02FAS-7

Lightweight HH503 Handheld Riveter

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ABSTRACT

The handheld (HH) electromagnetic riveter (EMR) has been proven to be an effective means of installing rivets up to 3/8” diameter. However, early versions were heavy and cumbersome to use. A new generation of handheld riveting systems has been developed with substantially reduced weight and improved ergonomics by incorporating a spring-damper recoil reduction system. Additional improvements include a simpler and more robust control system and a 0-1000V voltage range to improve efficiency.

INTRODUCTION

The handheld (HH) electromagnetic riveter (EMR) was developed in response to problems inherent in the traditional pneumatic hammer and bucking bar method of rivet formation. The handheld units replace reliance on operator skill with easily repeatable high quality rivet formation due to the computer control of operating parameters. The handheld systems also improve the work environment since the noise levels are 20-26 dB less than pneumatic hammers and only have a single impulse per rivet. (1)

Early EMRs had two major assemblies, a driver that is in contact with the rivet and the body. An EMR functions by discharging a bank of capacitors and sending a pulse of high current through a pancake coil, part of the body assembly. The EM fields generated by the coil induce currents in a copper plate in the driver assembly. The net result is a repulsive force that can exceed 130kN and the driver is forced onto the rivet. The force produced is dependent on the charge voltage of the capacitors. The actuator body is forced in the opposite direction generating a recoil impulse.

In order to control the recoil generated by the EMR process, the first generation handheld units were heavy making them slow to position correctly on the rivet. The HH500 weighed 80 kg. With the proven effectiveness of EMR, the next step was to reduce the weight. This was accomplished with the introduction of a spring-damper system to the HH503, the improved version of the HH500, to isolate the operator from the recoil.

Figure 1. HH503 EMR system

HH503 EMR SYSTEM

MECHANICAL DESIGN

The primary design goal for the HH503 was to substantially reduce the mass of the actuator while maintaining the force output and rivet quality.

Recoil System

Previous HH500 models relied on a massive actuator to reduce to recoil to comfortable levels while the HH503 uses a spring-damper system. In this system there are three major assemblies: a driver, a body, and a handle. As in the previous handheld systems, a recoil impulse is generated when the rivet is formed but instead of being transmitted to the operator, most of the recoil energy is absorbed by a spring.

Function of the recoil system:

1. The capacitor bank discharges through the coil, creating a repulsive force between the driver and the body.
2. The driver is forced onto the rivet. The recoil force gives a rearward velocity to the body.
3. The body compresses the recoil spring, which decelerates the body. The damper only operates in one direction so the damper does not have any effect during this part of the cycle.
4. When the spring has decelerated the body to a stop, it begins to return the body to its rest position.
5. The damper operates during this part of the cycle and slows the return stroke so the body comes gently to its rest position and does not create a shock when it strikes the stop.

The body recoils within bearing surfaces machined into the handle shroud. The handle shroud completely surrounds the body, eliminating all possible pinch points when the body moves. The spring is located on the common body-driver axis. Preload is adjustable to user preferences. Due to its length, the damper is located on the top of the body. A pin-pin connection eliminates side loads on the damper that could lead to early failure. The optimum spring rate and damping coefficient were determined from test results. The recoil stroke is 75 mm.

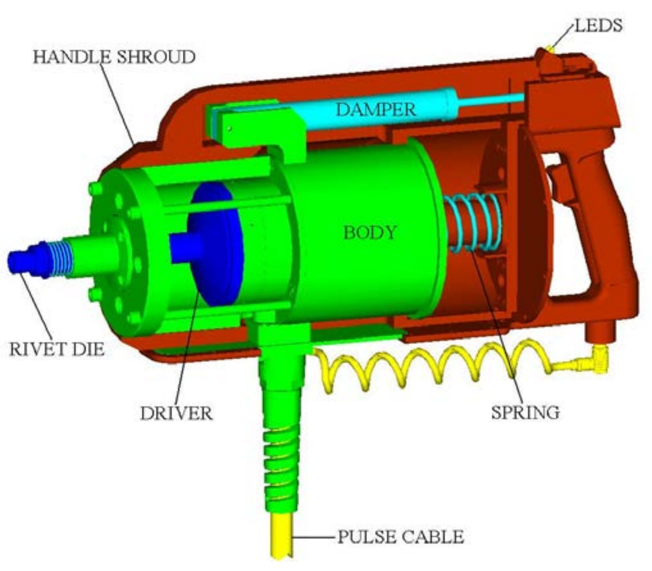

Figure 2. HH503 actuator cutaway

Mass Distribution

The ratio of the driver mass to the body mass is the controlling factor that determines the amount of recoil that is produced at a given output force. (3) Reducing the driver mass reduces the recoil. The driver assembly mass of the HH503 was reduced by 50% from the drivers used in the HH500.

With these changes, the mass of the HH503 was reduced from the 80 kg of the HH500 to 21 kg while still retaining the capability to upset 3/8" rivets and providing operator comfort. Seventy-five percent of the mass is concentrated in the body assembly.

Tooling

The time required to change tooling has been reduced. When an offset ram is used on the tailside actuator, the driver mass on the frontside actuator has to be increased by an equal amount to maintain proper rivet formation. Previous versions required that the front end of one of the actuators be disassembled when switching to offset tooling, a process requiring the removal and reinstallation of 9 fasteners. New tooling design in the HH503 eliminates the need for this, making a tooling change quicker and easier.

ELECTRICAL DESIGN

The maximum operating voltage of the HH503 was increased to 1000V. Operating at higher voltages offers a number of advantages. Figure 3 shows the force impulse of 1000V and 500V systems producing nearly identical peak forces. (2) The rise time for the 1000V system is much shorter. Since the area under the curve is the total momentum imparted to the system, the 1000V system produces substantially less recoil. In addition, at a constant power output, the voltage drop through a wire decreases as the voltage increases. This made it possible to reduce the wire size in the pulse cable from 2 gauge to 6 gauge resulting in a cable that is lighter, more flexible and easier to handle. The HH503 uses a 4" diameter coil and sixteen 3600 microfarad capacitors to provide 3/8" rivet capability.

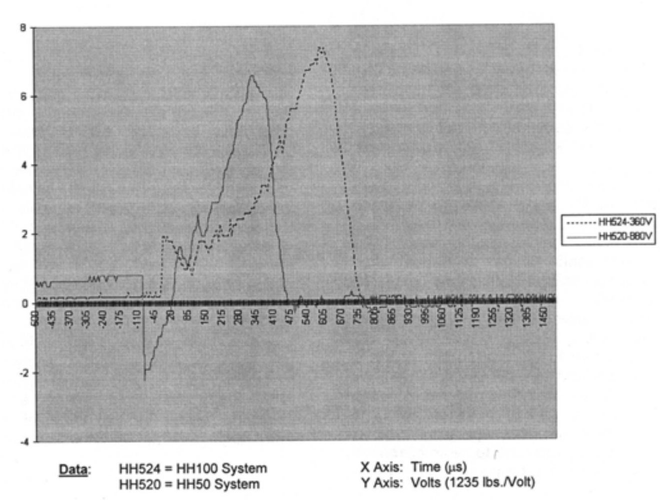

Figure 3. Comparison of 500V and 1000V systems

Simplified controls allowed the control elements to be incorporated into one of the capacitor boxes, eliminating the need for a separate control enclosure.

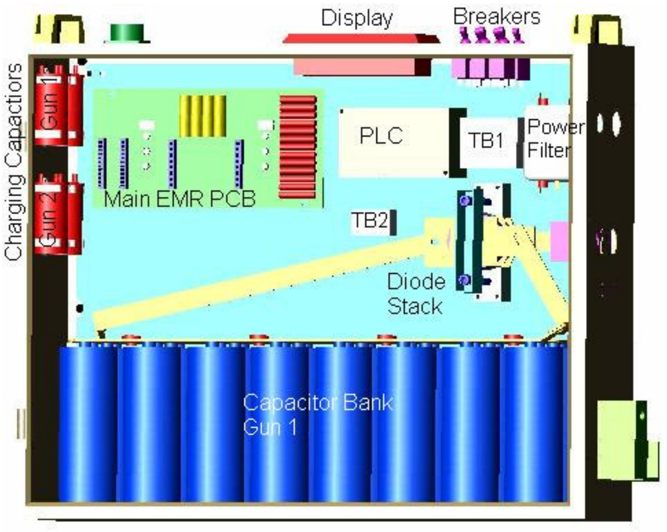

Figure 4. Control/capacitor box

CONTROL/USER INTERFACE

The HH503 controls have been completely redesigned with the emphasis on simplicity and reliability. The operation of the system is PLC controlled. The user interface is through a keypad with a LCD display. The display provides information such as mode, voltage and delay settings, and error messages. The keypad is used for mode selection, preset selection and parameter entry during setup.

Figure 5. Control Panel

Setup

During setup, the appropriate voltage levels for the head and tail actuators and the delay value are determined experimentally for each type of rivet that will be formed by the system. Once determined, the values are stored as a preset so that the system can be quickly reconfigured when changing between fastener types. The HH503 is capable of storing 20 presets.

Riveting

Handheld EMR systems require two actuators, one on the head and one on the tail of the rivet. The PLC fires both actuators simultaneously, or with a programmed delay, when both triggers are pulled. The system may be setup to fire only when the triggers are pulled in a specific order (master-slave operation) or regardless of which trigger is pulled first (both master). In the case of visual obstructions or noise, communication between the operators may be difficult. The actuators are equipped with two LEDs, a green one that signals that the respective actuator is ready to fire and a yellow one that indicates that the master trigger is pulled.

Other Applications

Besides riveting, handheld EMRs have also been used successfully for driving interference bolts for use with threaded or swaged collars and for removing the gaps left under the rivet tail by other riveting processes.

CONCLUSION

Handheld EMR systems have been proven to provide repeatable high-quality rivet formation efficiently with low noise. The new generation of handhelds retains these characteristics but with a new level of maneuverability and ease of use.

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