L. Application of Thread-Forming Fasteners (TFFs) in Net-Shaped Holes

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Objectives

- Move forward into the Technical Feasibility Phase applying thread-forming fasteners (TFFs) into net-shaped hole features in light alloy die castings for automotive applications as approved for FY 2005.
- Complete interim FY 2004 work scope that includes demonstrating the feasibility of applying TFFs into a cast engine alloy.

Accomplishments

- Successfully demonstrated concept feasibility for application of TFFs in net-shaped holes in FY 2003.
- Showed that clamp loads comparable to conventionally drilled holes and tapped fasteners could be achieved with TFFs in net-shaped holes.
- Completed casting and fabrication of as-cast engine alloy specimens for torque-tension mechanical testing.
- Assembled a broad-based team of contributors for moving forward with the Technical Feasibility portion of this program, including the automotive original equipment manufacturers (OEMs), fastener suppliers, assembly equipment suppliers, and manufacturers of cast components.

Future Direction

- Address, during the proposed Technical Feasibility Phase, a list of prioritized technical issues generated by the technical team:
  - casting variation
  - fastener design
  - assembling processing
  - in-service requirements
  - contamination and serviceability

Introduction

The Concept Feasibility portion of this project to investigate the use of tread-forming fasteners (TFFs) in net-shaped holes was successfully completed in 2003. The results of that phase indicated that comparable clamp loads to conventionally drilled and tapped fasteners could be achieved with TFFs in both aluminum and magnesium alloy castings. The Technical Feasibility Phase to address the highest priority technical issues resulting from the Concept Feasibility results has been proposed for FY 2005. An interim scope of work during FY 2004 was to obtain as-cast engine alloy nut and washer specimens and to perform initial torque-tension mechanical testing on these specimens.

Progress has been made in applying TFFs into machined or stamped holes featured in automotive applications for general assembly. Use of these fasteners eliminated the tapping operation and thereby reduced costs, reduced investment, and improved warranty while delivering better joint properties within an assembly. Opportunities exist to further reduce costs by using TFFs with net-shaped holes in lightweight castings by eliminating the drilling operation and associated equipment investment without sacrificing joint performance. Potential applications for using TFFs in cast components are numerous and include (1) powertrain (transmissions, engines, and rear axles); (2) chassis (control arms, suspensions); and (3) body structures that utilize large castings (inner doors, liftgates, under-hood attachments and supports).

Experimental Approach

The interim FY 2004 work scope to evaluate feasibility of applying TFFs into engine alloy cast specimens will be performed using the testing equipment and methods employed during the Concept Feasibility Phase, a summary of which is provided herein. Specimens for this testing have been cast and machined. Initial testing of these specimens will take place in early FY 2005.

To perform mechanical testing of TFFs into as-cast net-shaped holes, nut and washer plates were cast and machined into test specimens. X-radiography inspections were performed on a sampling of castings prior to final machining to verify structural integrity of the casting. The nut specimens included blind holes with 0.5° and 1.0° draft angles. A photograph and cross-section schematic of these specimens are presented in Figures 1 and 2, respectively. In addition, as-cast nut test specimens were prepared without a preset hole to allow for drilling and/or tapping of holes for comparison testing. Textron fasteners supplied 6-mm diameter (M6) Taptite fasteners with two coating types: (1) Magni 565, which is an organic coating, and (2) an electroplated zinc coating referred to as S437. Textron also provided

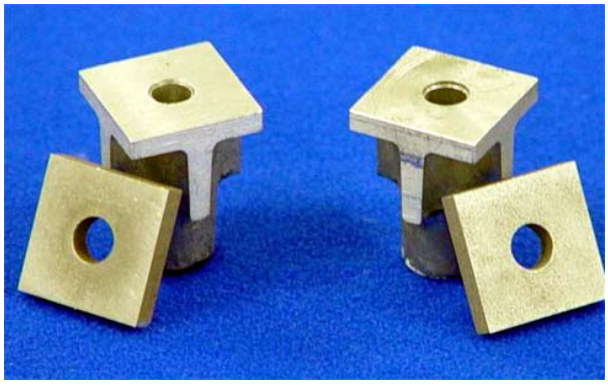

Figure 1. As-cast aluminum nut and washer specimens used for TFF torque-tension mechanical testing.

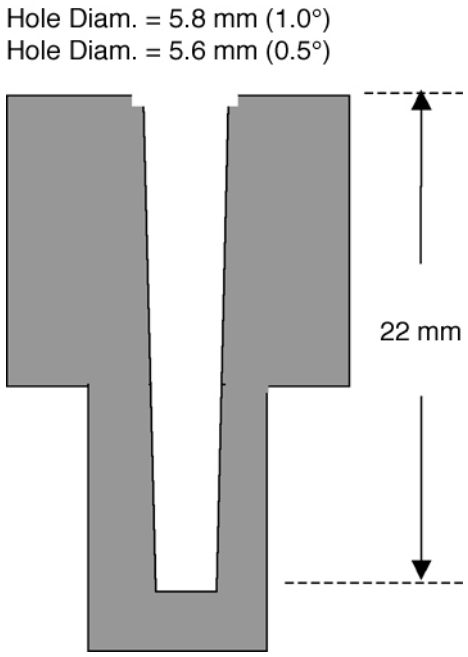

Figure 2. Cross section of nut specimen with blind hole at two draft angles (0.5° and 1.0°).

standard M6 machine screws coated with both the Magni 565 and S437 coatings for comparison testing. These fastener types were designed for use in aluminum.

The LabMaster Fastener Evaluation Test Cell was used to perform mechanical testing. This unit utilizes a slide bearing mount for the fastener drive system and mounting for the rotary torque-angle sensor and torque-tension research head. The fastener test system couples with a direct current (dc) electric nut-runner tool and controller, a rotary torque-angle transducer, a combination thread torque and clamp force transducer, and a computer control system for accurate test reproduction and data logging and reporting. The test stand equipment and nut-runner provided by Bosch Rexroth are shown in Figure 3. Individual mounting plates (Figure 4) were machined to size to hold the nut and washer specimens on either side of the load cell. The nut-runner was programmed to drive the fasteners to failure at a rundown speed of 240 rpm. During testing, the Labmaster software recorded clamp load, input torque, and failure torque vs time and angular rotations of the fastener for each test.

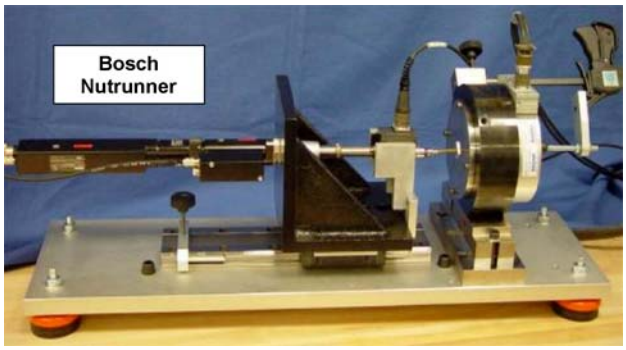

Figure 3. LabMaster Fastener Evaluation Test Cell from RS Technologies with integrated Bosch nutrunner.

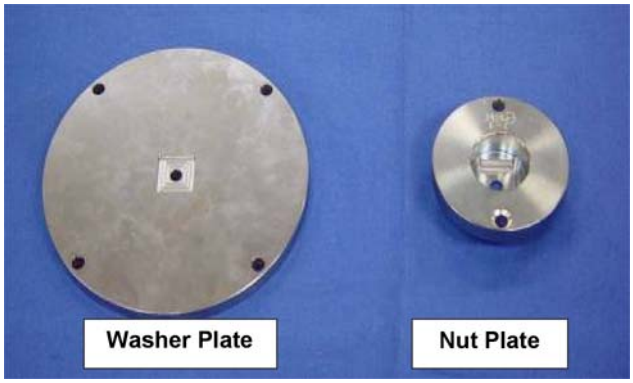

Figure 4. Washer and nut plates used with fastener test stand.

To better understand the role of hole geometry and type (net-shape vs drilled) and to compare TFFs to standard machine screws, a parametric study was designed that also included fastener coating type and thread engagement depth. This study was focused on aluminum, although some limited testing was performed on the magnesium specimens. The variables and a symbol for each are listed in Table 1. With two coating types and four hole types, a total of eight combinations are established for each thread engagement depth; for example, M0518 and S1015.

Table 1. Summary of test matrix parameters to be applied for engine alloy TFF demonstration

Variable	Description	Symbol
Coating	Magni 565	M
	S437	S
Hole type	0.5° draft angle	05
	1.0° draft angle	10
	Drilled hole	DR
	Tapped hole	TP
Depth	18 mm	18

Future Work

The Technical Feasibility Phase has been approved for FY 2005 to resolve the highest priority technical challenge to TFF application, casting variation. The major facets of casting variation are cast hole position (shape and size) resulting from the thermal, mechanical, and metallurgical effects of the die casting process. In addition, experimentation and field measurements in production die casting facilities and computer modeling are planned. Also to be considered in this phase are the closely related in-service issues of contamination and reusability. In addition, torque-tension mechanical testing will be completed on as-cast engine alloy nut and washer specimens.

Presentation

D. M. Paxton, “Application of Thread-forming Fasteners in Net-Shaped Holes,” presented at USAMP Casting Off-Site Meeting at USCAR, Southfield, Michigan, September 29, 2004.