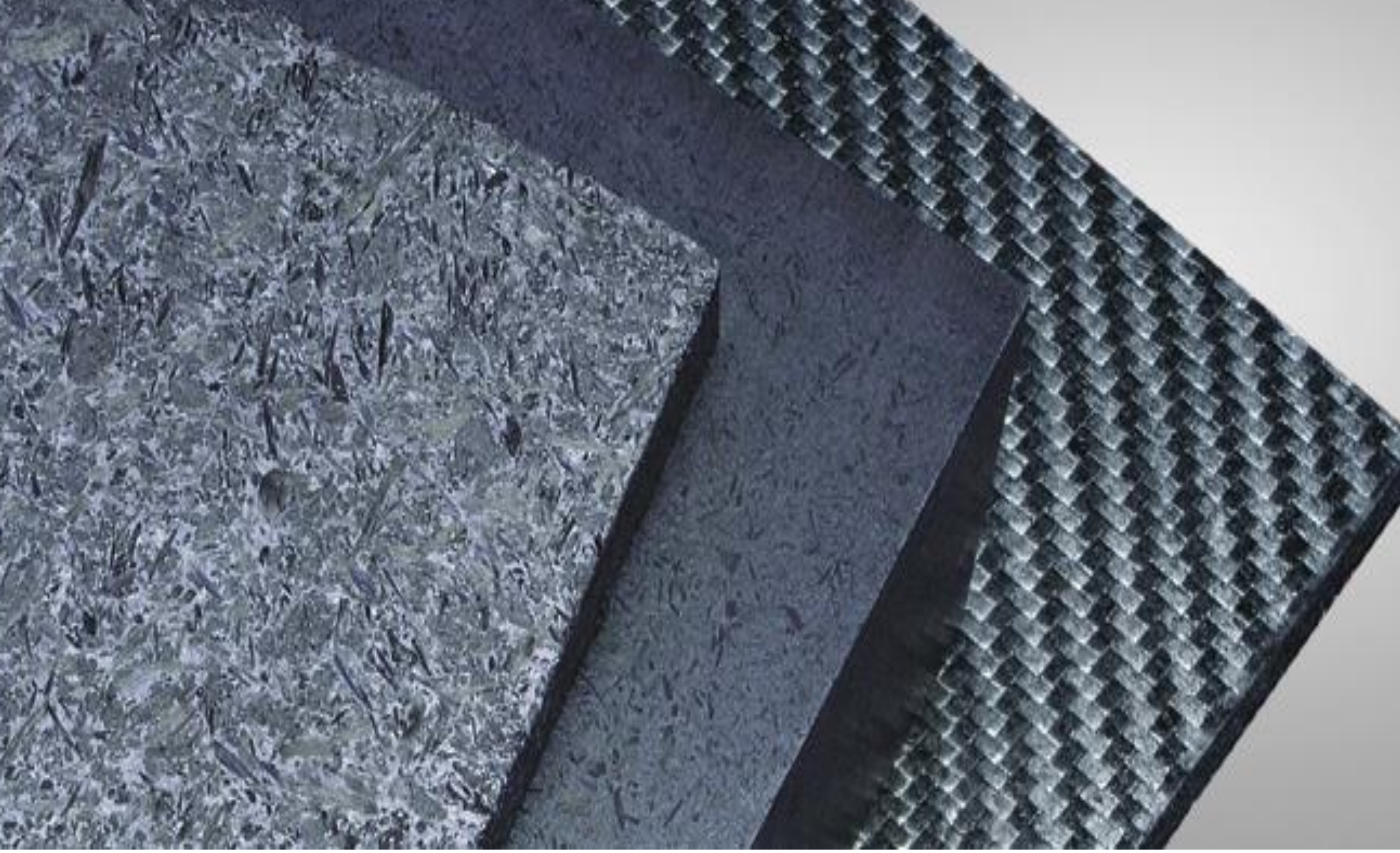

Manufacturing Yield vs. Kit Level Nesting Yield:

Taking Material Utilization to the Next Level

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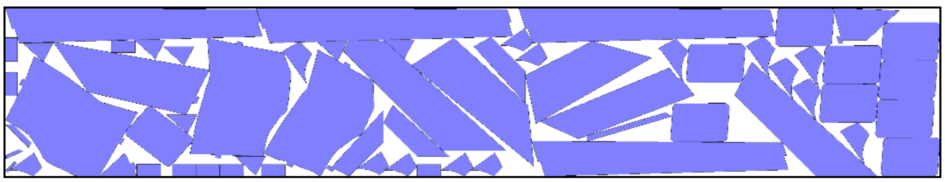
Introduction

Best of class manufacturers track their performance by measuring a set of key metrics for a variety of needs such as continuous improvement and bid (tender)-costing. Given the importance of these metrics, it is important to ask - **are the correct metrics being used, and which potential savings are overlooked when measuring the wrong ones?**

The topics of "material utilization" or "material savings" were the center of intense discussions and process evaluations conducted with dozens of manufacturers worldwide, specifically as it pertains to the composite materials storage, tracking, cutting and kitting. Effectively all manufacturers place a great emphasis on tracking their material yield. However, the vast majority of them measure the yield through the eyes of the Product/Kit-level nesting process. Such manufacturers measure their **'kit-level nesting yield' (Figure 1)**, which is the total area of the parts in a kit divided by the area of the material used for the nest. In many cases, the nests are prepared once per kit and then stored for future use and reference.

Figure 1 - Single Kit Nest:

Length: 9.3 meters. Nesting yield equals to 87% as the parts take up 87% of the composite fabric area.



Nesting Yield = 87% = Total area of parts / Total area of material used in the nest

By associating nesting with the **product-level** entity, this metric completely ignores the broader realities of manufacturing and the **actual level of material utilization** as driven by operational decisions such as scheduling of kits to cut, selection of raw material to use (including remnant utilization) and more. In fact, most manufacturers we meet are intuitively (and practically) aware that there is "additional waste in the process", but they accept it as an unavoidable cost given the [lack of] systems and processes they currently have in place.

By assuming that increased material utilization can only be driven by better 'Nesting' capabilities (software or huma many manufacturers feel they have already taken those to the limit, and therefore choose to focus on other area for continuous improvement.

To realize the true utilization of material in production, it is important to look at the overall **Manufacturing Yield**, that is – **the total material that becomes finished product, as a percentage of the total raw material purchased by the plant,** also referred to as the **'Buy to Fly'** ratio. This paper will focus on measuring material utilization during the nesting/cutting processes.

Table 1: Nesting Yield vs. Manufacturing Yield

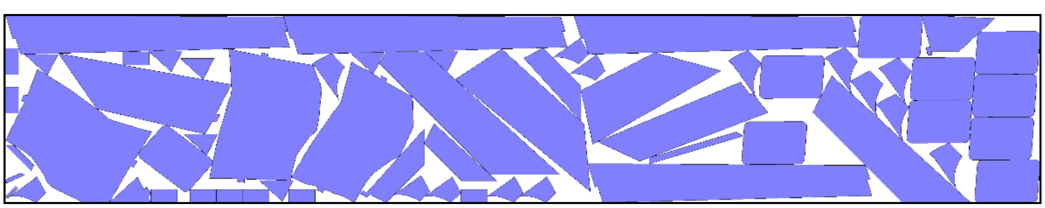
Kit-Level Nesting Yield	Manufacturing Yield ('Buy to Fly' Ratio)
<u>Total Area of the parts in a nested kit</u> **Total area of the material used for the nest**	**<u>Total material that becomes product</u>** **Total material purchased by the plant**
Engineering (CAD/CAM) oriented Metric	**Manufacturing**/Operational Metric
Independent of manufacturing plan	Tightly related to actual manufacturing
Static - Does not change as long as no new kits introduced	**Dynamic** - Changes daily according to actual product mix, scheduling decisions, selection of r material (including remnants) etc.

On site process studies have shown that the gap between these two metrics typically ranges between <u>5% and 10%</u>, exposing a set of significant inefficiencies. Conversely, overlooking these inefficiencies allows them to cement themselves and become a given 'cost of doing business', until the time they bubble up to management as some amortized – fixed – factor that is added in all decisions related to material consumption or costs. Then, the waste in production adversely impacts other processes and leads to excess purchase of raw material, overbidding on new contracts and more.

Example – Remnants Utilization and its impact on true Manufacturing Yield

To illustrate this concept, take for example the following nest, used to produce a single kit (Figure 2). This nest is 9.3 meters long, and its ***Nesting Yield*** is 87%.

Figure 2: Single Kit Nest, 9.3 meters in length, 87% Nesting Utilization



In a simplified world, let's assume this is the only kit in production, and that the manufacturer needs to produce 6 such units per day. By looking strictly at the single-unit yield, the overall yield would remain the same year-long at 87%.

However, by looking at the overall production sequence, one realizes the *Manufacturing Yield* is much lower.

For the sake of this example, let's assume a new roll of material is 50 meters long, and that the plant always cuts the same kit with the same nest. Therefore, they could fit 5 kits in a single roll (total of 46.5 meters), but cutting the 6th kit would require starting a new roll, while leaving 3.5 unused meters in stock.

Let's also assume that this remnant is discarded (we'll get back to this assumption later). In such a scenario, the ***Manufacturing Yield* drops to 81.8%** and the difference compared with the 87% ***Nesting Yield*** represents the waste ignored when using the wrong metric.

Table 2 –Comparing utilization metrics

	Nesting Yield View	Manufacturing Yield View
Kits #1 to #5	9.3 meters each (Total of 46.5 meters)	9.3 meters each (Total of 46.5 meters)
Kit #6	Uses Same Nest as Kits 1-5. Total: 9.3 meters	Uses Same Nest as Kits 1-5. Total: 9.3 meters
Remnant	**Ignored** in Metric	Remnant included in metric, but not used in production: 3.5 meters are discarded
Total Material Used (length)	55.8 meters	59.3 meters
Total Area of Material used (1.5 meter wide material)	83.7 Sq Meters	88.9 Sq Meters
Total Area of Parts Cut	72.8 Sq Meters	72.8 Sq Meters
Resulting Measurement	**87%**	**81.8%**

Utilizing remnants

In the previous example it was assumed that the unutilized remnant is discarded. This is a critical assumption which has a clear bearing on the ***Manufacturing Yield***, but <u>**no impact**</u> on the ***Nesting Yield.***

There are various ways that each manufacturer deals with remnants, both formally and informally. These are highly dependent on a variety of factors, and get further complicated by the questions of Shelf Life and Material Expiration, yet they could be consolidated into two main practices, as shown in **Table 3** below.

Table 3 – Main practices of dealing with remnants

I	**Return them to the shelf for future use, typically for re-cuts or testing, and then discard them if no use was found before they expire.**	Requires **additional labor** and attention on the shop floor, but at least **attempts** to use the material.
II	**Discard them immediately** (for example, "if the remnant is shorter than 3 meters*, discard it")	Loses the material, but saves the 'hassle' of managing it.

***** *The definition of a "remnant" also varies widely in the industry (typically between 3-5 meters).*

In practice, given the amount of labor and 'hassle' required to utilize remnants, those that are shorter than 3-5 meters are seldom used, certainly not consistently or in entirety. However, if one can boast a high level of remnant utilization, it would typically come at the expense of additional labor & WIP costs.

In any event, to the extent remnants are used, the gap between the ***Nesting Yield*** and ***Manufacturing Yield*** will be narrowed accordingly.

Increasing your Manufacturing Yield

Once the ***Manufacturing Yield*** is established as a more accurate metric, the obvious question becomes how can one improve it, or in this example, how to **methodically utilize remnants in the routine manufacturing processes?**

First, why are remnants not typically utilized? In most cases we see, the Nesting process is tied to the Engineering room, or more precisely to the CAD system. The nest is pre-prepared for any given kit (or mix of kits), and is then retrieved and cut each time the kit(s) are needed. Thus, nesting is typically **disconnected** from the production realities and variability such as order mix, material inventory, material expiration date and more.

Therefore, if a given kit requires 9 meters of material (as in this example), three distinct capabilities are required to routinely use rolls shorter than 9 meters for it, let alone 3-5 meter remnants:

1. **An Integrated or Holistic Approach:** the knowledge that such remnants exist at the time the nesting decision is made.
2. **A Dynamic Approach**: given the knowledge about the remnants, the ability to utilize them by creating a suitable nest **on-demand**.
3. The practical ability (software algorithm or human-based) to **nest a single kit to multiple rolls of various sizes**

   To be more precise, using software to support the third capability saves tremendous amounts of labor and ensures optimal decisions are made every time.

Given these three capabilities, one can routinely utilize the remnants in stock, with each day presenting a different demand for kits and a different set of rolls as resources. **Figure 3** illustrates the usage of remnants corresponding to the example above where 3.5 meters would otherwise remain uncut.

Figure 3 – Splitting a single kit to be nested on a 3.5 meter remnant and an additional section of a new roll

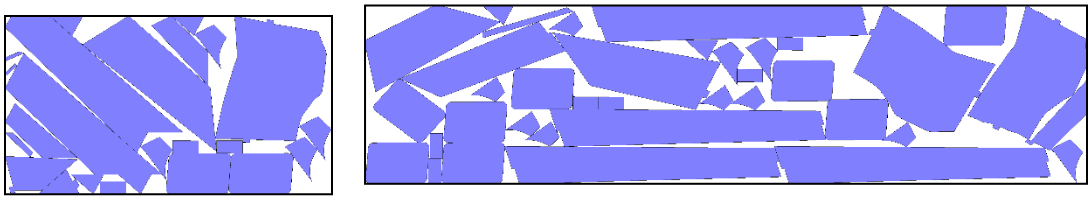


Table 4 (below) summarizes this example:

I. When remnants are both discarded and ignored in measurement, the ***Nesting Yield*** shows an **illusion** of a higher yield in production **(87%).** This deviation then adversely impacts other decisions such as purchase of raw material, costing etc.

II. When remnants are considered in measurement, but not used in practice, the ***Manufacturing Yield*** is exposed at **81.8%**

III. When remnants are methodically used in production, the ***Manufacturing Yield*** climbs up to **86.5%** and represents a true figure.

	Nesting Yield View	Manufacturing Yield View ('Buy to Fly')	
	I	II	III
Treatment of Remnants in Process	Remnants are discarded	Remnants are discarded	Remnants are utilized
Treatment of Remnants in Metric	Excluded	Included	Included
Kits #1 to #5	9.3 meters each (Total of 46.5 meters)	9.3 meters each (Total of 46.5 meters)	9.3 meters each (Total of 46.5 meters)
Kit #6	Uses Same Nest as Kits 1-5. Total: 9.3 meters	Uses Same Nest as Kits 1-5. Total: 9.3 meters	6.1 Meters in New Roll + 3.5 Remnant from First Roll
Remnant	**Ignored** in metric	**3.5 meter remnant is discarded**	**3.5 meter remnant is utilized**
Total Material Used (length)	55.8 meters	59.3 meters	56.1 Meters
Total Area of material used (1.5 meter wide material)	83.7 Sq Meters	88.9 Sq Meters	84.1 Sq Meters
Total Area of Parts Cut	72.8 Sq Meters	72.8 Sq Meters	72.8 Sq Meters
Yield	**87%**	**81.8%**	**86.5%**

Summary

Effectively all manufacturers place a great emphasis on tracking their material yield, yet a vast majority of them measures it through the eyes of the Product/Kit-level nesting process. By associating Nesting with the **product-level** entity, this metric completely ignores the broader realities of manufacturing and the **actual level of material utilization** as driven by operational decisions such as scheduling of kits to cut, selection of raw material to use (including remnant utilization) and more.

In fact, most manufacturers are aware that there is "additional waste in the process" beyond what they measure, but they accept it as an unavoidable "cost of doing business". After a while, this waste becomes a given: manufacturers do not attempt to reduce it, and factor it uniformly into a wide range of decisions made in the plant such as material purchasing, project costing and more.

The *Manufacturing Yield* therefore represents a more accurate metric, and measuring it is a big first step towards improving it. The challenge of utilizing short rolls is just one of many difficulties dealt with daily in an attempt to increase the ***Manufacturing Yield***. Other dilemmas include those of Scheduling, WIP Optimization, and managing Material Expiration (Shelf- Life).

Addressing these challenges methodically and efficiently requires a dynamic and integrated optimization approach, based on close collaboration between the various teams involved (Engineering, Manufacturing etc.), and bridging that gaps between the systems they use (ERP, CAD, PLM etc.). Solving this truly complex problem requires suitable optimization software tools and processes. Without them, improving the ***Manufacturing Yield*** becomes a labor-intensive task that is often set aside.