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THE POWER OF VALUE ENGINEERING - CONVERTING SCREW MACHINE PARTS TO COLD HEADED PARTS

As markets become more global, customers are ever demanding new ways for suppliers to deliver them value. Over the last ten years or more, these same companies have been reducing their engineering and purchasing staffs, creating a new dependence and responsibility in their vendors to generate both quality and cost improvement ideas. For many distributors, this new responsibility is an unwelcome diversion in their already hectic and changing environment. However, for a select few, these new expectations present a unique opportunity to be exploited and profited from.

Many customers have placed demands on distributors to provide annual cost downs in order to receive a contract. In many cases the supplier feels trapped by the necessity to provide cost downs to win the business, but believes that because their products are simple, commodity parts they have no means of cost reduction except to lower price and erode margin. However, if the customer is enlightened with a company philosophy of continuous improvement, their product is complicated, or their engineering and purchasing resources are thin or not well versed in cold forming technology, there may be some significant opportunities to conduct value engineering exercises that net significant quality improvements to their product, cost savings, or both.

One particularly constructive value engineering exercise is reviewing the possibility of converting screw machined parts to cold formed parts. I recall working on a project a number of years ago for a large automotive manufacturer. They were purchasing a threaded ball stud which acted as a pivot point for a gas strut used to assist in lifting the rear pane of glass on an SUV. They were purchasing the ball stud in high volume from a screw machine source for well over a dollar each. This part was converted to a net shaped cold headed part at a savings of nearly 75%. Not a bad savings for the customer and the part ended up providing the new supply chain with excellent margins.

At the outset, it should be clearly understood that upwards of 80% to 90% of the screw machined parts one might have a chance to review are, in fact, no opportunity at all. The engineers, designers, or purchasing agents have employed the correct process technology. However, in those remaining cases, where opportunity resides, the advantages and results of conversion may be very compelling, and provide one the ability to meet a customer's cost reduction criteria, strengthen a relationship, or expand one's part portfolio.

This article will explore the three primary considerations one should review when attempting to convert a screw machined part to a cold headed one. These considerations are cost savings, improved throughput (or yield), and strength.

In many customers' eyes, the one and only consideration is cost. Unlike the cold forming process which has minimal or no material waste, screw machining fundamentally involves material removal, often in significant amounts. When dealing with a low carbon steel that is priced at $0.75 pound this may not be significant, but is a severe handicap when exotic alloys and red metals costing many times that are utilized. In addition to the waste of removed material, the cycle times are often long which equates to added cost of attributed labor and machine burden.

The second primary consideration is throughput. Although the screw machining process makes a great deal of sense for small lots of parts with complicated geometries, the pendulum can swiftly swing the other way as lot sizes increase. This is quickly understood when one compares screw machining run rates of maybe several parts a minute to cold forming run rates of up to several hundred parts a minute. Naturally this is dependent on obtaining a cold headed blank as near net shape as possible so that the required secondary operations to achieve the final part geometry do not offset the throughput advantage from the cold heading process alone.

The final primary consideration is strength. Because cold forming and thread rolling deform and reposition the material, the grain flow is realigned with the shape of the part. In other words, if a head or collar is formed, the axial grain of the material is “bent” around as those features are formed. This realignment can provide significant additional strength. Like features on screw machine parts have not had the grain direction changed as they have been formed by cutting away excess material and thus don’t have this added strength benefit.

Anyone who has ever split an oak log for firewood can appreciate this phenomenon. If the log being split is from the clear, center section of the tree, the log splits cleanly down its axis with minimal effort. However, if a similar log had a branch sprouting from the side, so that the grain was bent around the protuberance, one can attest that the effort to split the log through that bent grain portion is considerable.

Although these three generally represent the primary considerations, there are a number of specific characteristics one should look for when reviewing whether a part is a good candidate for conversion. These include:

Round Parts with Multiple Steps and Transitions

Multiple diameter reductions are common and well suited to the cold forming process, however, in screw machining, each reduction represents increasing metal removal time and scrap. Figure 1 illustrates several cold headed parts exhibiting multiple diameter steps.

Figure 1

Round Parts with Collar or Significant Diameter Differences

When the diameter differential is small, as one finds on many shafts or pins, there may be little advantage to cold forming, however, when that diameter difference is significant, as illustrated in Figure 2, once again, the metal removal time and scrap from screw machining can be substantial.

Figure 2

Parts with Internal Recesses

The screw machine process is unable to form internal recesses. To achieve such internal drive features, costly, secondary drilling and broaching operations are required. Figure 3 illustrates several common recesses that have been cold formed.

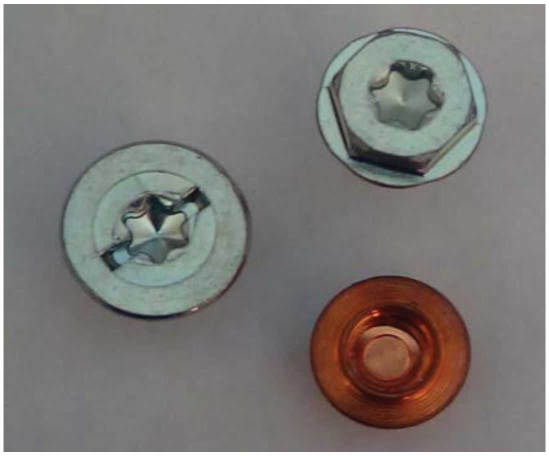

Figure 3

Parts with External Hexagonal Features

Although hexagonal bar stock is commonly utilized in screw machining, if the hexagonal feature is smaller than another feature on the part (such as a washer or flange feature below the hex), the process will require milling or some form of secondary. These would likely be time consuming and expensive compared to the trimming or forming processes employed in cold forming. Figure 4 illustrates several common hex shapes, including a hex stem on the far right.

Figure 4

Parts with Internal Bores

Long or stepped internal bores can be time consuming metal removal processes and may be more efficiently created using a cold forming, back extrusion process. Figure 5 shows three internal bore features on cold formed parts. The two upper parts are copper. Forming the internal bore eliminated a significant amount of expensive material scrap.

Figure 5

Parts Made of Expensive or Exotic Materials

Today, even steel, is expensive, but this is quickly magnified when one is working with red metals, aluminum, nickel based and other exotic materials. In cold forming, there is little or no waste of material, whereas a screw machining process may remove a significant portion of the pre-machined bar. When material costs are four to five dollars a pound (or much more for the nickel and exotic alloys) the savings can add up very quickly. Figure 6 illustrates parts produced with a variety of non-ferrous materials. The two parts on the left are copper, the upper middle part is aluminum, the lower middle part is stainless steel, and the part on the left is an exotic nickel based material.

Figure 6

High Volume Parts

It is difficult to say there is a specific rule of thumb here, as each case needs to be reviewed on its own merits. However, once a part begins to approach an annual usage of one hundred thousand or more pieces and possesses one or more of the other considerations for conversion, it would normally become a good potential candidate.

Parts with Special, Extruded or Trimmed Features

Often parts require special flats or splines, such as shown in Figure 7, that allow them to lock something in-place or transmit power. These features would normally require the screw machine version to be milled or broached, while it might be possible to form the same feature by extrusion or shearing in the cold forming operation.

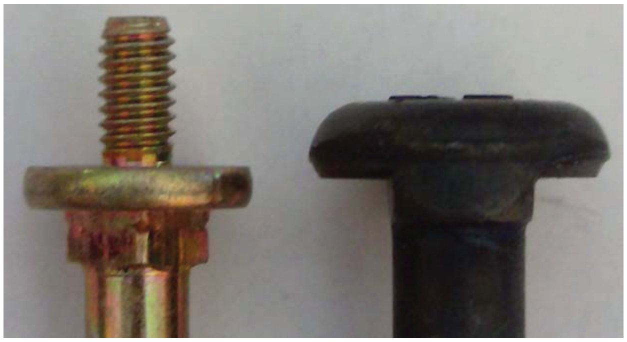

Figure 7

Parts Requiring Extra Strength or Fatigue Resistance

Cold formed and roll threaded parts, as previously described, provides mechanical performance benefits that increase strength or fatigue resistance.

The following case studies provide several real examples of how these considerations were employed to convert a part that was screw machined to cold formed. One of the significant advantages of screw machining is the tighter dimensional tolerances that can be achieved. To duplicate these, therefore, it would be commonplace to include secondary operations on the cold formed blank to end up with an equivalent part to the screw machined version. Naturally, this will offset some of the savings that could be obtained by conversion, yet, as these following examples illustrate, the improvements are often so compelling that even with the offset they make good sense.

Case Study 1: Aluminum Piston

Figure 8 illustrates an aluminum piston. This part was originally screw machined and then precision ground to obtain required dimensional tolerances on several of the cylinder diameters. Figure 9 shows the external view of the cold formed blank and an internal cut away. One immediately notices the significant reduction of material from the collar to shank diameter and the long internal bore. Although the outside of the cold formed blank required multiple secondary operations to meet the required dimensional tolerances, the internal bore was back extruded complete with no additional work needed. In this case, conversion to a cold formed part saved significant cost by reducing the amount of expensive aluminum scrap, reduction of metal removal time on both the exterior and internal bore, and increased the strength of the collar.

Figure 8

Figure 9

Case Study 2: Spindle

Figure 10 shows a spindle which was originally screw machined. On the right is the cold headed blank and on the left the finished part. It should be noted that the blank pictured was an early prototype and does not include the extruded double flat on the end, pictured in the finished part. The final version integrated these flats in the cold forming process. Although there were secondary operations required on this part, the cold formed version provided increased strength to the collar, threads, and flats on the end (important for reduced fatigue risk), reduced overall manufacturing time, reduced scrap, and provided sufficient capacity to fulfill the high volume requirements.

Figure 10

Case Study 3: Aluminum Piston

Figure 11 illustrates another aluminum piston. This is one of a family of similar parts that were historically screw machined. The right illustration is of the finished part. One sees the complex geometry and can envision the precise tolerances that go with these features. Although at first blush this may look like it would be best screw machined, it is also an excellent example of a potential candidate for conversion. Like the example in the first case study, there is a significant diameter differential, and being aluminum, cold forming significantly reduced the amount of expensive scrap and time-consuming metal removal that was required. Like the previous examples, the cold formed version required secondary operations to machine the top and point the end, yet even with these operations the reduction in process time was noteworthy. In an additional interesting development, this part was originally tempered to a T6 aged condition after forming, but eventually a process was developed to use wire in the T6 condition, forming the part into a finished complete state, and providing additional cost saving advantages.

Figure 11

In summary, there are usually compelling reasons that a part is screw machined, so that true candidates for conversion are in the minority. However, in those cases where parts possess some of the characteristics discussed in this article, the cost savings can be significant. In this day and age where customers are expecting value engineering from their suppliers, and suppliers are looking for ways to stand out from the crowd, this is one area that may be worth pursuing.