

Alternative Method for Permanently Attaching High Integrity Injection Fittings to Repair In-Service Valve Stem and Packing Leaks

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Portable Friction Forge Bonding – An Important Emerging Repair Technology

Abstract – In recent years, regulatory authorities have increased emphasis on reducing fugitive emissions resulting from leaking valves, connectors, and associated piping. This regulatory focus has increased the need for equipment owners to identify and implement new, more cost-effective solutions for maintaining and improving valve and connector reliability.

This need to assure higher reliability has resulted in a growing industry trend to de-gas and remove from service, de-gas and repack or replace valves to improve emission performance. This operating strategy requires improvements in valve repair practices to assure each valve completes its expected life cycle between planned equipment shutdowns. This prerequisite need has created opportunity for development and implementation of alternate, cost effective, in-service repair methods that allow valves to remain below leak detection thresholds between scheduled monitoring periods, and minimize fugitive emissions.

Most valve maintenance programs for refineries, chemical plants and the oil and gas production sector are required to comply with NESHAP (National Emission Standards for Hazardous Air Pollutants) or NSPS (New Source Performance Standards). These regulations require application of Method 21 LDAR (Leak Detection and Repair) monitoring results and extensive recordkeeping and reporting to demonstrate compliance. While this approach is very effective at identifying requirements for leak detection it is less detailed with respect to specific repair methodologies for (in-service) valves that continue to leak. This lack of specificity generally results in the use of repair techniques that are generally unreliable, temporary in effect, and



Example of valve with multiple temporary repairs.

actually cause permanent damage to the valve. Given the limited success of in-service repair alternatives that exist today, recommendations and use of these legacy practices are generally left to the sole discretion of individual repair technicians. In fact many of the repair methods currently in use today have remained unchallenged for decades due to few advancements or technological improvements.

The purpose of this white paper is to assess the benefits of an emerging valve repair technology being offered by Forge Tech, Inc. That technology utilizes **Portable Friction Forge Bonding (PFFB)** to permanently attach a double sealed, injection port to the valve packing area of in-service leaking valves in order to allow injection of new generation sealants into the packing gland to meet regulatory mandated leakage thresholds.

INTRODUCTION

Friction forge bonding is a proven solid-phase metal joining process that produces very high strength metal-to-metal joints. It is a derivation of rotary friction forge welding, a well-proven manufacturing process that has been used for over five decades within major industries such as aerospace, automotive, and heavy construction equipment. In its generic form, this process is generally accomplished by use of large, in-place machine tools for joining materials with extreme or mission-critical product applications, as well as joining similar, dissimilar and exotic materials. [1]

PFFB was first introduced in the 1990's as a means of utilizing this reliable solid-phase joining process in remote or in situ work locations, including marine, off shore and underwater applications. It has since been identified as having significant potential for use at work locations where traditional joining methods, such as arc welding and other fusion methods are impractical or environmentally prohibited. Examples of these

locations include offshore platforms and petrochemical process plants. [2]

More important to the application usefulness, PFFB has, since the early 1990's, been consistently demonstrated and documented within industry literature as a safe process for use on live pipelines and within identified hazardous or explosive environments without creating a source of ignition. [3], [4], & [5]

Recent advancements in portable forging equipment design and joining methodologies have improved the strength and reliability of PFFB joining results, while lowering operating temperatures to improve safety.

Currently specialized application tools and equipment are available to address a wide range of industrial worksite applications that benefit from PFFB over more traditional fusion welding methods, especially where open flame and high bonding temperatures are prohibited, such as within Zone 1 areas on offshore rigs and production platforms. [6]

ESSENTIAL ELEMENTS OF THE PROCESS

Portable Friction Forge Bonding is a solid phase metal joining process that produces coalescence of materials by friction generated by mechanically-induced motion between rubbing surfaces under pressure. The essential process elements are:

- Axial force
- Rotational speed
- Durational cycle time

The process involves holding the parts to be joined together under significant axial pressure, and then rotating one part against the other to generate friction at the junction or interface. When forging temperature is achieved, sufficient to plasticize the materials being joined, rotational motion abruptly ceases, and continued axial pressure is maintained during the cool-down phase which causes coalescence of the contacting surfaces. This combination of physics results in a controlled short term operating temperature, high strength full-surface mechanical bond that has demonstrated to be free of voids and injurious flaw. [7]

MECHANICAL CONTROL OF THE PROCESS

The above described process takes place in just seconds and is mechanically controlled, therefore the process results are not dependent on human craft skills typical of traditional

joining methods, as used by fusion welding or brazing methods utilizing electro-arc or oxy-acetylene heating and melting and hand controlled application methods.

To be utilized effectively, the PFFB process requires specifically designed machine apparatus and coupled controller to govern the following factors:

- a. Regulating the rotational speed based upon the metallurgical characteristic of the materials to be joined, and the diameter of the material at the interface.
- b. Applying and maintaining the required axial pressure between the two parts to be joined, before, during and following rotation.
- c. Controlling process time -- that is, the time related to plasticizing the metallurgy, based on shape and size of surface area, which is typically just a matter of seconds.

The actual operational sequence of the machine is automatic and is controlled by a sequence controller which can be set according to the predetermined cycle schedule established for the materials being joined and by prior bench simulations and test qualifications.

The PFFB process utilizes forging principles and characteristics, producing a much lower joining temperature when compared to arc/gas fusion methods. Furthermore, this mechanical process is completed within a physically shielded inert process envelope for additional ignition source management, completely separating the workspace from its external environment.

Since process cycle normally is completed in just a matter of seconds, this significantly minimizes heat transfers through the pipe wall or substrate including surrounding work surfaces. Yet, despite this very short cycle time and lower joining temperature, it is widely accepted that friction forge joining is capable of producing one of the strongest metal to metal joints achievable.

During qualification of the PFFB procedure the completed bonds were tested under enhanced micro-examination, the bond area typically displays a defect free, very fine equiaxed microstructure grain, and when samples are subjected to destructive testing the bond is invariably found to be stronger than the base materials being joined; tests consistently demonstrate that failure occurs to the parent or substrate material and outside the actual bond area.

FIVE IMPORTANT BENEFICIAL CHARACTERISTICS

PFFB has several advantages over traditional joining and welding methods. Five are most significant regarding evaluation of this technology for attaching in-service injection ports; they are:

1. Much safer design process, eliminating hazards associated with drill and tap methods.
2. Superior strength.
3. Ability to join dissimilar metals.
4. Low bonding temperatures.
5. Completed on in-service equipment.

Of these, the low bonding temperature is fundamental toward establishing the appropriateness and usefulness of the technology. Utilizing PFFB for the installation of in-service injection port attachments, essentially creates a permanent injection port that becomes an integral part of the valve being repaired.

Use of this technology considers the need for defined safe work practices within hazardous or potentially explosive environments and the intrinsic safety of the equipment to make the attachment. The safety in design of PFFB technology offers a unique opportunity for making high integrity attachments to in-service leaking valves which are normally associated with out-of-service hot work.

Additionally, PFFB attachment methods have significant quantifiable advantages over drill and tap attachment:

- Elimination of a potential leak at interface,
- Fitting becomes permanent,
- Stronger and less prone to damage, and
- Hazards associated with pre-mature break-through are eliminated.

Essentially, PFFB can uniquely combine the best characteristics of both cold and hot work methods into one simple repair solution.

CURRENT PRACTICE:

REPAIRING VALVE STEM AND PACKING LEAKS

A. Drill & Tap Process:

Currently, in-service injection fittings are commonly attached using a drill and tap process. This requires identifying wall thickness by external measurements. The required thread engagement routinely requires drilling to within millimeters of the pressure boundary. The process consists of drilling through

the injection port into the pressure boundary of the packing gland (referred to as the “break-through step”) and could contain a High Pressure Packing Gland (HPPG).

This method has been viewed by many as temporary and a potential source of future leakage. This fitting is also subject to unauthorized removal. If the fitting leaks at the threaded interface, then the valve to which it is attached is designated as a leaking component and must be repaired. Remedies of this situation can include: addition of another injection fitting and reinjection or seal welding. Seal welding can only be safely applied when the leaking component is out of service and is free of vapor or liquid.

Drill & Tap Injection Process: This process is performed as a separate step allowing for an undetermined amount of release or leakage to pass the stem within the injection port while the bit is still contained within the packing chamber. The injection port is then closed and the packing chamber (HPPG) is removed. During this entire process of (1) closing the injection port, (2) removing the packing chamber from the injection port, and until (3) sealant is injected into the injection port, an undetermined amount of emissions occurs. (This rate can vary from minimal to severe.)

An undetermined release of emissions always occurs between the break-through step and the injection process. A more severe uncontrolled release potential can occur during the Drill & Tap process by inadvertently drilling too deep prior to installation of the injection port (referred to as “Premature Break-Through”). Forging the injection port prior to the injection process eliminates this severity potential.

All injection ports utilized across the entire leak sealing industry leak through due to the fact that they do not incorporate positive seal seats. *All injection ports leak by until they are injected with sealant.*

B. Forge Tech Inc. PFFB Leak Repair Process:

Forge Tech, Inc. has developed an **EPIK (Extreme Pressure Injection Kit)** specifically designed to repair valve stem and packing leaks on both standard and high pressure valves. The system incorporates the break-through step and injection step as a simultaneous process, preventing any external release of process thus providing 100% containment.

The result is a combined restoration solution which includes three primary elements:

1. Permanent Maintenance Platform that has a forged injection port and is re-servicable,

2. Extreme Pressure Injection Kit that provides 100% containment, simultaneous drilling and injecting, and a 2400 psi rating at 800 degrees F, and
3. Injectable Sealants which are compatible, compressible and Do Not adhere to internal valve components.

EXAMPLE OF INJECTION FITTING ATTACHMENT

The result of this combined restoration solution is a safer installation process, more permanent solution, with reduced VOC emissions.

*Valve serviced using
Forge Tech PFFB Leak
Repair Process*



PFFB VALVE INTEGRITY

The PFFB process has proven to have no detrimental effects on the valve quality, strength and use. It is superior to other in-line injection methods currently in use.

CONCLUSIONS

Portable Friction Forge Bonding technology has been specifically adapted and designed for safe use in the normal in-service valve work environments, including hazardous zones. It is useful and available for installation of injection ports for in-service valve packing restoration and also includes additional leak sealing applications. As a result, this technology holds great promise for making safe, cost-effective, reliable on-line service repairs and extending the operating life of leaking valves.

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AUTHOR INFORMATION

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Mr. Sadik's career prior to joining Forge Tech Inc. includes over 40 years of broad-based engineering experience within major petrochemical facilities. His professional experience includes major worldwide projects in new and operational plants in ExxonMobil Chemical Company. He is considered a specialist in detection and control of fugitive emissions and pollution control and consults internationally on air pollution control technologies.

Daniel Rybicki

Mr. Rybicki is an expert industrial technologist with over 26 years of welding engineering and design experience within aerospace and other leading commercial metal working industries, prior to joining Forge Tech Inc. He holds an MSc in industrial technology with emphasis in metal joining and has eight welding-related U.S. patents. He is a respected member of the American Welding Society (AWS), including participating membership on the AWS Peer Review Panel and several AWS committees.

Scott Todd

Mr. Todd holds a BSc in Mechanical Engineering Technology with academic and professional emphasis on engineering design, finite element analysis, capability maturity model integration, and earned value measurement. His experience prior to joining Forge Tech Inc. includes controlling the fabrication of experimental prototypes and commercial hardware for various NASA, Department of Defense, and industrial projects, including products designed to withstand the harsh environment of space and corrosive chemicals.