A group of innovators, including Lawrence Scott, Fred Lewis, Earl Reynolds, and Hal Harman, played pivotal roles in developing this new metal repair technique. Hal Harman is credited as the original creator of the metal stitching technique, having filed a patent for it on August 7, 1937.

In 1938, Scott was officially recognized for inventing a variation of metal stitching known as Metalock while still working alongside Harman. Scott obtained patent rights for this repair method and its associated materials. Using his patents, Scott established the 'Metalock Repair Process' and began offering franchises under the Metalock Corporation name after launching his own venture in Long Island City, NY. The first company to acquire a franchise was Thomas Oliver Ltd., based in Ontario, Canada.

Fred Lewis, another contributor to the development process, obtained a franchise and initiated operations in Chicago, IL, in 1942. Around the same period, George Jackman Sr. departed from T.O. Oliver Ltd. to establish Metal Locking Service, Inc. as an independent entity.

Hal Harman continued to refine his method, named Chainlock. Initially, both Harman and Scott provided competing metal stitching repairs, leading to legal disputes over patent infringements and design rights. Eventually, Harman emerged victorious in these legal battles, and Scott was forced to transfer ownership of the process to others.

The initial applications of this repair technique were in hazardous oil fields during the 1930s. Subsequently, it was clandestinely used on US Naval vessels just before and during World War II, gaining recognition as a standard repair method approved by the US Navy post-war. This period marked the validation of the process as a credible alternative to welding.

Over time, various iterations of metal stitching processes emerged, using terms like Metal Stitch, Metal Locking, and Metalock to describe their repair techniques. Lock-N-Stitch, a slightly modified stitching method developed by Gary Reed, evolved from the original concept of metal stitching.

Metalock USA

Over the years, the multiple Metalock franchises over the country consolidated. Metalock, merged with Engineered Casting Repair Service, is currently located in Denham Springs, Louisiana, and operates under the Metalock name. Metalock USA is the owner of the Metalock trademark in the USA. The firm specializes in mechanical repairs, weld repairs, and in-house and field machining services on industrial equipment. In cases when a repair is not practical, Metalock has the capability to design replacement parts and source vendors to manufacture the new components. Metalock personnel can perform stress analysis, non-destructive and destructive, metallurgical, and mechanical testing. Its primary customers are the aluminum extrusion and mining industries.

Advantages of the Metalock Process

Cast iron is considered one of the most difficult of all common metals to weld. Welding methods for cast iron have proven to be less than satisfactory and, in many cases, resulted in more extensive cracking. The unsatisfactory weldability of cast irons is primarily a result of the high carbon content and their microstructure which results in high hardenability and high hardness after welding. This is particularly important when preheating is not possible or impractical, and repairs on thick cross sections are attempted. For example, if steel is welded and cooled rapidly from above the critical temperature and reaches approximately 300°F (149°C), martensite begins to form. The martensitic microstructure results in residual tensile stresses and, in conjunction with the brittle nature of the material, leads to a crack-prone environment. If cracking does not occur, the residual stresses can result in unacceptable component distortion. Finally, since welding is avoided with the Metalock process, a wide range of materials can be repaired. In fact, even dissimilar materials can be Metalocked.

Besides the microstructural drawbacks that can occur during welding, the logistics of welding in confined and/or remote locations can make it impractical and/or unsafe. Resistance welding requires significant electrical power, can require shielding gas (depending on the method), can produce toxic fumes, and creates a fire hazard, to name a few welding drawbacks. Furthermore, some welding methods and alloys are limited to certain positions (flat, horizontal, vertical, overhead), which can make performing a weld in a confined space difficult. Installation of Metalock components can be performed with hand tools, if necessary, but generally air tools are recommended to install Metalock components. This results in a Metalock repair being preferred in locations such as underground mining equipment and the in-situ repair of ship propellers, and immobile turbine, engine, pump, and/or compressor cases. In some cases, the repair can be installed while the component is still operating.

Repairing a component is generally more economical than replacement. This is primarily due to the lost production that results from the equipment being out of service. This means that a repair that minimizes downtime is attractive. With the exception of perhaps short, single-pass weld repairs, a Metalock repair will be faster to complete. This is not only due to the nature and simplicity of a Metalock repair but also the reduced equipment mobilization required. Welding may require arc gouging equipment, welding machines, shielding gas, heat-treating machines, associated support equipment, cables, and hoses. Scenarios also arise where a Metalock repair can provide a palliative repair. A palliative repair occurs when a replacement component is either ordered (long lead times) or on-site, and the repair needs to last until the replacement arrives or the next scheduled outage when the replacement component can be installed.

Additional benefits of a Metalock repair can include:

1. The repair acts as an expansion joint for equipment exposed to thermal stresses.
2. Redistributes tensile stresses away from areas subject to fatigue.
3. Maintains a stress-relieved condition resulting from internal stresses generated by plastic deformation. This is particularly true in situations where a component fails due to overload.
4. Repairs can be pressure-tight with careful placement of Metalock components. Additional sealing can be provided by applying sealing to Metalock components prior to installation.

Limitations of the Metalock Process

While the Metalock process offers numerous advantages, it is essential to consider its potential disadvantages and limitations:

1. Metalock repairs require precision drilling and expertise in the Metalock technique. Improper application or lack of training can lead to suboptimal results.
2. Metalock may not be suitable for thin or highly stressed components where the introduction of Metalock components could weaken the component.

3. In some cases, the location or accessibility of the damaged area may pose challenges for performing Metalock repairs, requiring creative solutions or disassembly of surrounding components.

4. Metalock repairs may not always match the original appearance or finish of the component. Machining, finishing, and or painting after completion of the repair may be necessary to restore the component's aesthetics. This is generally less of a concern on industrial equipment.

5. While Metalock repairs are generally durable, factors such as environmental conditions, loading cycles (fatigue), and material properties can influence the longevity of the repair. Regular inspection and maintenance may be required to ensure continued performance. Metalocks can fail in fatigue and, in some instances, become loose. This requires Metalock replacement and/or reswaging. This also means that installing Metalocks inside of rotating equipment should be performed with great care or avoided altogether.

The Metalock Process

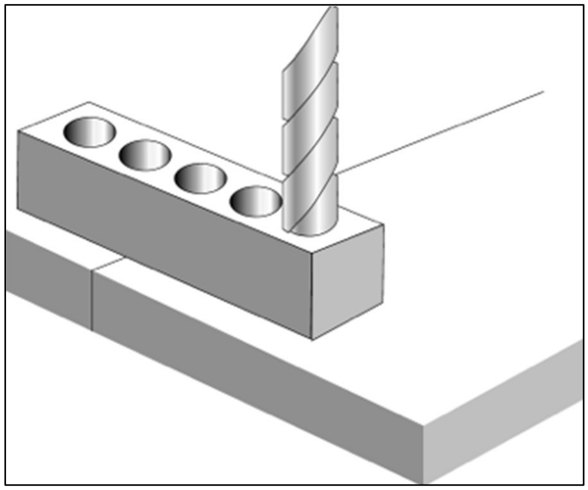
From a technical standpoint, the Metalock process is relatively simple. However, experience provides insight into the most appropriate installation technique, Metalock layout, and repair limitations. Additionally, a considerate technician with an appreciation of craftsmanship ensures the crack is aesthetically pleasing and functional upon completion. It is cliché, but the Metalock repair process is an art as much as it is a science.

The Metalock process is as follows:

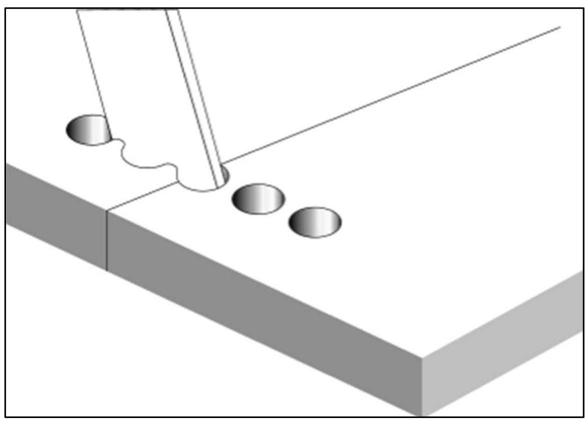
1. The extent of the cracking is verified visually and/or with the aid of non-destructive techniques such as magnetic particle and/or dye penetrant methods.

2. The final size, spacing, and location of the Metalocks are laid out on the surface.

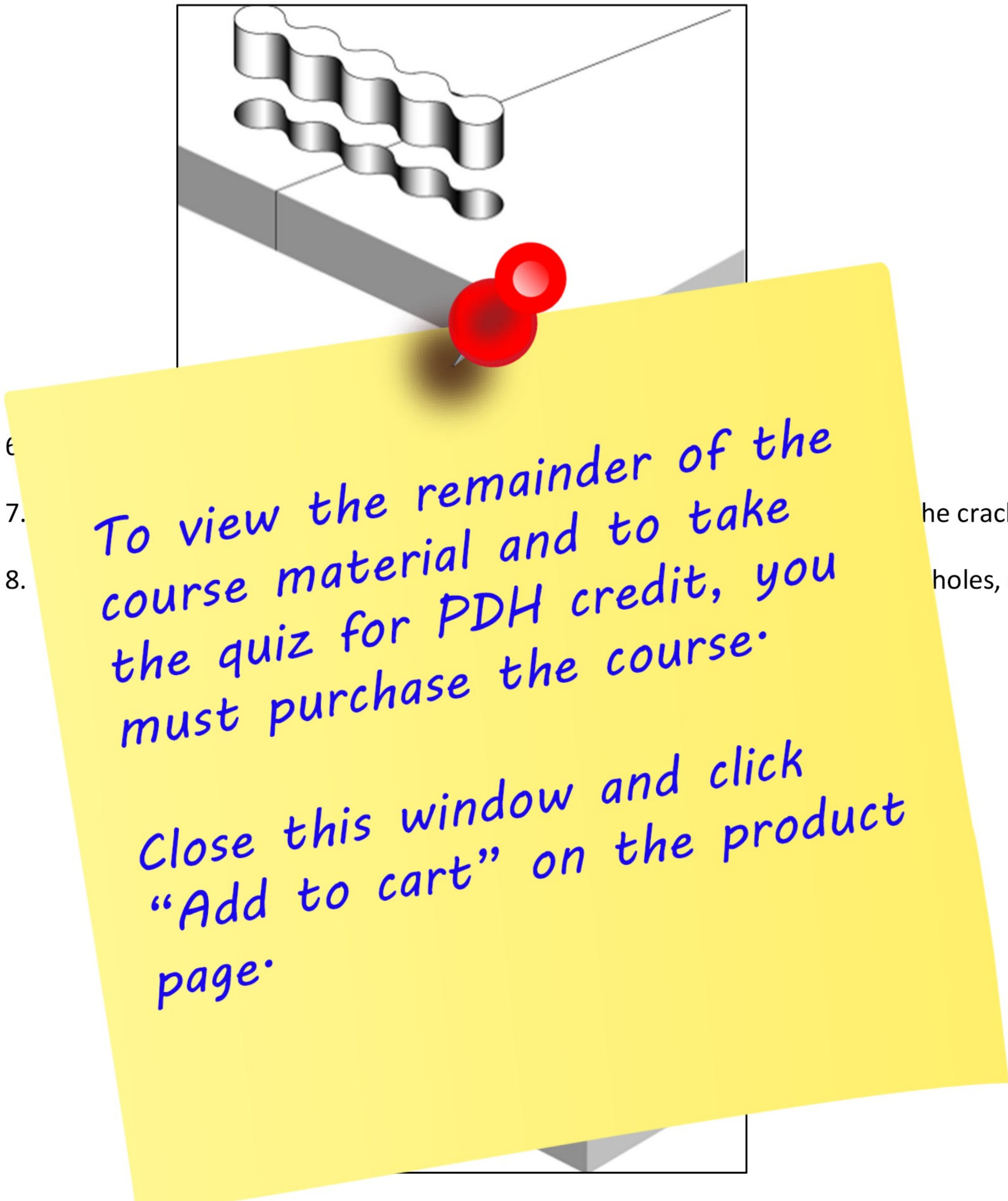
3. A drill guide is placed on the crack, and holes are drilled in a row perpendicular to the crack. The depth of the holes is based on the thickness of the casting and the depth of the crack. The axis of the holes needs to be in the same plane and parallel. Generally, the hole depth is limited to about 4” – 6”. See the illustration below.



4. The drilled holes are connected by removing the web of material between them. This is typically done with a chisel. Care is taken to ensure the bottom of the holes are flat and clean. See the illustration below.



5. The Metalock is installed in the resulting aperture, driven to the bottom, and swaged in place. Swaging the Metalock not only ensures a tight fit, but the cold work increases the strength of the Metalock. See the illustration below.



6.

7. … he crack.

8. … holes, cut

9. Step 8 is repeated until the crack is filled with screws. The screws are installed such that they overlap the adjacent screw or Metalock.

10. After the crack is filled with Metalock components and given a final swage, the Metalocks are left slightly proud of the surface where possible. If the Metalocks are installed in a mating surface the Metalocks can be ground or machined flush or below flush. Swaging secures the components in place and the cold work increases the strength of the components. See the illustration below.