# Variables of Thread Forming Screws into Aluminum and Magnesium Cored Holes

## Introduction

**This article will focus on key variables to implement thread forming screws (TFS) into die-cast, net-shaped holes in aluminum and magnesium alloys.** By definition, a thread forming screw generates an internal thread through material displacement. TFS generally have a lobular end, tri-lobular being the most common, to create pressure points for forming the material as the fastener is driven into the hole. There are many TFS manufacturers, examples are ATF, REMINC and Acument Global Technologies.

**Using these fasteners has 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 TFS's with net-shaped holes in lightweight castings by eliminating the drilling operation and associated equipment investment without sacrificing joint performance.** (**Diagrams 1** and **2**.)

There are significant hurdles to be overcome to appreciate this opportunity. Thread forming fastener technology is well understood for drilled holes in mild steel applications, it is not for aluminum and magnesium castings.

*Diagram 1.*

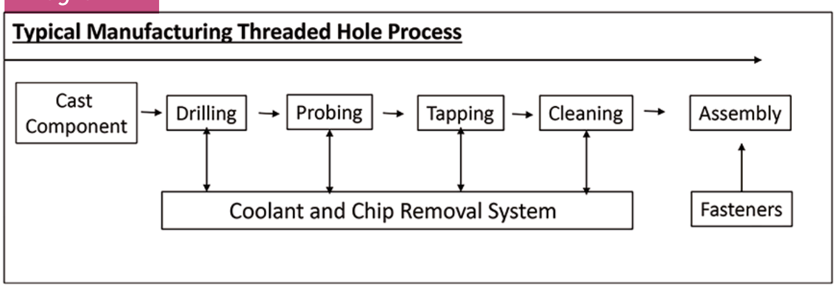
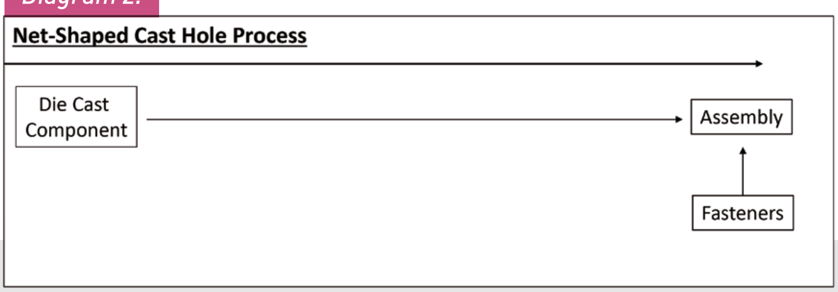



*Diagram 2.*




Dimension A is the length to screw nominal diameter.
Dimension B is the thread engagement: Aluminum, 2.5 x nominal diameter.
Dimension B is the thread engagement: Magnesium, 3.0 x nominal diameter.
Dimension C is the dimension B plus 4 mm.
Dimension D is the diameter at depth C.
Dimension E is the diameter at depth B.
Dimension F is the diameter at depth A.

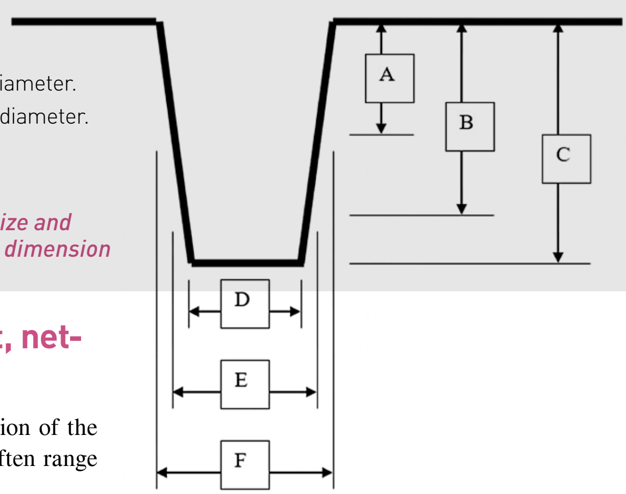



*Figure 1. Hole Size and Shape dimension*

## What are the basic dimensions for die-cast, net-shaped holes?

There will be slight dimensional changes based on the selection of the pin draft angles shown in **Figure 1**. Draft angle ranges on pin often range between 0.5 degrees and 1.0 degrees.

## Does the coating effect the assembly performance?

Coatings affect the assembly torque performance; reduction in thread galling and galvanic corrosion concerns. Also, coatings and thread geometry effect power tool assembly speeds. Often, the fastener manufacturer will provide recommended power tool assembly speeds.

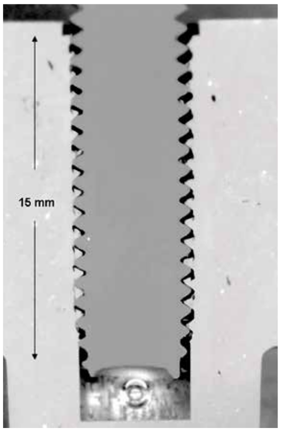



Photo 1.

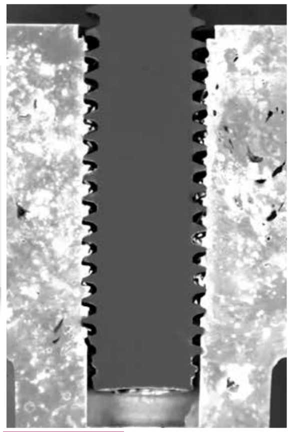


Photo 2.

*Photo 1. Cross-Section metallographic sample of M6 TFS at 15 mm depth into 0.5° draft angle as-cast hole in A380 aluminum.*

*Photo 2. Cross-Section metallographic sample of M6 TFS at 18 mm depth into 0.5º draft angle as-cast hole in AZ91D. magnesium.*

## Are there limits to external thread engagement?

There needs to be sufficient thread engagement to break the screw into two pieces as a failure mode. Avoid designs that the failure mode is stripping the thread before the screw breaks. Because there are many different mechanical properties of the aluminum and magnesium, a starting rule of thumb is 2.5 times the TFS nominal diameter for aluminum and 3.0 times the TFS nominal diameter for Magnesium (**Figure 1, Photo 1** and **2**).

## Are there assembly torque adjustments because of thread configurations?

The difference in thread geometry can result in a different torque performance especially during the initial assembly. Often on the first rundown when forming a thread, the tool speed is slower then increased to final assembly torque.

## What are some of the types of corrosion protection?

Often TFS are coated with Magni 565 for aluminum castings (A380) and ZinKlad for magnesium castings (AZ91D).

## Can different thread types of TFS be interchanged on the same die-cast, net-shaped holes at assembly?

Changing TFS with different thread configurations can change torque performance and increase contamination debris. It is recommended to use the same TFS as originally released.

## Robustness Testing

To understand the robustness, you may want to investigate a wider range of variation in cast hole sizes and shapes. The object is to see what happens to torque performance if the hole sizes were .05 mm larger or smaller than shown in **Figure 1**.

## Approach to Reusability

The purpose of reusability is to evaluate the capability for a fastener to maintain clamp load after repeated installation of the same fastener into the same die cast hole. To estimate the clamp load potential (without using a load cell), randomly select a minimum of 5 TFS from the lot being evaluated to establish the test torque. Apply torque to the TFS until ultimate failure occurs. Hand or power tool tightening is acceptable; however, the selected tightening method must also be used in performing the final manufacturing assembly. The average maximum torque for all 5 TFS failures is the ultimate failure torque. To evaluate the reusability, repeat 6 consecutive rundowns into the same hole using 80% of the ultimate failure torque. Allow time between rundowns to reduce heat buildup. Monitor debris and any thread damage (galling).

Photo 3.

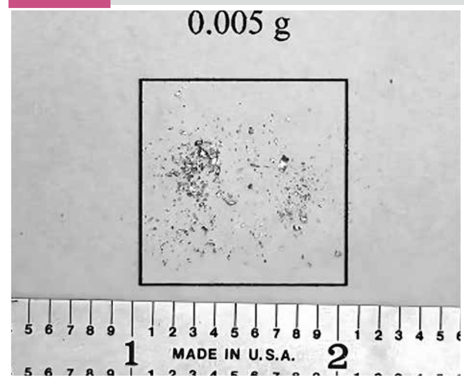



Photo 4.


Photo 5.

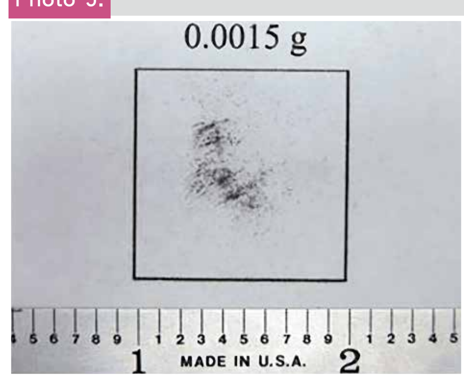



*Photo 3. Debris a fine powder*
*Photo 4. Debris with metal shaving*
*Photo 5. Debris of standard screw*

## Debris Contamination

A possible technical concern is contamination in the form of debris generated while TFS's create threads in die-cast, net-shaped holes. Based on the reusability 6 run downs, monitor the debris which could be a fine powder (**Photo 3**) or have miniature shavings (**Photo 4**). Lower hole tapper angles promote more debris (i.e., tighter holes). Also, the TFS thread design and surface coating will make a significant difference on debris. Note: Even a conventional die cast hole drilled and tapped for a standard screw will have debris. (**Photo 5**)

## What conditions effect the change in die-cast steel pin dimensions?

Holes in die-castings are created using steel pins inserted in specific locations in the die block. The potential exists for the dimensions of the die pin to change in diameter or taper resulting from repeated contact with the molten metal filling the die cavity. At high temperatures the molten aluminum and magnesium can distort the steel pin leading end which is the hottest area because a large die block acts as a heat sink. These changes have the potential to cause variation in the size and shape of the resulting hole in the die casting.

## Is there an approach to in-field casting variation for size and shape?

Instead of measuring actual cast holes, this approach is to measure the core pins that made the holes. Core pins are measured before dies are put back into service from major maintenance overhauls. Most dies are taken out of service every 20,000 to 40,000 cycles for routine maintenance and core pin replacement.

## What about casting variation for hole position?

Accuracy of hole position within a bolt circle is important to reduce any amount of shadowing of mating holes that affect the installation of the fastener. The cast hole position will ultimately be determined by the product design requirements and the designer's ability to accommodate the position variation in the specific application.

## Conclusion

The before mentioned are some of the highest priority issues associated with applying thread-forming screws in die-cast net-shaped holes in lightweight alloy castings. The combination of fastener testing and net die cast hole geometry can verify the capability to use thread-forming fasteners in as-cast components currently in production today. Environmental benefits and quality improvements result from this technology. The major hurdle to implementation is lack of confidence in achieving desired clamp load.

*Article by: Ralph White*