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ORBITAL HEADFORM STAKING
APPLICATIONS FOR MINIATURE
ELECTROMECHANICAL ASSEMBLIES

Technological Spinoff Report

C. W. Elder, Jr., Project Leader

Published August 1973

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**Kansas City
Division**

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C. W. Elder, Jr.
Department 822

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ORBITAL HEADFORM STAKING APPLICATIONS FOR MINIATURE ELECTROMECHANICAL ASSEMBLIES

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Prepared by C. W. Elder, Jr., D/822

A riveting method known as orbital headforming or "noiseless riveting" was investigated for potential application in the assembly of miniature electromechanical components. In this process, the punch contacts only a small area of the part at any time. Consequently, staking or swaging can be achieved with small tool pressures and minimum distortion of the part's grain structure: small delicate parts or parts of brittle materials (ceramic or plastic) used in electromechanical assemblies can be swaged or staked by this method. Sample parts were tested which simulated rivet and pin configurations, sizes, and materials found in miniature electromechanical devices. Most of the tests were successful. With refinements, orbital riveting would be a useful assembly method.

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THE BENDIX CORPORATION

KANSAS CITY DIVISION

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SUMMARY

As part of a process development on miniature mechanisms, orbital headform riveting was evaluated for potential use on staking and swaging small rivets and pins. The process "roll forms" the rivet or pin into the desired shape by constant pressure of the tool point. A rotating punch, held at a 4° angle to the vertical axis and mounted in a vertical rotating spindle is brought to bear on the part. During the forming cycle, the tool orbits as it turns or spins around the radius of the part being headed. Only a small portion of the part is contacted at any time by the punch. Consequently, less pressure is required to form the rivet head, and distortion of the rivet's grain structure is minimized.

Four rivet configurations 0.060 inch (1.5 mm) diameter or less and five materials typically found in miniature assemblies were made into samples and assembled on an existing machine. Pull tests then determined the holding ability of each. The results showed orbital headform riveting to be a useful method for many applications in miniature mechanisms assembly.

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DISCUSSION

SCOPE AND PURPOSE

Orbital headform riveting was investigated as part of a process development study of new staking methods to determine if the process showed potential application in miniature electromechanical assembly work.

Modern technology demands smaller components and assemblies; new methods of staking and swaging must be found to fasten these smaller parts together. Many staking methods are available for larger parts, but impact pressure and punch configurations render these methods impractical at times on miniature assemblies. Because of part size, material, and design, areas to be staked or swaged may be inaccessible to conventional punch design; the use of such punches may also damage the parts involved (ceramic or plastic materials, for example). The orbital riveting process with its low tool pressures and lack of impact forces offered a potentially useful assembly method for these situations.

To evaluate the process for this application, sample parts representing four typical rivet joint configurations were staked, subjected to pull tests, and analyzed.

ACTIVITY

Orbital headforming equipment has existed for many years and is in general use in industry. No information was found, however, about its use on the rivets of 0.060 inch (1.5 mm) diameter or less found in miniature mechanisms. Such rivets approach the low limit of size capability of this orbital headforming equipment. Therefore, trial samples were made to determine if the equipment would produce adequate results in this size range. The four rivet configurations (Figure 1) selected were representative of parts found in a miniature assembly: semi-tubular, solid internal hole stake, and external diameter stake.

These five rivet materials most commonly used in miniature mechanisms were selected for evaluation:

- 303 Se annealed stainless steel,
- 6061 T-6 aluminum,
- Soft brass,

SEMI-TUBULAR

SOLID

INTERNAL HOLE STAKE

EXTERNAL DIAMETER STAKE

Figure 1. The Four Rivet Configurations Used

- 17-4 PH annealed stainless steel, and
- 15-5 annealed stainless steel.

With exceptions, five semi-tubular samples were staked along with eight samples of the other three. All samples were held and centered in a special fixture (Figure 2). An adapter was designed for the machine spindle to hold interchangeable tool points (Figures 3 and 4).

Figure 2. Fixture Used to Center and Hold Samples

Figure 3. Tip Holder

Figure 4. Interchangeable Tips Used With Tip Holder

The machine had three separate limit controls of the staking operation. A dial set the extreme downward travel of the staking tool during the machine cycle; a control limited the tool pressure on the rivet and cut off the cycle if the limit was reached; and if neither the pressure or travel limit was exceeded, an adjustable time control cut off the machine cycle. The three controls and the compressed air line pressure to the machine were varied to give the best stake for each sample configuration. When the machine settings were optimized for each rivet and material combination, joints typical of Figure 5 were the result.

During the staking process metal fragments, slivers, splitting, and galling occurred to some extent on the samples. However, it is felt that improved punch design would alleviate the particle and galling problem while a post-machining annealing would prevent split rivets.

To evaluate the effectiveness of the staking operation, each sample was subjected to pull testing on an Instron tensile tester and the yield force recorded. Figure 6 illustrates the average value for each combination of joint configuration and material. The results were generally as expected, with the solid rivet joints and steel parts exhibiting the greatest holding power.

ACCOMPLISHMENTS

The orbital headforming machine was found capable of producing good staking results on pins of 0.060 inch diameter (1.5 mm) or less.

The quality of the staked joint depends on using a tool tip with good surface finish and smooth radiused edges.

The best staking results were obtained when the time control was the limiting factor ending the machine cycle.

Overall, better results were obtained on the stainless steel samples than on the aluminum or brass parts. The brass samples were the poorest in quality.

FUTURE WORK

A machine for the miniaturized electromechanical assembly area and further process refinements for particular assembly applications will be secured.

15-5 STAINLESS STEEL SEMI-
TUBULAR RIVET CONFIGURATION

BRASS SOLID RIVET CONFIGURATION

303 STAINLESS STEEL SOLID
RIVET SHOULDER STAKED IN
A HOLE

Figure 5. Examples of Rivet Configurations After Orbital Headforming

Figure 6. Pull Test Data