The Price of Quality

by Peter Standring

In a previous article for Fastener World, this Author addressed, 'The Price of Failure.' It considered the expense which could result if a Company manufacturing fasteners or supplying to it were unaware of or unable to appreciate the technical issues which concern the whole of the supply chain. As perhaps a natural follow on, this current article considers how successful 'quality' in manufacture is being achieved and the cost?

'Fit for purpose' is a legal term which states the acquired product, item, whatever, must be satisfactory in carrying out its design function. For example, an aluminium ladder will safely carry a given loading to a specified height. Unless stated, this would not be expected to be used horizontally to cross a crevasse in an ice field or to function as a replacement for a roll steel joist. Similarly, a tablet or laptop designed for home use would not be expected to function satisfactorily or for long in an aggressive industrial environment where robust use could cause its premature failure.

The word 'quality' is not used in the definition of 'Fit for purpose' because 'quality' is an attribute which may have little to do with satisfying the 'function' for which the product was made.

Of course, no one buying 'designer goods' would ever dream of paying the often exorbitant price unless they were assured of purchasing a 'quality' product. In this case, the 'designer brand' is the instant identifier of 'quality'.

For the humble fastener, 'Fit for purpose' is taken as read but the OEM purchaser also requires 'quality'.

So, assuming all of the components are 'Fit for purpose' and that the OEMs practice a zero parts per million defect policy, what does the term 'quality product' actually mean?

Issues of Manufacture

Figure 1, shows the typical percentage cost breakdown of manufacturing a forging. Naturally, this includes the direct and indirect elements of: equipment, material, transport etc.. The ubiquitous overheads are in effect a bucket into which often 'sloppy' accounting systems throw all the difficult to add in items.

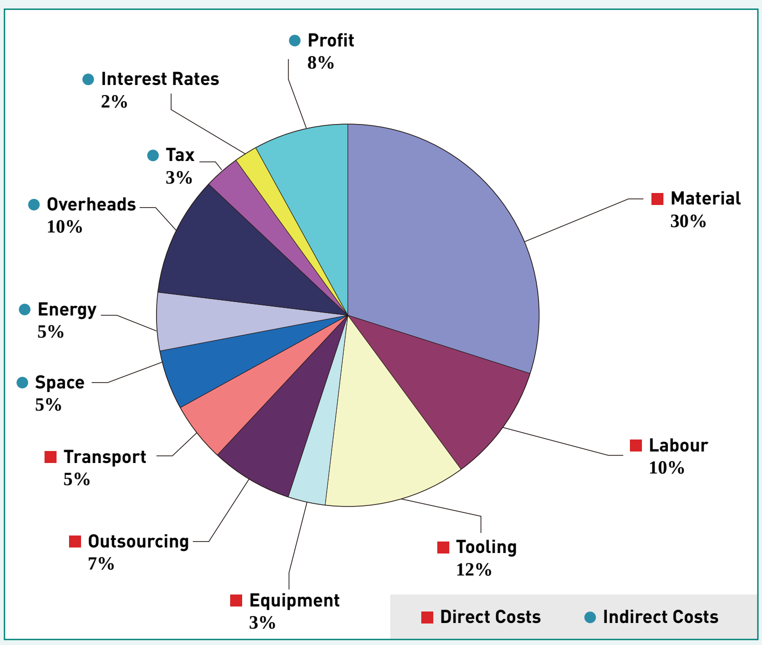

Figure 1 Typical Cost of a Forging.

Overheads can lie between 100 to many hundred percent of labour depending on the 'sloppiness' of the Company or the desirability of the brand. Considering only the direct 'manufacturing' costs, for any metalforming operation these would include: labour, equipment, tooling, outsourcing etc.. Any competent Manufacturing Manager will know and be in a position to assess the percentage cost of each element in the manufacture of a product. For example, x% on labour, y% on material, etc., and clearly using a simple Pareto analysis, work out where and how the largest cost savings can be made. It is not the purpose of this article to suggest engineers do what engineers should do, rather to offer additional insight into perhaps less common considerations which undoubtedly influence 'quality' and hence the cost of manufacture.

Labour. Clearly, those engaged in manufacture must be qualified and competent to do the job. No problem you might think, particularly where the employer offers the incentive to all workers, to enrol for educational courses up to degree level at a local University. One such global OEM the Author worked with did just this whilst operating a 'competitive' environment across all its factories. Each was able to bid in open tender against their own facilities elsewhere and other outside sources to ensure the lowest, most competitive price was obtained. However, the OEM's internal costs on labour were extremely high and this in turn contributed to the Company installing, where possible, fully automated systems. Also, in the accounting process, all equipment costs, depreciation etc., were included in the 'overheads.' Naturally this produced an overheads charge as a percentage of labour in the hundreds. The conversion of raw stock into finished parts being fully automated carried no labour charge and since the equipment etc., was charged to overheads, no costs were involved. Hence, all of the OEM's external competition for the work were immediately eliminated.

Where, personnel were involved in manufacture, these were classed as unskilled machine operators supported by 'engineering' qualified staff located elsewhere. For all machining operations, the facility worked well and was under 'control'. However at corporate level, the Company had adopted and installed a complex cold forming operation which the local engineering staff had no knowledge of or budget with which they could obtain the necessary external support to make it work. The result was the 'engineering' staff basically left the operation of the cell to the unskilled operators to figure out. This produced extremely high scrap rates which forced the intended single shift system to be changed to a continuous three shift operation to fulfil the required daily output. Being bonus driven, at the end of every shift, each team zeroed all machine settings so the next shift had to re-establish process control. Interestingly, many of the unskilled operators were in fact highly skilled in other ways and a number had obtained degrees from a local University utilising the Company's own 'education' policy. However, the often highly qualified workers had no intention of seeking promotion from their unskilled status simply because they claimed it was too stressful. Also, the pay rates didn't justify it. In this case, the OEM investment in automation and education though laudable, had totally unintended and undesirable consequences giving rise to a significant negative impact on 'quality.'

Materials. As stated in the previous article on The Cost of Failure, the more complex the alloy, the more expensive the means required to both form and obtain the desired output.

During the 1960's to 90's the 'quality' (Fit for purpose) of steel produced in the Eastern Bloc of Europe was well behind that of the West. One of the consequences was the development in the East of many novel cold metalforming processes to enhance the material properties. In the West, better refined, higher 'quality' steels were adopted for use making cold working an unnecessary way of achieving 'Fit for purpose' specifications. In the USA, steel was considered cheap and at a dollar a pound (in weight) irrespective of the geometry of the part, machining became the favoured route for production.

In today's globally competitive market, such simple distinctions between the 'haves and 'have nots' no longer pertains and the strength, fatigue life improvements obtained by cold working coupled with the material savings should never be discounted in the cost/quality equation. Getting more from less is the ethos of 'Industry 4.0' and if you can enhance the properties of material whilst you are making the part that must make better economic sense than paying more to obtain it?

Equipment. Decisions around equipment used to do a job are always complex. A one off piece of kit to do just one job can be uniquely profitable but it is also tantamount to having all your eggs in one basket. At the other end of the manufacturing scale, getting by using old, often worn out equipment will produce just what the International Tolerance (IT) chart suggests it will do. Getting a higher IT value out of inadequate equipment can be done but at a high scrap rate and with little confidence in the 'quality'. Moreover, to use equipment properly and to obtain the best performance requires the same level of competence in the personnel who set up and use/run it.

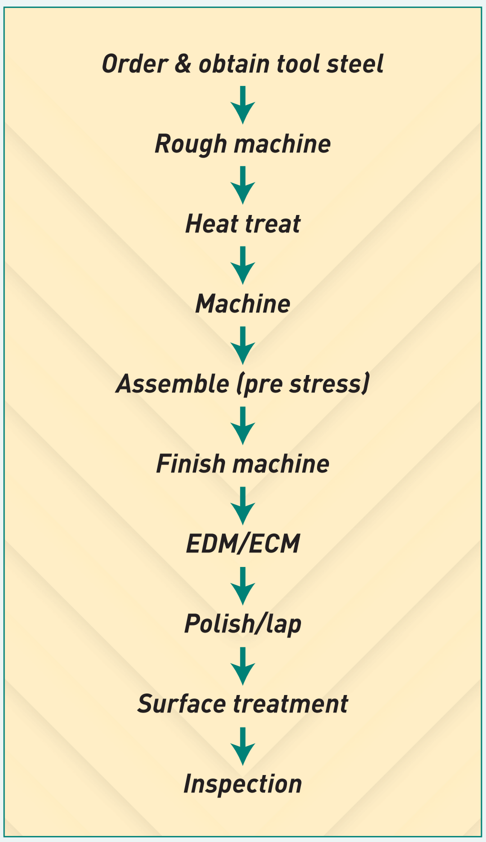

Figure 2 ICFG proposed operations for the manufacture of cold forging dies. (Details can be found in 'Tool Life & Tool Quality in Cold Forging', Part 2: Quality Requirements for Tool Manufacturing, Document No. 16/04).

Consolidation and rationalisation among the top metalforming players in the supply chain is continuing to create the same effect within the ranks of the equipment suppliers. Big is becoming bigger and 'specialist' remains just that. In between, the space previously occupied by long standing manufacturers of equipment is getting emptier! If this apparently inexorable trend continues, the only logical conclusion is that the 'big' players needing the 'specialisms' which are no longer be available, will have to do their own thing. In so doing, they will be returning to the vertically integrated facilities of Mr. Ford at Dearborn of a century ago. The James Bond song, "Nobody does it better", comes to mind which, if no one else does it, must be true!

Tooling. In the dim and all too distant past, almost every Company made their own tooling. It was the tooling which allowed you to do what you did and without tooling you couldn't produce anything. So the toolroom enjoyed a special place in all establishments as did the personnel who worked there. This view still largely pertains today only, where are they?

Cost reduction brought about by Standardisation and Rationalisation of both product and producers has led to a massive increase in the output of standard parts with just as dramatic a reduction in the number of Companies which make them. Perhaps toolmaking has been harder hit than most engineering specialists yet, without it, no technological progress can be made.

In cold forging and particularly multi platen powder metallurgy, it is the toolmaker's skill which transforms the often apparently crazy ideas of the designer into a cost effective reality. Cost effective in that the required highly stressed tools can be made and will survive the numbers of cycles needed to make the process cost competitive.

The International Cold Forging Group (ICFG) have been working and publishing detailed information for many years through the activities of their Tool Life/Tool Quality sub group (https://www.icfg.info/activities/subgroup-activities/tool-life-tool-quality-aims.html).

Figure 2 lists a sequence of operations which the ICFG propose should be made in the manufacture of dies for cold forging.

It is clear from Figure Two that each of the itemised elements introduces its own 'quality' considerations and each one could be directly or jointly responsible for the tool's ultimate failure.

Assuming that all has been done as well as possible, (and this will be costly) then the tool 'quality' may be established in terms of: accuracy, surface finish, hardness etc..

However, despite meeting all the specified 'quality' aspects, the ultimate factor for success is 'Tool Life.' In short, will it produce the 5, 50, 500 thousand parts it was designed to make or, despite all the cost and effort put into its construction, will it suffer catastrophic premature failure?

It is here that perhaps the reality check kicks in? The long held rule of thumb was that the instrument used to measure a part was capable of determining the dimension to at least an order of magnitude better than required. The same rule was used in tool making that the tooling should be ten times more accurate than the part. So with statistical process control (SPC), the tooling had to be one tenth of the component tolerance and on the side which could accommodate wear assuming the tool lasted that long. In today's seemingly crazy world where micro manufactured assemblies are being made, measured and assembled, the question this raises is, what defines the limit of accuracy which can be sensibly achieved?

Returning to the OEM problems introduced by automation and education mentioned above, the root of the complex cold forming problem lay with the preform design. In this case, preforms were fully automatically machined and inspected from hot forged raw stock. Unfortunately, the preform design created unintended unbalanced material flow inside the die cavity during forming. Every second shift this caused catastrophic failure in a series of high tensile bolts holding one of the tools. The maintenance staff who had to remove the sheared bolts quickly introduced a regime whereby the failing bolts would be replaced after every shift and before they failed. Although the unbalanced flow problem was identified and resolved, the schedule of bolt replacement was continued, just to be safe!

In another situation this Author was involved with, a global automotive Tier One won a contract to supply an OEM with specialised parts produced by an advanced cold metalforming process. A series of development trials had demonstrated that by using a specific steel in a ductile condition, the strains obtained during the cold forming process would provide the necessary as formed core strength levels required. This combined with a subsequent low temperature plasma nitriding operation would fulfil the design function. The key to the process lay in the preforming tool which produced the necessary preform geometry. Unfortunately, due to rationalisation within the Company, the team which had done the development work was replaced by a number of cost-cutters before implementation. One of the first cost cutting actions the new staff undertook was to cancel the preform tool order and to purchase a much simpler tool from elsewhere and at half the cost.

The result – you guessed – an oversize preform just where it could do the most damage to the final part tool.

The consequence, having no budget for a replacement preforming tool, the Company quickly discovered they were paying £1 per part final tool costs which pushed the process into negative equity. Even worse they were under contract to not only produce parts for the whole of the vehicle life but also the aftermarket way into the future.

Fastener Quality

I want a fastener, maybe a screw, a nut and bolt, a rivet, a split pin. It may be for decorative, security or simply general use but in each case the specific term is ‘use.’ If I never use it, it has no purpose; if I use it and it fails it is not ‘Fit for purpose.’ So the basic element in making my fastener a success is, does it satisfy my need? This should be quite properly defined in the ‘specification’ to which the item is manufactured. Since no customer should ever receive a defective product, nothing more is required.

However, although with 100% inspection no defective parts may emerge from the Despatch Department, defective parts will be produced and scrapped internally. It is this rate of scrapping which can seriously influence the balance sheet and which sometimes may be hidden. In the OEM case discussed above, every morning at 7.00 am, the Plant Manager walked along each aisle of the $700 x 106 worth of equipment making a note of the scrap levels at each station. Committing this to memory he then nodded to the recycling contractor following behind who immediately whisked all trace of the scrap off the plant. In such an environment, obtaining evidence of failure and identifying its cause(s) is almost impossible.

A well planned and organised approach tackling each element of direct cost within the manufacturing area and involving all parties in the discussions will pay off. This should result in the on-going recording and monitoring of performance of all aspects of production demonstrating the benefits obtained and the progress made. This is where the true value of ‘quality’ lies and where the costs occur if you get it wrong. Statistical Process Control charts indicate the time and need for intervention before the process goes out of control. A similar approach should be applied for the whole of the manufacturing plant. If this is done properly, the information gained can be acted on knowing that you are in control.

As an old friend had on his mouse mat “If you always do what you always did, you’ll always get what you always got!

Hey and he was so right but then, his always was a ‘quality’ act!