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Compact HH-553 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 7/16" diameter. However, early versions were heavy and cumbersome to use. A new generation of HH-EMR systems has been developed with substantially reduced weight and improved ergonomics by incorporating a spring recoil reduction system with dampened return. In addition, it has been reduced in overall size allowing operators to work much closer to a panel, by implementing a center-less coil/driver assembly and using a high-density Tungsten Back Mass to pack the needed recoil weight into compact space. Other improvements include a 0-1000V voltage range to improve efficiency, a simpler and more robust Siemens Touch-Panel PLC control, an insolated driver plate with a keyed pulse cable for a more robust operations, and a combined Air-Signal spiral line that runs separate from the main pulse cable, which significantly improves the life span of each component.

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. (1)

Recently most Health and Safety regulations have started to prohibit continuous use of pneumatic hammering to a few hours a day. Mainly due to continues noise levels violations and also due to continues shock throughout the hand of the operators. This handheld system improves the work environment because it is uses single impulse per rivet and provides ergonomics that reduces the stress to operators.

Early EMRs had two major assemblies, a Driver Assembly that is in contact with the rivet and the Body Assembly. 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 Assembly is forced in the opposite direction generating a recoil impulse. (4)

In order to control the recoil generated by the EMR process, the first generation handheld units were heavy and long making them slow to position correctly on the rivet. The HH-550 weighed over 100 kg and was over 0.75 m long. With the proven effectiveness of EMR, the next major step was to reduce the weight and the size of each actuator to improve the ease of handling.

Other goals were to implement additional technologies to improve, signal and air management and protection, making the system more robust.

The reduction of the weight and the size of an EMR actuator were accomplished with the incorporation of a spring-damper system, a center-less coil/driver assembly, and a high-density Tungsten Back Mass to pack the needed weight into compact space. The improved HH-550 system also features a combined Air-Signal spiral lines that runs separate from the main pulse cable. This split significantly improves the life span of each component making this system more reliable and robust.

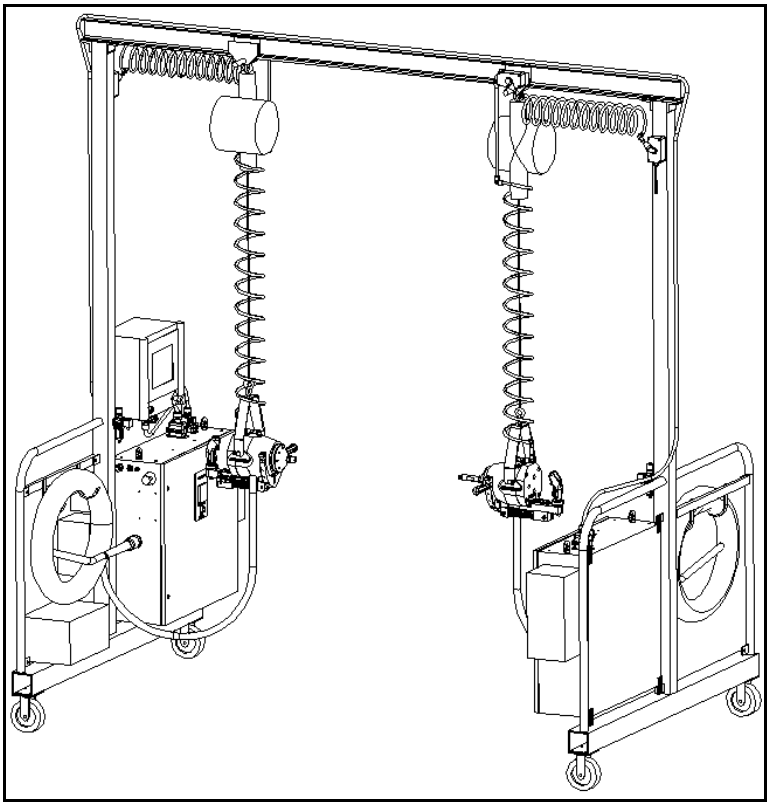

Figure 1 - HH-553 Riveting System

HH553 EMR SYSTEM

MECHANICAL DESIGN

The primary design goal for the HH-553 was to substantially reduce the weight and the size of the actuator while maintaining the force output and repeatability in rivet quality.

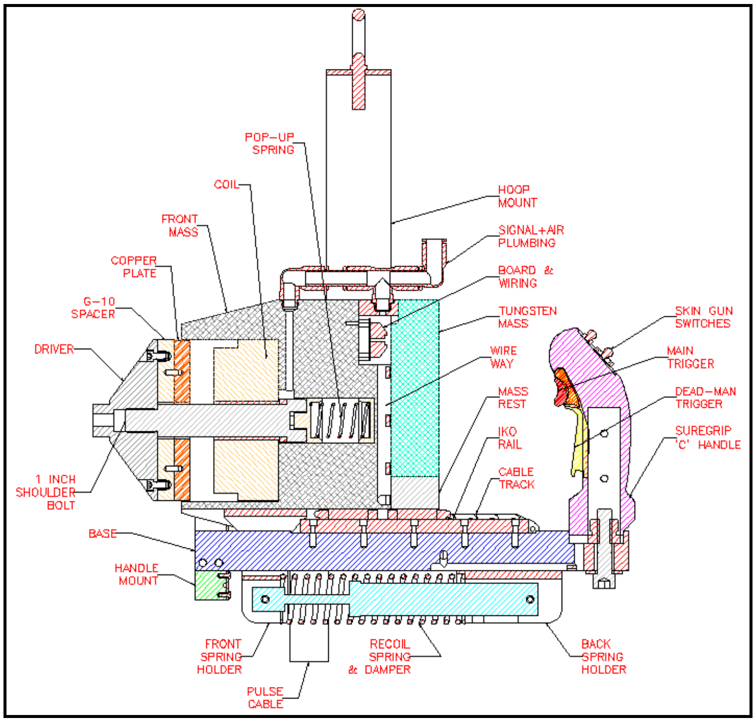

Figure 2 - HH-553 Actuator Cutaway Diagram

<u>Recoil System</u>

Previous HH-550 models relied on a massive actuator to reduce the recoil to comfortable levels, while the HH-553 uses a pre-loaded “spring recoil” with a one-way “return damper” system. This allows for an overall reduce weight of the system.

As in the previous handheld systems, a recoil impulse is generated when the rivet is formed but instead of being transmitted to the operator or to a large mass, most of the recoil energy is absorbed by a spring. Then, a damper slows down an already compressed spring from a rapid return.

Function of the recoil system:

1. The capacitor bank discharges through the coil, creating a repulsive force between the driver and the coil, which is attached to the recoil mass.
2. The driver is forced onto the rivet. The recoil force gives a rearward velocity to the recoil mass.
3. The recoil mass compresses the recoil spring, which decelerates it. 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 mass to a stop, it begins to return it to its rest position.

5. The damper operates during this part of the cycle and slows the return stroke so the mass comes gently to its rest position and does not create a shock when it strikes the stop. (4)

The spring and damper are nested to save space and are located just bellow the mass. A pin-to-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 less than 2 inches (51mm) at maximum power.

<u>Center-less coil</u>

Early EMRs had two major assemblies, a Driver Assembly and Body Assembly. The Driver Assembly is in contact with the rivet, and travels on the bearing located on the outside of the Body Assembly.

The HH-553 uses the same basic principle but with Center-less coil mechanism. Its major advantage is that it allows for the bearing to be position inside the coil. This permits for a for a much shorter and lighter driver shaft, which in this case is replaced with a 1” shoulder bolt. The overall Driver Assembly also includes a small mass, insolating spacer and copper plate on the threads of the 1” shoulder bolt. A safety pop-up spring is now installed behind the 1” shoulder bolt to keep the copper plate away from the driver unless it’s collapsed during normal operation.

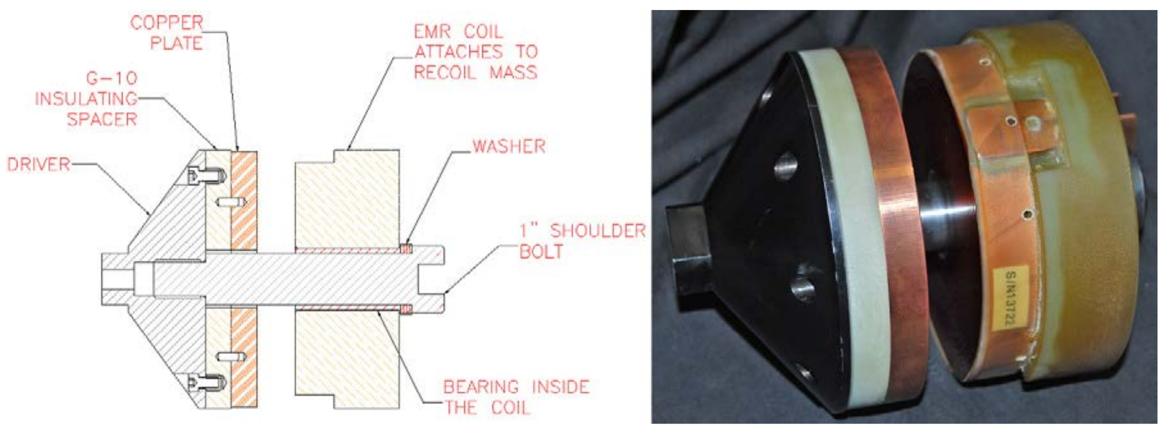

Figure 3 – Center-less Coil Driver Assembly

<u>Mass Distribution</u>

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. Reducing the driver mass reduces the recoil. (3) The driver assembly mass of the HH-553 was reduced by ~50% from the drivers used in the HH-550.

With these changes, the overall mass of the HH-553 was reduced from over 100 kg of the HH-500 to 54 kg while still retaining the capability to upset 7/16” rivets and providing operator comfort. Eighty percent of the mass is concentrated in the recoil mass assembly.

Combined Air-Signal Spiral Line

In the early models of HH the air line to cool the coil and the signal cable were bundled together with a large pulse cable. This grouped together bundle was very hard to manage.

In the new HH-553 the pulse cable is routed separate form the rest. The airline and a signal cable are combined in a very unusual, but very practical way. The small 1/4” OD cable is actually feed through the 3/8” ID spiral airline. This allows for enough cooling air to pass though, and the nylon walls serve as a signal cable protector. This Air-Signal line runs up-and-down from Actuator to the I-beam trolley and side-to-side to the frame. An airtight joint box on the I-beam trolley acts as both air and signal junction connection.

This split from the pulse cable significantly improves the life span of each component making this system more reliable and robust.

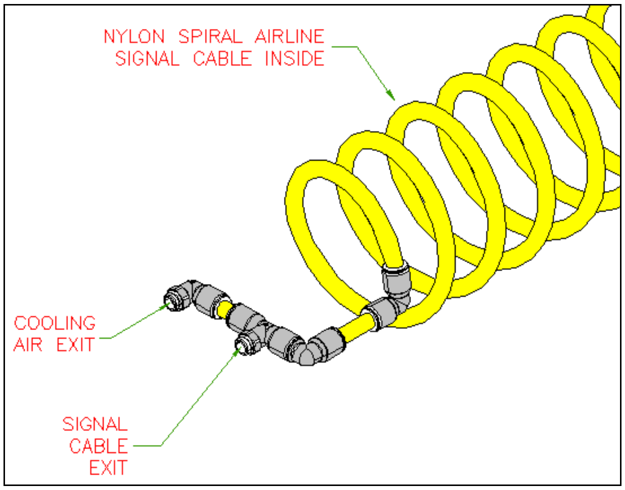

Figure 4 – Air-Signal Segment (Actuator end)

ELECTRICAL DESIGN

The maximum operating voltage of the HH-553 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.

The HH-553 uses a 5” diameter center-less coil, which in area is equivalent to out standard 4” diameter coil. The coil is connected to the a bank of capacitors by a 2/0-AWG cable. Each capacitor bank is equipped with sixteen 3600 microfarad 500V capacitors in 1000V configuration. All of this makes 7/16” riveting possible.

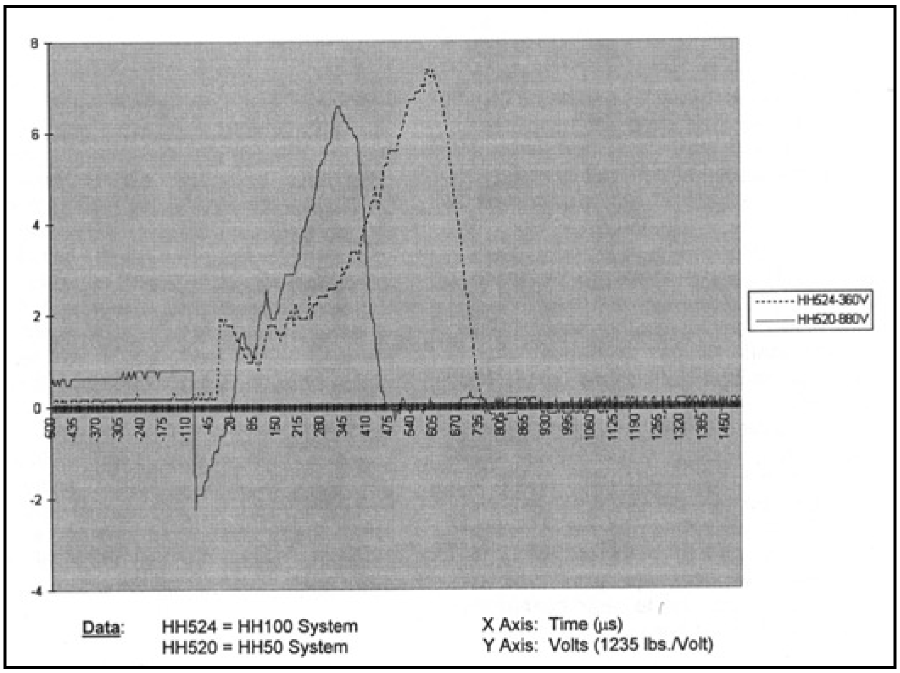

Figure 5 - 500V vs. 1000V EMR Comparison

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

CONTROL / USER INTERFACE

The HH-553 controls have been completely redesigned with the emphasis on simplicity and reliability. The system is controlled through a Siemens C7-636 10” touch screen PLC. The display provides information such as operating mode, voltage settings, various tests modes, and error messages. An example screen shot is provided in figure 6.

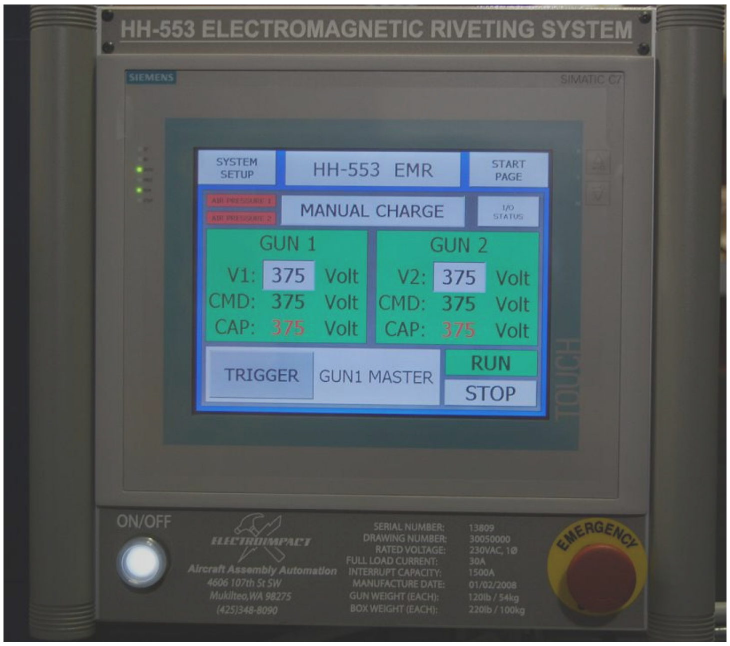

Figure 6 - Siemens Touchscreen PLC

Setup

During setup, the appropriate voltage levels for the head and tail actuators 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 HH-553 is capable of storing hundreds 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, when both triggers are pulled with the specified trigger sequence. The system may be set up 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 on each side of the gun, 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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