Kropp Forge Quiets Vibrations from Giant Hammer

Revolutionary, new elastomer shock system performs beyond expectations in foundation revamp.

Kropp Forge, Cicero, IL is a forger of aerospace components, known for its expertise with difficult-to-forge materials like titanium, high-temperature nickel, and stainless alloys. A vital part of its extensive line of equipment is a 50,000-lb, steam-powered Erie forging hammer. One of the largest of its kind, it gives Kropp Forge the ability to produce large, intricate, exceptionally durable high-stress forgings used in critical components for military aircraft and vehicles, construction, mining, helicopter rotors, and more. Weighing more than 1.6 million lb, it is estimated that this enormous hammer is capable of generating 550,000 ft/lb (750 kilojoules) of energy.

Operating a piece of equipment of this magnitude requires unique manufacturing expertise. Large parts, made from exotic alloys and a specific grain flow, with dependable strength consistency and reduced weight are among the hammer's capabilities.

Kropp Forge installed two of these forging hammers in the early 1950s, side-by-side in pits with 42×36×23.5-ft deep foundations weighing more than 5.5 million lb each. One hammer was later replaced with a 40,000-lb CECO steam hammer.

Foundation problems

In 2002, the Erie 50,000-lb. hammer began to exhibit significant movement during operation. Also, the hammer appeared to be tilting sideways and forward several degrees.

An examination of the pit floor at the hammer subplate confirmed the hammer had shifted unevenly. One corner was noticeably lower. A wet, mud-like, rocky material was being extruded from below the hammer subplate and accumulating at one end.

Vibro/Dynamics Corp. was one of several companies contacted by Ajax Technologies (another company in the Park-Ohio organization) for assistance, and its engineers met with Kropp Forge and Ajax Technologies personnel within several days of being contacted, to assess the installation. Historical records and interviews with Kropp personnel revealed that a variety of materials have been installed beneath the hammer over the years, as attempts to prevent the hammers from destroying the supporting foundation.

The earliest methods used multiple layers of massive oak timbers. Later, timbers were com-

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Erie 50,000-lb steam hammer ready to operate after installation of Vibro/Dynamics MRM Isolation Elements.

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bined with layers of pad material, and these were replaced in the 1990s with alternating layers of pad material and steel plates.

The most recent system (alternate layers of laminated fabric pad material and steel plates) was installed on top of a mixture of concrete and grout poured into the original pit, to compensate for a height difference between the timber/pad system and the new pad/plate system. The material extruded from beneath the hammer was examined and found to be a mixture of concrete, grout, pad material, and water.

The original foundation design and subsequent modifications were carefully examined. The installation of the CECO 40,000-lb. hammer in the adjacent pit was also studied. The findings indicated the additional concrete added at the bottom of the original pit had deteriorated and failed due to a combination of the transmitted shock and vibration, insufficient strength, pit flooding, and the new concrete not being securely anchored to the original foundation.

A long-term, successful installation of a piece of equipment of this magnitude presents a variety of unique challenges. In addition to its massive static weight, each blow of the hammer generates an enormous amount of shock and vibration.

Tremendous heat, steam, and water are always present in varying degrees, stressing all components to their limits. The combination of the severe operating conditions and the tremendous forces exerted on the installation make installing this steam hammer successfully a most challenging application.

Vibro/Dynamics engineers carefully analyzed the operating and structural characteristics of the hammer installation, using proprietary modeling software to predict the magnitude of the forces generated by the operation of the hammer.

The engineering analysis identified the following factors required to design a successful, long-lasting, high-performance, hammer installation system:

1. The ability to model accurately the forces generated by the hammer;

2. The ability to predict accurately the isolation system's response to the hammer's forces;

3. Design and apply the isolation system so its components operate at a low level of working stress; and,

4. Design the isolation system for severe and "worst case" operating and environmental conditions.

MRM Isolation Elements being lowered into pit using hoist rings.

Custom isolation system

To meet these requirements, Vibro/Dynamics engineers designed the first high-performance, unitized elastomeric isolation system — the MRM Isolation Element — specifically designed for forging hammer installations.

At the heart of the MRM System are modular, resilient cushions. Unlike sheets of pad material, each module is molded individually to tightly controlled stiffness and damping specifications. All modules are made using modern, high-quality polymers, specially compounded for severe manufacturing environments.

The modules can be molded in different stiffnesses, load capacities, durometers, and thicknesses, and also molded, bonded, or unbonded, to a steel plate. All of these variables are used to achieve the proper performance characteristics required for a successful hammer installation.

The modules are then rigidly fastened to a series of interlocking plates and assembled into a one-piece, unitized construction, called a MRM Isolation Element. The number of modular layers and columns is configured for each application.

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Quick and easy installation

Heavy threaded bolts keep the layers together and provide a way to lift and install each Element using hoist rings. This simplifies and speeds the placement and positioning of the entire isolation system, compared to manually placing and positioning individual pads and plates, layer after layer.

Taking the design a step further, Vibro/Dynamics engineers built in additional protections against "worst case" scenarios. In addition to the interlocking bolts and pins that maintain the position of the individual components, when multiple Elements are used, side buttress bumpers are used to maintain the position and spacing of the elements beneath the hammer.

The entire 1.61 million-lb hammer was installed on sixteen pre-assembled MRM Isolation Elements. Each Element was individually packaged and shipped by truck on simple skids. Once on-site, the shipment of Elements was placed next to the open hammer pit. Each Element was numbered, corresponding to the installation diagram, making it simple to determine the placement of each Element.

Hoist rings were attached to the lifting bolts on each Element, which then were lowered into the pit and placed directly on the concrete foundation. Installation proved to be quick and easy.

The following additional precautions were taken to prevent the Elements from shifting under any unanticipated operational conditions:

- 8×8-in. oak beams were placed around the pit perimeter and between the MRM Elements to secure the positioning of the elements.
- A series of flat bars and plates were welded across the elements, tying the entire system together.

Then, the hammer was stacked and assembled on the MRM system.

Vibro/Dynamics engineers calculated the expected isolation performance difference between the previous installation method and the MRM system. When compared to the previous installation method it was predicted that Vibro/Dynamics MRM system would:

- Isolate approximately 31% more shock vibration;
- Increase the bearing area on the foundation surface by 205%; and,
- Reduce dynamic force transmission to the foundation by 77%.

Before the revamp, foundation failure caused Kropp Forge's Erie steam hammer to tilt to the left and front.

When the 50,000-lb. hammer was first installed, neighbors more than a block away had reported vibration when it was operating. That situation changed with the installation of the Vibro/Dynamics MRM system.

The installation was completed on a Friday afternoon, with production set-up planned over the weekend. After working in his office across the yard for several hours on the following Monday morning, Kropp's president phoned down to the production floor to ask why the 50,000-lb. hammer wasn't running. The production supervisor responded it had been running all morning. Also, approximately a month after the 50,000-lb. hammer had been in full production, a manager at a printing company across the street ran into the president of Kropp Forge and asked when he'd get his big hammer running again — not realizing that it already was in production.

In summary, the unique design and features of the MRM Isolation system resulted in superior shock isolation, and a faster, easier installation. Elastomers with proper stiffness and damping, applied at minimal stress levels, will provide a long-lasting, trouble-free installation.

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