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Overall Yield of Processes

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1 Introduction

1.1 General

Most organizations are involved in producing some kind of output, be it in the form of manufacturing, assembling bought components and selling them as a system, or combining ‘old’ knowledge to new approaches to name just a few.

Every process has a Yield. Yield in the context of this paper is defined as process-inherent output (before any quality control, auditing or testing) that meets specifications or customer expectations.

To keep the terminology simpler, this paper deals only with manufacturing despite the fact that the results are universally applicable.

1.2 Importance of Yield

Your customers expect a certain level of quality. A number of products even require some sort of certification. Quality control, auditing, or testing are common tools to reach the required levels of quality, but they add costs to the process (e.g. additional rework and/or scrap, higher shipment and restocking fees for returns or the costs associated with warranty and reduced customer satisfaction). Most of these costs can not be properly tracked, they disappear somewhere in the overall costs of doing business.

1.3 Elements

Manufacturing in the broadest sense is assembling (self manufactured and/or purchased) components to a final product. Each of these components has its specifications (or drawings) and has to be assembled in a defined way in order for the final product to work as required. In the context of this paper, each parameter of the individual specification and each assembly instruction for each component are considered an “Element”.

This paper looks into the correlation between Yield and number of elements on a purely mathematical basis. Even if organizational reality is the result of countless dimensions, looking at the relationship between two specific ones helps to better understand what to expect.

2 Yield

2.1 Some Math basics

To understand the mathematics, let’s look at tossing coins. Heads is the ‘required’ result.

With one coin, the probability of the ‘right’ result is 50 % (if one neglects the possibility of the coin coming to rest on its edge).

With two coins, the probability of two ‘Heads’ reduces to

$$0.5 \times 0.5 = 0.25 \quad \text{(or 25\%)}$$

Adding a third coin reduces the probability of an all 'Heads' result further to

$$0.5 \times 0.5 \times 0.5 = 0.125 \quad \text{(or 12.5 \%)}$$

In general the Yield (in the case of this example the probability of having an 'All Heads' result) is calculated with the formula:

$$\mathbf{Y = (1 - E)^{n}}$$

Where: Y is the Yield
E is the error rate or the probability of an individual coin showing 'Tail'
n is the number of coins

2.2 Yield of a Process

The above formula can be used to calculate and graph the Yield of a manufacturing process for different Error Rates per Element (an error rate of 1 / 1000 Elements is a 'good rate' of 99.9%, 5 / 1000 is 99.5% good elements, etc).

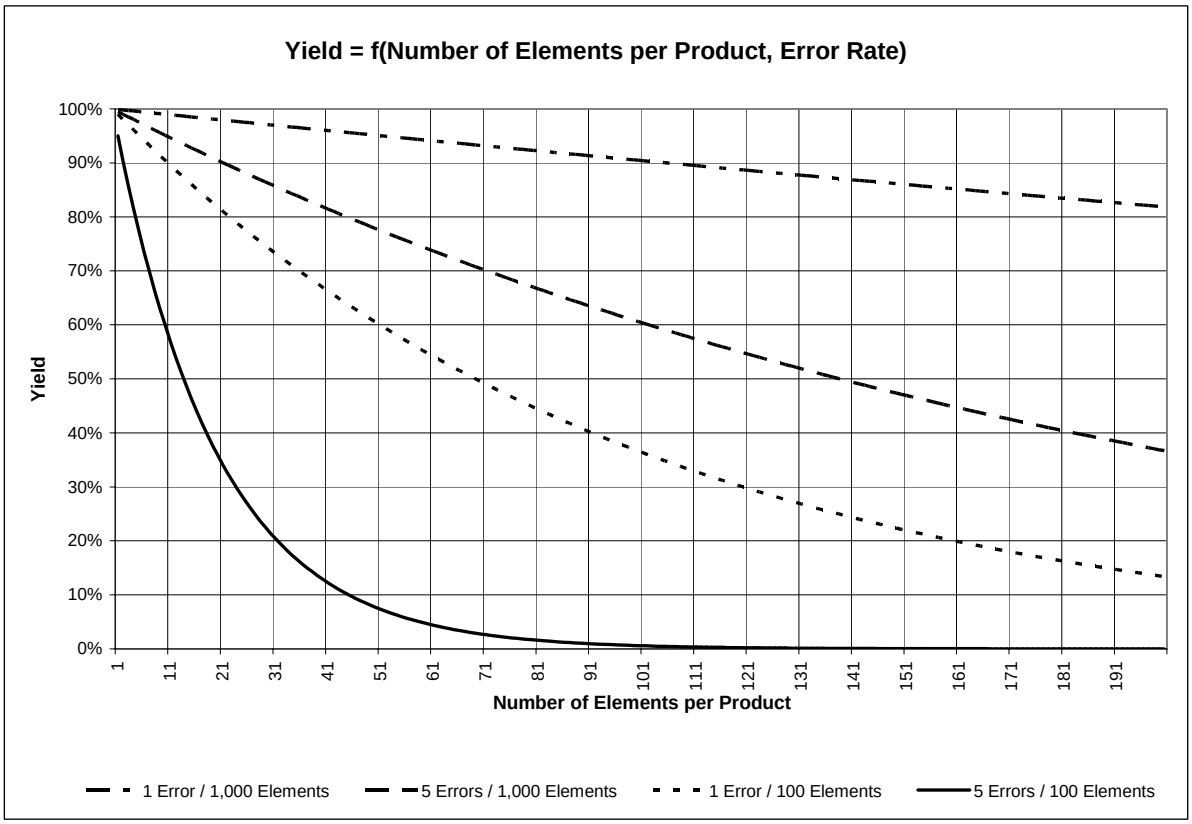

Fig. 1 Yield = f (Number of Elements per Product and Error Probability per Element)

3 Discussion of Results

Today's products are more complex than yesterday's, and tomorrow's will be even more complex than today's. Increased complexity of products means nothing else but an increased number of elements per product.

The above graph shows that even with a constant Error Rate, the yield will drop with an increasing number of elements. If you think that your organization does not perform as well as just a few years ago, you are probably right; not because your employees are less diligent, but because of the nature of the beast.

Throwing more Quality Control (QC) at the problem is probably not the most cost effective solution. Not only because QC has a yield too (QC only finds a certain percentage of non compliances), but rather because the mistakes have already happened and correcting them costs more money.

The errors responsible for your Error Rate happen throughout the process, from the moment a new order comes through the door or even earlier. Every step along the way adds errors to your Error Rate.

What you want to achieve is minimal costs per unit to provide your customer with the quality product he/she requires. It does not matter where you spend the money, up front in the administrative steps, QC of parts (purchased or manufactured) or at the end of your process with Quality Control and rework, as long as your costs per unit are minimized.

Unless your products don't change, review the way your organization operates every few years. How you generate and handle data and information has to be part of this review, because this is an area in your process with a high potential to add errors.