MANUFACTURING WHITEPAPER SERIES

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The ROI of Improving First Time Yield

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When it comes to manufacturing, one of the most commonly used metrics is the production yield, i.e. the number of good parts produced divided by the total number of parts started in production. But yield on its own can be deceiving if parts can be re-worked or re-tested.

For example a 98% yield may sound great, but if 90% of the parts require some amount of re-work, the manufacturing process may actually be very inefficient. In situations like this a better metric is the First Time Yield, or FTY for short. This is defined as the percentage of good parts produced that make it through the entire manufacturing process without any failures. The problem is that in a complex process where there are many steps, and parts can be re-worked or re-tested multiple times, keeping track of whether a part passed each step in the process without ever failing can be a time-consuming and laborious undertaking. As a result, too many manufacturers simply do not track first time yield on a regular basis. What they may not realize is that this oversight could be costing them millions of dollars each year.

For these manufacturers, we must answer the question: how important is it to regularly, and accurately track FTY? What kind of return can you expect on your investment, if you put in place the infrastructure and processes necessary to collect this information? The simplest way to demonstrate the importance of FTY is by exploring a quick example that illustrates how even small improvements in first time yield can produce very large savings in your product costs.

Calculating FTY

Let's start by reviewing the basic math. We begin by breaking things down into the individual yield-contributing process steps, i.e. any stage in the process where a part can be passed or failed. At each of these steps, we calculate an FTY, independent of what takes places at all other steps in the process. As described above, this involves counting only those parts that passed on the first time through the station, then dividing by the total number of unique parts that have been processed there. Note that this is fundamentally different from the station's final yield, which is the number of good parts produced (independent of whether they passed on the first try, or how many times it was re-worked and tested before it was finally passed or scrapped) divided by the total

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number of parts that were started. In the FTY calculation, each serial number is only counted once. These equations are illustrated in Figure 1 below.

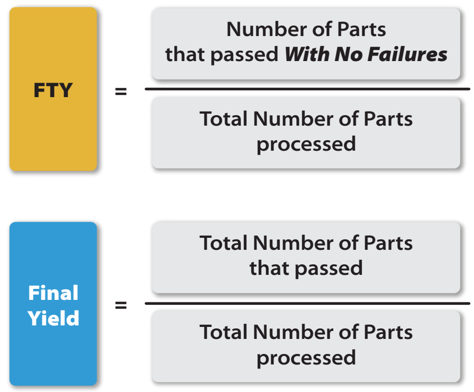

Figure 1: FTY and Final Yield calculations

This calculation is repeated at each step, to produce a series of station FTY values. These are then multiplied together to provide the overall, end-to-end yield, as shown in Figure 2. This is sometimes referred to as the Rolled Throughput Yield, or RTY. The advantage of calculating the overall FTY in this manner is that it eliminates the need to track each individual serial number through every step in the process to ensure that it actually passed without any failures. Furthermore, if the overall cycle time is long and it can take parts several days or even weeks to get through the entire process, each individual part history would actually span a significant period of time. Parts that failed at the first step, were re-worked, and finally came out the end two weeks later may have been affected by a temporary problem at that first step that has since been resolved. In other words, today's FTY value might appear low due to a problem that no longer exists. If you're trying to identify the primary causes of low FTY, getting to the bottom of a scenario like this can be a time-consuming and frustrating exercise. By calculating the RTY as described above, you get an accurate indicator of what your overall yield is based on current conditions across the line, allowing you to quickly identify which stations are having the largest impact on your overall FTY *right now*.

Figure 2: RTY calculation

Determining Costs

Now that we know how to calculate FTY and RTY for our manufacturing process, with a little additional information we will be able to calculate the impact on product costs. In the simplest case, where there is no re-work or re-test, calculating the cost impact of FTY is relatively straightforward. The unyielded product cost is the unit material cost plus the transformation cost. The transformation cost includes the labor, factory overhead (heat, hydro, etc.), capital depreciation, etc. Since there is no re-work or re-test, any parts that fail on the first time through are scrapped, and the final, yielded cost is simply the raw cost divided by the FTY. This simple approach is typically taken when the part cost is very low and the added expense of re-work cannot be justified.

Now let's consider the case where the part cost is higher, and re-work is justified. In this case, we also need to know the repair and re-test costs per unit (including all associated overheads), and the average yield at re-work. The total cost of performing the re-work is then given by the number of re-worked parts multiplied by the repair and re-test costs per part, where the number of parts is simply the number that failed the first time through the process. In many cases the re-work costs exceed the initial transformation costs, because the part must be partially disassembled to perform the repair, before going back through the process. Also, because in the process of disassembling the part and repairing defects, new ones are often created, the yields for re-worked parts are typically lower than the first time yields.

This increases the product costs from the raw, unyielded value of $5,000 to an actual value of $5,556.

The Cost of FTY: A Simple Example

To illustrate the cost impact of FTY, let's explore a simple example where the part cost is significant and therefore re-work is implemented on parts that fail the first time through. In our example the unyielded product cost is $5000, which is split equally between the raw material and transformation costs (i.e. both are $2500), and the annual target production run rate is 10,000 parts. Let's consider the case where the FTY is 90%. If the manufacturer does not re-work the failed parts, then 11,112 parts must actually be started to achieve the target output of 10,000, and $5.6M of scrap (1,112 parts at $5000 each) is thrown away each year! This increases the product costs from the raw, unyielded value of $5,000 to an actual value of $5,556.

A	raw material cost	$2,500
B	transformation cost (unyielded)	$2,500
	total raw cost (A + B)	*$5,000*
C	production run rate (annual)	10,000
D	average first pass yield	90%
	parts manufactured to meet target output	*11,112*
	annual scrap {(C(A+B)*(1-D))}*	*$5,556,000*
	true product cost (A+B)/D	**$5,555.56**

Table 1: Details of Product Cost calculation for the base example

To reduce the amount of scrap and the production costs, the manufacturer implements a re-work process that successfully recovers 80% of the failed parts, to bring the overall yield up to 98%. Note that the FTY remains 90%. The cost of the re-work is 50% more than the initial transformation cost, or $3750, which appears to be a worthwhile investment when compared to the $5000 already committed to the failed part. However, when we account for the $3.8M being spent annually on re-working these parts, the total part cost

E	Average cost of re-work	$3,750
F	Average 2nd pass yield	80%
	Parts manufactured to meet target output	*10,205*
	Total cost of reworking parts	*$3,826,875*
	Final yield	***98.0%***
	Final average product cost	***$5,485.19***
	Total cost savings per part	**$70.37**
	Total annual cost savings	**$703,681**

Table 2: Details of the product cost calculation when rework is introduced

Now what if we had been able to achieve 98% without re-work? In other words, what is the impact of improving FTY to 98%, such that we can eliminate the need for re-work? Re-running the numbers with an FTY of 98% and no re-work produces an average cost per part of only $5,102. When compared with the original product cost, this represents a cost savings of $454 per part, or a whopping $4.5M per year! So while the overall yield is the same in both cases, the product costs are dramatically different.

A	Raw material cost	$2,500
B	Transformation cost (unyielded)	$2,500
	Total raw cost (A + B)	*$5,000*
C	Production run rate (annual)	10,000
D	Average first pass yield	98%
	Parts manufactured to meet target output	*10,205*
	Annual scrap {(C(A+B)*(1-D))}*	*$1,020,500*
	True product cost (A+B)/D	***$5,102.04***
Total cost savings per part		**$383.15**
Total annual cost savings		**$3,831,467**

Table 3: Details of the product cost calculation for the example when the FTY goes to 98%

Now it's easy enough to talk about improving FTY from 90% to 98%, but the fact is that finding the process enhancements and fixes necessary to achieve this degree of yield improvement generally take some time. However, even a 1% improvement in FTY can generate significant cost savings. Let's consider what happens if instead of implementing the re-work process, we simply improve FTY by 1%. In this case, the final product yield is only 91% (compared to the 98% achieved with re-work), but the product cost is $5,495 – just $10 more than the cost with rework. This represents a cost savings of $610k annually, which is only slightly less than the cost savings achieved through rework.

This clearly illustrates how misleading final yield can be, and how important FTY is when it comes to true product cost. If we choose to address an FTY of 90% by implementing a re-work process, we can achieve a final yield of 98% - which sounds great. However, the same cost savings can actually be gained through a small improvement in FTY of slightly more than 1%. Eliminating rework has other benefits as well: it streamlines your overall manufacturing process, and reduces capital and labour requirements.

How-to-Improve FTY

Clearly it should be the goal of every manufacturer to eliminate rework in favour of improving FTY to achieve the lowest product costs possible. But to do this requires a methodology for accurately measuring and tracking FTY throughout the manufacturing process, since it is impossible to consistently improve or maintain something that isn't quantified. This involves recording results at each step in such a way that FTY can be calculated while properly accounting for the rework and re-testing of failed parts. Sciemetric's QualityWorX software has been designed to record every result on a serial-number-by-serial-number basis, enabling it to accurately track both FTY and RTY. Using the Web Reporter or Dashboard reporting interfaces, the manufacturer can track FTY by station, date, shift, model or other part-specific parameters to quickly identify where the most common defects are being created. This allows the process or quality engineers to systematically eliminate these defects at their source, and thereby increase FTY.

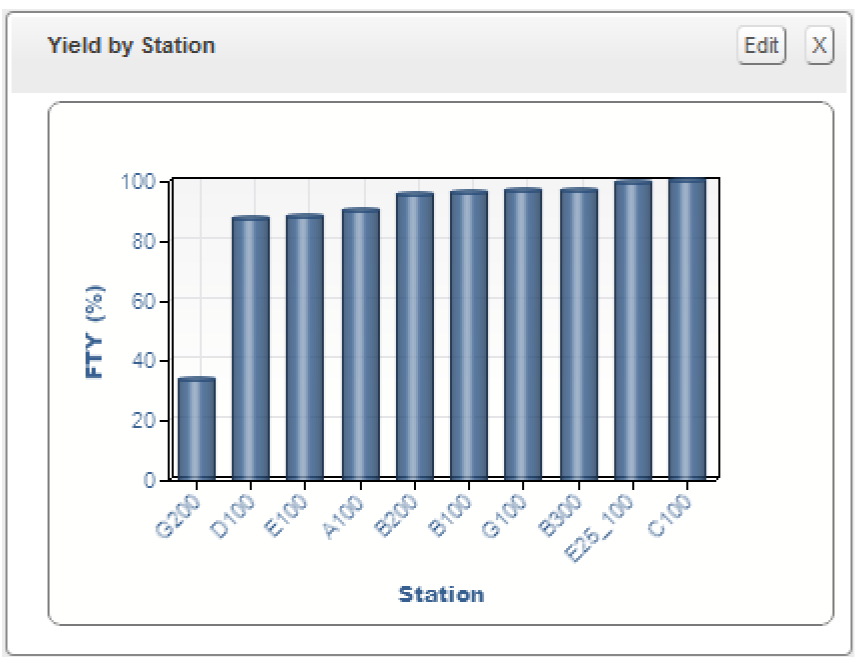

Figure 3: example of an FTY plot vs. station generated using Sciemetric's QualityWorX software

The Bottom Line

Every manufacturer should eliminate rework in favour of improving FTY to achieve the lowest product costs possible.

Today's highly competitive global marketplace puts more pressure on manufacturers to cut product costs than ever before. And yet too many are still focusing on overall yield and output, rather than FTY. As shown in our example, a 98% overall yield achieved through costly rework of failed parts produced virtually the same cost savings as simply increasing FTY from 90% to 91%. Meanwhile, achieving a 98% FTY would produce annual savings of nearly $4M dollars, which would not be possible using a rework strategy even if the second pass yield was 100%. It is also important to point out that this example considered only a single product – imagine the many millions of dollars in product cost that could be saved if this same approach was applied across all of a manufacturer's product lines. Clearly the argument for investing in the tools and methods for improving FTY is a strong one, with a payback that can often be measured in months. So if you're not currently tracking FTY, take a moment to consider your manufacturing processes and make sure that you're not missing out on a golden opportunity to dramatically reduce your manufacturing costs.

If you'd like to improve first time yield on your production lines, contact us.

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