What Is The True Cost of Final Finish Tire Testing?

How high-quality integrated tire measurement equipment can save you money

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Maximize Investment Return

If a tire manufacturing company was asked whether or not it was interested in saving money on final finish tire testing equipment, the answer would definitely be, "Absolutely!" However, in many instances, the opportunities to avoid extensive life cycle costs and increase the value that the equipment investment provides are ignored or overlooked. There are ways to minimize expenditures on final finish tire testing and measurement, but it requires a focus on the "right things" during the supplier evaluation process, the purchasing process, and throughout the operational life of the equipment.

Investment in a single final finish line to perform tire uniformity, dynamic balance and geometric runout testing and measurements can exceed $1M USD – a significant purchase indeed. In actuality, this initial purchasing cost only represents a small portion of the expense that the final finish operation will incur over the life of the equipment. Typically, these costs are less than 20% of the total outlay over a 10-year life cycle. By focusing on the "right things," and through comprehensive analysis of potential suppliers and equipment options available in the marketplace, a better purchasing decision can be made during the equipment acquisition phase. This results in the minimization of costs to the organization for providing this critical capability.

Recent developments in high-quality, highly-integrated tire testing systems have enhanced a tire company's ability to address this difficult situation as well. These new systems are optimized to deliver high customer value throughout the equipment's lifetime, while adding other special features that make the tire testing process easier to manage. By shifting a company's sole focus away from initial purchase costs to total life-cycle costs, and through careful consideration of these newly developed integrated final finishing systems, a tire company can dramatically reduce its overall required investment in tire testing equipment.

<u>Piece (per tire) Cost</u>

The most popular metric utilized to evaluate the overall value of purchased equipment is *Piece Cost*. This calculated value is defined as the total cost per tire required to evaluate each tire's force variation uniformity, dynamic unbalance and geometric runout characteristics, for the purpose of final quality screening before delivering that tire to a customer. All costs required to purchase, install, maintain, and operate the equipment on an annual basis are rolled up and divided by the total anticipated yearly throughput of the equipment. That is,

Of course, the tire producer's goal is to minimize *Piece Cost*, which can be accomplished by ensuring the highest equipment throughput possible while minimizing annualized costs. In order to accomplish this, the correct equipment must be chosen during the acquisition phase of the equipment and complementary strategies must be implemented that will sustain those purchased competitive advantages over the life of the equipment. In the remainder of this paper, these two critical goals of throughput maximization and annualized costs minimization will be discussed. The analysis will also include a comprehensive review of a rarely discussed or quantified cost component associated with machine repeatability-related measurement performance.

<u>Throughput Maximization</u>

Equipment throughput is simply defined as the anticipated number of tires tested per year. This key metric is a direct function of the equipment utilization typically expressed in units of [seconds/year] and the total system cycle time typically expressed in units of [seconds/tire]. The annual equipment throughput of the machine is calculated by dividing these two individual quantities such that

As a result, the equipment throughput can be maximized by both purchasing and adequately maintaining the "most productive" equipment, therefore ensuring the possibility of maximum utilization of machines operating at minimal cycle times.

Two notable items deserve attention when trying to ensure superior equipment utilization:

- Production availability of the equipment
- System reliability of the equipment

The scheduled operation of the machine, along with daily scheduled downtime, defines the production availability of the equipment. This quantity depends solely on production scheduling and is the same regardless of the final finish equipment used. The other major contributor to machine utilization is the system reliability. This factor represents the percentage of time that the machine will stay running in an automatic mode. For automated equipment in a tire plant such as this, it should take into consideration both the frequency of breakdowns as well as the time to recover from each instance. Not all equipment suppliers are equal in this category.

The calculated effects of small differences in system cycle time and system reliability on daily machine throughput are summarized in Table 1 below. The equipment is assumed to be available for production for 90% of a 24 hour day. The throughput improvement resulting from even a small cycle time or system reliability improvement is quite dramatic.

Table 1 – Machine Throughput (Tires/Day) based on System Cycle Time and System Reliability

System Cycle Time (seconds)	System Reliability (%) 86%	88%	90%	92%	94%	96%	98%	100%
40	1672	1711	1750	1788	1827	1866	1905	1944
38	1760	1801	1842	1883	1924	1964	2005	2046
36	1858	1901	1944	1987	2030	2074	2117	2160
34	1967	2013	2058	2104	2150	2196	2241	2287
32	2090	2138	2187	2236	2284	2333	2381	2430
30	2229	2281	2333	2385	2436	2488	2540	2592
28	2388	2444	2499	2555	2611	2666	2722	2777
26	2572	2632	2692	2752	2811	2871	2931	2991
24	2786	2851	2916	2981	3046	3110	3175	3240
22	3040	3110	3181	3252	3322	3393	3464	3535
20	3344	3421	3499	3577	3655	3732	3810	3888
18	3715	3802	3888	3974	4061	4147	4234	4320
16	4180	4277	4374	4471	4568	4666	4763	4860

In the typical equipment operational range for a final finish testing process, highlighted in Table 1, one second of cycle time improvement can provide more than 200 extra tires per day (that's 68,000 tires per year or more than 11% additional testing capacity). And, one percent of system reliability improvement can provide more than 40 tires per day (that's 14,000 tires per year or more than 2% additional testing capacity).

Total system cycle time and system reliability are two very important factors that deserve attention and evaluation when selecting a supplier for tire testing equipment that will maximize throughput. Selecting equipment that achieves high availability through excellent system reliability performance while operating at sustainable total system cycle times as low as possible will ensure the best return on investment for that equipment. A trade-off exists when designing equipment that will operate at low cycle times and concurrently maintain high system reliability. For a given mechanical design, if mechanical motions are programmed to execute and complete rapidly in order to minimize cycle time, wear and tear on components will occur and typically cause more breakdowns and reduce system reliability. The reader is cautioned to recognize and consider this negative interaction when evaluating equipment for purchase. This phenomenon must be understood and accounted for while the supplier is designing the equipment.

Annualized Costs Minimization

As previously mentioned, there are several components that go into determining the annualized costs for a system of equipment. These factors include but are not limited to the acquisition costs, installation costs, maintenance costs, and operating costs of the equipment. All of these factors are important, but in reality have a very different impact on the total annualized cost of the equipment.

The installation costs are undoubtedly important, but dwarf in comparison to the large amount of capital outlay required to initially purchase such a testing system. With production tire testing equipment, installation costs and other costs associated with "start-up time" are similar among different suppliers. The equipment is heavily automated and can be well-tested before leaving a supplier's facility, so it typically can be made production-ready in a short period of time. Installation materials and labor are also minimal, especially when compared to other tire manufacturing equipment. Hence, this is typically not an area where testing equipment suppliers can differentiate themselves.

The most widely discussed component of total cost is the up-front acquisition costs for procuring testing equipment. Examples of these costs include the complete system purchase price, taxes, duties, and shipping. Clearly, this component is an extremely important consideration when purchasing equipment; however, it is many times incorrectly used as the primary driver in making purchasing decisions. When total life cycle costs are analyzed for this type of equipment, the acquisition cost is typically less than 20% of the overall equipment life costs when compared to the other cost categories.

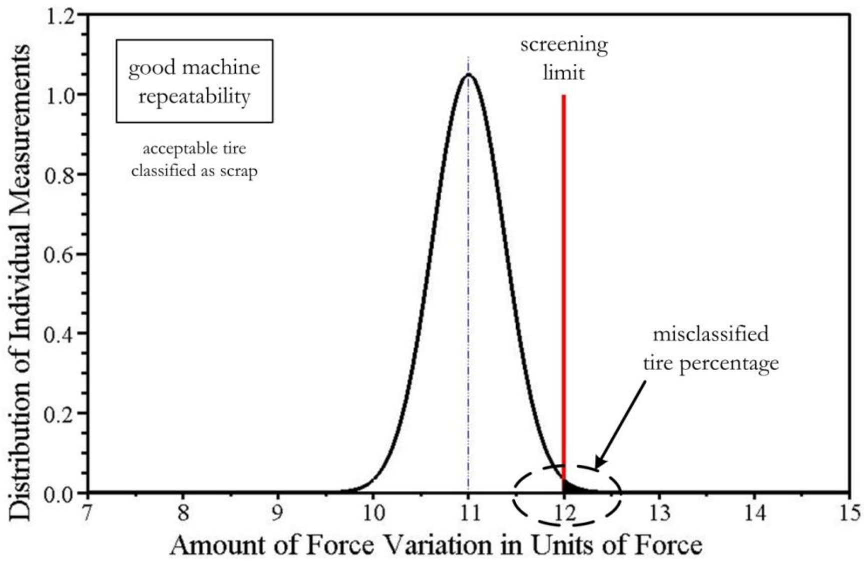
The single largest contributor to annualized cost is unquestionably the operational costs for the equipment. There are a huge number of items worth considering in this category. These include, but are not limited to, operating labor, electric power, compressed air, marking tape, bead lubrication material, hydraulic fluid, grease, various maintenance costs, training costs, and spare parts. There is significant potential for equipment suppliers to differentiate themselves in all of these areas. A small amount of design intent can go a long way towards reducing costs in each of these categories. And, since the costs are incurred repeatedly over the life of the equipment, they can grow quite extensive.

Unfamiliar Cost Contributor

An additional high-impact operating cost component, rarely discussed today, is related to the measurement performance of the testing equipment in operation. Not only can insufficient quality of measurement performance directly increase annualized costs by forcing incorrect screening decisions for a given tire, it can indirectly increase costs through the erosion of tire consumer confidence. Direct costs may be accumulated by incorrectly scrapping or downgrading a tire that is truly below the screening limit and considered acceptable. In addition, in some instances, increased tire adjustment costs may be incurred as a result of mistakenly shipping an unacceptable tire to a customer.

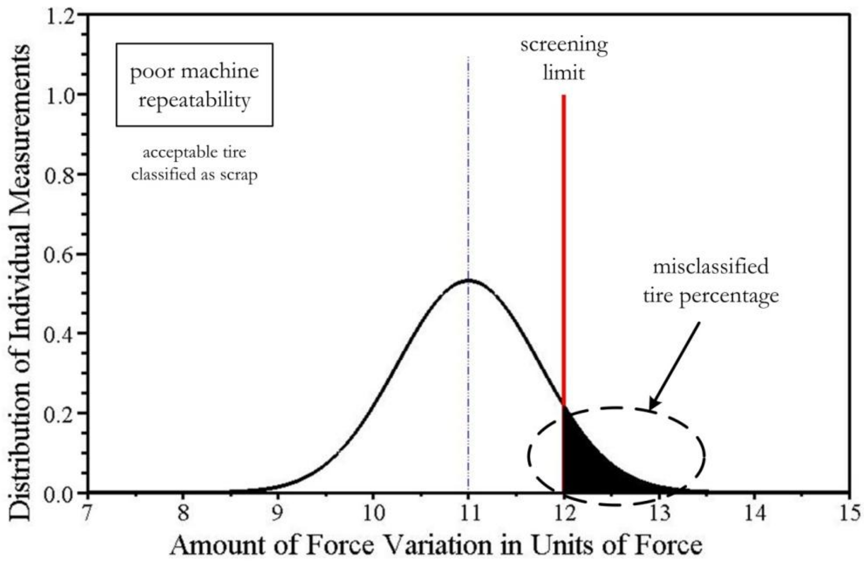
Consider the example of collecting multiple uniformity measurements of an arbitrarily chosen tire that is known to have a “true” uniformity value of 11 units with a machine that has a repeatability standard deviation specification limit of 0.38 units. Under a reasonable assumption of a normal distribution of measurements, the resulting distribution of measurement values may look something like that shown in Figure 1. The solid vertical red line in Figure 1 represents a potential screening limit for that particular tire. During a small percentage of the time, the tire will measure above the specification limit and be rejected unnecessarily. This percentage of time is represented by the small black shaded region. This tire would, at a minimum, get measured a second time requiring extra handling, labor and time. In the worst case, the tire would have been downgraded or scrapped unnecessarily. The closer the tire’s truth value to the grading limit, the greater percentage of the time a potentially devastating decision may be made on the disposition of the tire.

Figure 1 – Normal Distribution of Uniformity Measurements (S = 0.38 units)



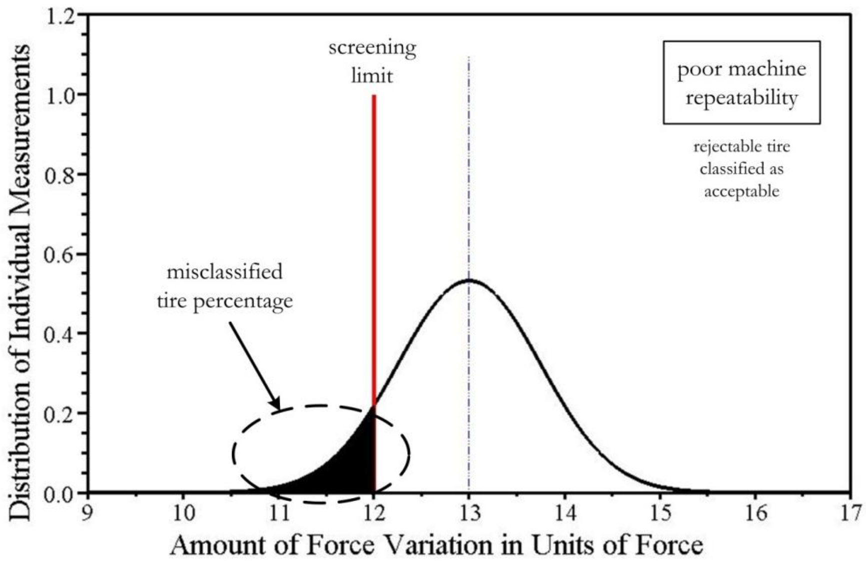
Now consider a similar scenario, with the same tire, where the tire is measured by a machine with a comparatively worse repeatability standard deviation specification limit of 0.75 units. The resulting distribution of measurement values is shown in Figure 2. When measuring this same tire through a machine with inferior measurement repeatability, a poor decision will be made a much greater percentage of the time, thus increasing the number of tires over a given year that are unnecessarily downgraded or scrapped. The number of tires unnecessarily scrapped over the course of the year depends upon the distribution of tires as produced in relation to the specification limit. Under typical plant production conditions, the percentage of tires that may be misclassified in this way can exceed 1.5% of tire production. **Imagine a tire uniformity checking system testing over 1,000,000 tires per year and unnecessarily scrapping over 15,000 tires that year. At an estimated cost of $30 per tire, that's over $450K USD of unnecessary scrap.**

Figure 2 – Normal Distribution of Uniformity Measurements (S = 0.75 units)



There is a similar but different mode of incorrectly assessing the disposition of the tire that relates to the machine's measurement performance. Consider now measuring another arbitrarily chosen tire with a known "true" uniformity value of 13 units with a machine that has a repeatability standard deviation specification limit of 0.75 units. The possible distribution of measurement values would look something like that shown in Figure 3. In a similar fashion, one can observe that during a percentage of the time that the tire is measured, the tire would have measured below the specification limit and would have been incorrectly classified as an acceptable tire. This percentage of time is again represented by the black shaded region. Not every one of these tires "escaping" the production facility will turn into a tire adjustment or customer ill-will; however, a small percentage of them may have that unintended consequence. These incidents are fewer in number but more costly than an incorrectly scrapped tire. There are real tire processing costs and replacement tire costs not to mention the indirect cost of customer and consumer disappointment. Under typical plant production conditions, the percentage of tires that may be misclassified in this way can exceed 1.0% of tire production. **If even 10% of these tires are returned at an adjustment cost of $150 USD per tire, the overall costs can exceed $150K USD a year.** This decision-making failure mechanism can also occur in a similar fashion during dynamic balance and geometric runout screening.

Figure 3 – Alternate Normal Distribution of Uniformity Measurements (S = 0.75 units)



There are a vast number of factors that affect the annualized cost for such an investment in tire testing equipment including installation costs, acquisition costs and operating costs. One very important consideration in procuring equipment is the acquisition cost but it should not be incorrectly used as the primary driver of a purchasing decision for such a large capital investment as it represents a relatively small portion of true life-cycle costs. Operating costs are certainly the dominant expense of which one rarely-discussed example is those costs associated with repeatability-related rejects and adjustments. It is clear that measurement performance and each of the other components of operating costs should be a major consideration in the purchasing decision-making process when procuring tire testing systems.

The Bottom Line

When confronted with the daunting task of acquiring several lines of final finish tire testing equipment, both the equipment supplier and the specific equipment should be chosen with the goal of minimizing piece cost in mind. There are suppliers on the market with tools available to assist in the evaluation of the important factors, which drive piece cost. Financial models can be used to compare equipment from two or more suppliers enabling the buyer to analyze and compare each of the important considerations presented in this paper. An example of final output from such a financial model, developed for adding 20,000 tires per day of tire testing capacity, is shown in Table 2.

Table 2 – Example Financial Model Output Comparing Equipment From Two Suppliers

	Supplier A	Supplier B	Units
Purchase Price Per System	$1,017,880	$967,850	$ USD / system
System Cycle Time	22.0	26.0	seconds
Number of Systems Required	7	8	required systems
Total System Purchase Price	$7,125,160	$7,742,800	$ USD
Annualized Process Cost	$3,742,475	$6,400,385	$ USD / year
Annual Throughput	5,875,724	5,694,114	tires per year
Piece (per tire) Cost	$0.64	$1.12	$ USD / tire

In this particular example, Supplier A's equipment is approximately $50K USD more expensive per individual system than Supplier B's equipment and completes a measurement cycle 4 seconds faster. This results in a requirement of seven Supplier A systems, as opposed to eight Supplier B systems, to provide the 20,000 tires per day of testing capacity. Even though Supplier A's equipment is initially more expensive per system, selection of this supplier results in an approximately $600K USD lower initial equipment investment because of the need for fewer systems. In addition, because of the characteristics of Supplier B equipment, the annualized process costs are more than 70% higher for Supplier B when compared to Supplier A equipment. The bottom line is an almost doubled piece cost if supplier B equipment is chosen. With an in-depth look into the annualized costs along with specific throughput information, it becomes clear which equipment will ensure the greatest delivered value over the life of the machine. Equipment suppliers should be challenged to provide this critical process cost information and chosen based not on their initial system acquisition price but on their ability to provide the best performance at minimal process cost per tire.

For more information about how to improve efficiency and minimize costs associated with final finish tire testing, please contact Dr. Shaun Immel at Micro-Poise Measurement Systems, LLC at simmel@micropoise.com.