Fault Diagnosis - what to look for

by Dr. Peter Standring

"If only we knew then what we know now!" This plaintiff and often despairing cry must have been one of mankind's most oft heard utterances. The language is universal – "where did it all go wrong?"

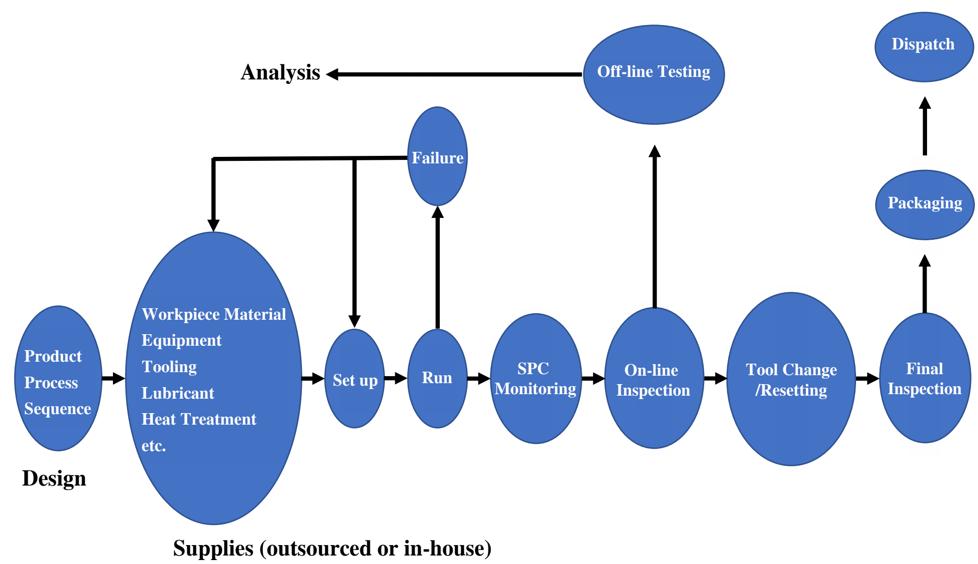
The wringing of hands following some unexpected failure is an entirely proper reaction since it shows a realisation that something untoward has taken place which in turn should prompt an enquiry as to why.

Unlike the religious penitent seeking support from a supernatural source, engineers see the ball firmly in their court and recognise it will remain there unless they do something about it.

So, where to start? The failure must be the most valuable source of all engineering information. I was once invited to witness a controlled, automotive crash test costing upwards of $1 million. My memory of the occasion was not of the sensors, cameras, noise or result but of the consternation on the faces of the engineers when they realised that what had happened was not what their hugely expensive and complex software models had predicted.

It is the unpredictability of a failure which makes the failure so valuable since the opportunity to accurately replicate it is often beyond our capabilities to achieve. To throw a failure away without using it as the primary source of evidence as to why it happened is both woeful and wasteful. Solving any problem leads to knowledge and that knowledge gives rise to understanding. Engineers who don't understand are very likely to experience the same mistakes again. In a research environment, this may be an acceptable risk, in the commercial world, it is not!

Figure One. Fault Diagnosis: In-House



Tracing the source

'Self distancing' is a term which the world has very sadly come to recognise and which only a few months ago was largely unknown. But the reaction is one which all manufacturers and their customers have practised for years. Under normal conditions, when all is well, things continue as before. Find a fault and immediately self distancing kicks in followed by methods to diagnose the cause and eliminate the problem. Found inside the manufacturing plant, faults can be dealt with discretely. Picked up outside the manufacturing base, then the issue becomes very much more serious and can/will have reputational and financial consequences.

As shown in **Figure One**, all fastener manufacture begins with design. Naturally, the product which is being manufactured together with all the processes, equipment, sequencing, etc., which are required to produce the part. It is a generally accepted axiom that 95% of all manufacturing costs are design related. An inappropriate choice of material and/or treatment, processing methods etc., can reduce the effectiveness of a well designed product. Alternatively, no matter how good the manufacturing system may be, a poorly designed product will remain just that.

The very best opportunities for fastener manufacturers to succeed are when they have full control over the product design. Of course, for standard parts and customer specific designs, this is not possible. However, where possible full manufacturer/customer participation can not only generate a functioning partnership but also allows the supplier to create a customer confidence that can cement the relationship.

Assuming both product and plant capacity are deemed satisfactory the manufacturing process begins with the material. Delivery, storage, inspection before use and in process sampling etc., will naturally vary depending on the scale of fastener manufacture. A large throughput will require in-house inspected facilities to continuously support every stage of the manufacturing process. These off-line activities will supplement the on-line equipment based sensors which provide piece part monitoring and information of machine performance for statistical processing control (SPC). The more sophisticated the data acquisition coupled with the analytical methods to monitor trends, the greater the control the plant management will be able to exercise. With such information, scheduled tool changes, maintenance can be sequenced to obtain maximum efficiency of throughput.

The volume of a large fastener manufacturer may be many times that of a smaller, perhaps specialist producer. Yet, through process control, the chance of defective products leaving the plant undetected is often much smaller. This is because the large scale throughput can justify the plantwise investment in quality control methodology and equipment to ensure the quality standard is assured.

Where a manufacturer has to purchase random wire/rod etc., at varying frequency, then the nature of the input material, although standard, will also be variable. This is because primary producers of metal alloys are cost competitive on volume. Therefore, the more they produce of a given product, the lower the price. However, although the chemical composition and processing route remains within a specified standard, from batch to batch they will vary. So, for a small fastener manufacturer running a range of small batch products, the material being processed will behave differently. In the main, this may pose no problems. But if, due to limitations of equipment, the processing route pushes the material to the limits of its performance capabilities, then problems may arise.

Catastrophic tool failure is self evident. However, cracked tools may provide defects on the formed parts which may not be picked up by visual means. These and other non visual defects as potential stress raisers due to excessive cold working, could, during heat treatment and/or in service, lead to fastener failure.

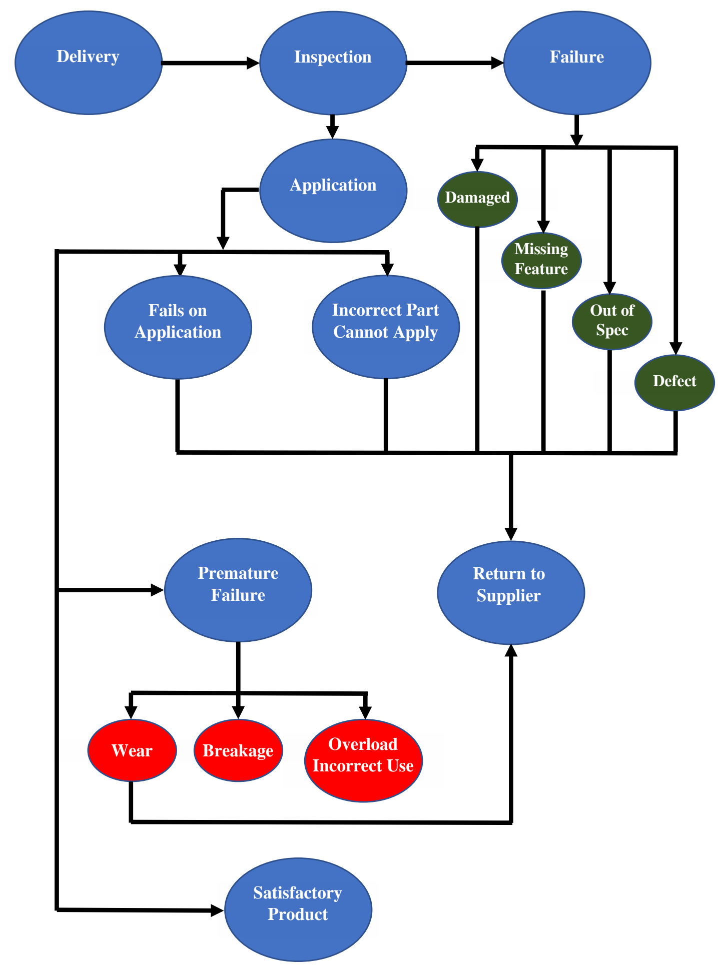
For the large, well established fastener manufacturer, it is the invested science, testing and trend analysis which ensures success. At the other end of the fastener production sector, it is primarily, the hands on skill, familiarity with the equipment and knowledge of the staff which, within their capabilities and experience, fight the constant fear of the unknown. A new type of failure here almost always involves detailed diagnosis of the complete process.

A classic example with which this author was involved concerned a specific light metal alloy fastener for a military application. The material was sourced overseas as individually cut items and obtained in the normalised condition. Production runs were carefully scheduled. The forming process was pushing the limits of the material. A sporadic problem was noted which, when it occurred, resulted in tool breakage and poorly formed parts. In short, the process would not run. The timing of these failures occurred after company shutdowns and was determined to result from the age hardening of the input material due to unscheduled storage. This, coupled with the nature of the deformation, exceeded the stress limits of the tooling thus causing tool and part failure. Once the normal production schedule was resumed, the normalised material worked perfectly satisfactorily. In this particular situation it required an understanding of sequencing procedures along with the relevant failures and material characterisation in order to diagnose the true cause and provide an acceptable solution.

Failure Outside the Factory

Figure Two, illustrates a sequence of possible In-Service failures which might occur post delivery of a fastener order. Rapid identification of damaged or inappropriate goods might pose the least problem? The inability to employ the fasteners, although presenting difficulties could also be handled without downstream potential disaster.

Figure Two. Fault Diagnosis: In-Service



However, once in service, premature failure through unanticipated wear or breakage could be indicative of inadequate material properties due possibly to batch variation in heat treatment? Catastrophic failure due to overload/fatigue etc., would be an issue related to the design of the product and its not being fit for purpose.

A one off failure picked up and reported during servicing or following a non related problem (crash etc.) should be registered but without further action. A number of such similar failures, depending on the seriousness of the problem could lead to warranty issues and customer recall.

As stated previously, self distancing from a high profile, in-service failure, will often result in significant reputational and possible financial damage. To be successful, the 'humble' fastener needs to remain fully functional, maintain a low profile, and be part of the story. For a fastener to become 'the story' could prove very costly indeed.

Conclusion

The old saying, 'Don't cry over spilt milk', is sound advice. For all fastener manufacturers it will clearly be better not to spill any milk in the first place but if such an accident were to occur, make sure the milk stays in-house.