

Product and Process Benchmarks for World-Class

Cotton Yarn Manufacturing

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Abstract

Over the past few years, the concept of World-Class Manufacturing for textile processing has been researched, published, embraced, and proven viable. The various strategies and components of this descriptor of the globally competitive manufacturer have won the prestigious Malcolm Baldrige National Quality Award. One key component in the transition to WCM status is called "benchmarking". Essentially this involves the identification of the best worldwide measurable performance in all aspects of a company's activities, not exclusive to similar companies.

Through the use of Uster Statistics and the ITT databases, individual yarn properties can be readily benchmarked. Achieving World-Class yarn quality requires benchmark performance at each step of the manufacturing process beginning with bale selection for the laydown. This paper suggests benchmarks for the products and the processes prior to yarn spinning that can help ensure the production of consistently superior quality cotton yarns.

Introduction

Product and process benchmarks are presented by fiber processing step for a typical

manufacturer of 100% cotton yarns. Those performance items most often not attained in plant producing yarns of only average quality have been highlighted and discussed. Average and superior yarn quality data are presented initially as the reference point and ultimate target of the preparatory process benchmarking efforts. In the final summary section, labor content benchmarks are provided for 100% cotton ring, open-end, and air jet spinning plants. The yarn manufacturer's goal should be to reach each benchmark presented and then to surpass it, becoming the benchmark producer themselves.

Discussion

Individual Quality Reference Values for Ring and Open-End 100% Cotton Yarns

The Institute has been developing and utilizing yarn quality databases for several decades. This capability allows the presentation of data in Table I which includes the averaged and the 175 index quality values for individual 30's Ne count yarn properties for carded ring, combed ring, and carded open-end 100% cotton yarns. The quality index reflects the number of standard deviations an actual quality value is from the database mean value with the following partial scale definitions:

It is obvious from these data that superior quality is quite a leap above average quality. At the 175 index a yarn quality parameter can be considered to be over the threshold into the World-Class category. Also, it is not likely that any one yarn can be superior in all measured properties, but the best yarns tested have an average quality index of 145 and above.

<Table 1> ITT 175 index (99.9th percentile) and averaged quality values for individual properties of 100% cotton 30's yarns

	Carded Ring		Combed Ring		Carded Open-End	
Yarn Property	175 Index	Avg.	175 Index	Avg.	175 Index	Avg.
Count Vb %	0.9	2.7	0.2	2.3	0.1	1.8
Single-End Strength, gms.	375	279	550	348	375	152
S.E.S. V ₀ %	6.7	11.0	5.3	9.4	6.7	10.8
Elongation %	7.0	5.8	6.9	5.8	8.1	6.0
Elongation Vb %	2.1	5.8	0.7	4.5	1.0	4.6
Appearance Index	131	93	137	117	137	113
Uster Evenness CV %	16.3	21.2	9.3	14.7	14.9	17.7
Uster Evenness Vb %	0.8	3.8	0.3	3.1	0.1	2.4
Periodicities	0	N/A	0	N/A	0	N/A
IPI Thins	14.4	193	0.3	11	7.2	92
Thicks	302	1067	4	109	35.8	221
Neps	39	358	2	51	22.3	425
Classimat Minors	260	3762	19	322	8.5	82
Majors	1.7	11.3	0.7	11	0.1	0.4
Long Thicks	0.6	8.6	0.3	5	0.1	2.0
Long Thins	27	616	0.7	54	0.4	15

- 100 index is average,
- 125 index is above average at one standard deviation from the mean.
- 150 index is excellent at two standard deviations better than average,
- 175 + Index is superior at three deviations better than average or at the 99.9th percentile, and
- 225 index is the maximum assigned at five standard deviations from the mean.

ITT Suggested Benchmarks from Cotton Bale Laydown Through the Yarn Formation Preparatory Processes

Table 2 contains the more practical benchmarks for each product and process prior to cotton yarn spinning. These are listed in no particular priority and do represent performance actually documented in manufacturing practice. Opportunity areas generally needing more attention by the spinner are discussed by process step. It is assumed that all machines are kept clean and are well maintained.

Cotton Bale Laydown and Blending

Product opportunities in the laydown area include the leveling out of fiber moisture and temperature through a minimum of 24 hours of conditioning in the controlled ambient of the opening room. This is not the case in too many plants. Longer conditioning time with the bale straps removed has been reported to lessen the negative processing impact of a high sugar content in bale stock.

A benchmark process opportunity is for all bales to be HVI tested, including the newly available NIR tests for sugar content and maturity. For blending of the various cotton bales in the laydowns, the machinery line should have a calculated blend factor of at least two times the regarding this calculation and the sequencing of machines necessary to reach this benchmark in blending capability.

Cotton Opening

A properly opened cotton stock will measure 140+ cc/gm ITT openness index in the card mat form. Since card chutes generally recompress the stock slightly, an openness index of 150+cc/gm at the exit of the card line feed unit is necessary. A more open card mat translates to more effective carding and subsequently improved yarn quality.

Table 2. ITT PRODUCT AND PROCESS BENCHMARKS FOR WORLD-CLASS
COTTON YARN MANUFACTURING PREPARATORY PROCESSES

Benchmarks		
Process	Product	Process
Bale Laydowns & Blending	- Minimum bale short fiber - Bales conditioned 24 hours minimum - All bales represented in stock cross-section from last blender - Reworkable fiber opened to 100 cc/gm minimum or to match virgin stock at entry point	- Bales 100% HVI tested including NIR sugar and maturity tests 40 bales minimum - Controlled ambient conditions - Machinery line blend factor at least 2x number of bales in laydown - Reworkable fed early and consistently
Cotton Opening	- Top feeder product at 135 + cc/gm openness - Card mat at 140 + cc/gm openness	Progressive stock opening avoiding recompression
Cotton Cleaning	- Minimal fiber damage - Minimal nep creation 50-60% coarse trash removal prior to carding	- Capable of removing seed coat particles - Zero unscheduled machine interruptions - Continuous run time for opening/cleaning machines
Cotton Carding	- Mat weight controlled to under 5% Vo in card room 16-18 oz/yd mat under feed roll - Sliver Uster CV < 4% - Uster insert range (3-yd lengths) < 7.5 percentage points - Sliver ITV coarse trash content 0.05% maximum 60-65 gram/yd sliver - Sliver Analyzer defects per pound < 3.5 - AFIS neps/5 grains < 5 - Visual web neps/trash count < 20/5 grains - Sliver weight Vo: 3-yd lengths < 3.4%, 100/150-yd lengths < 1.2% - Full cans with no sliver breaks or splices 85% +	- Autoleveler used 80 lb/hr maximum (new cards) - Adequate coil spacing in sliver cans - Cards stopped for air hose cleaning - Nep removal 80% + - Stop rate < 1/700 lb - Full can sliver crown height consistent with 12-inch maximum
Lap Preparation	- Minimum lap splitting - Target grains/yd at 80 ± 5% per inch of lap width - Lap weight/yd Vo < 1.1%	8-12 total draft between carding and combing - Noil removal Vb: comb-to-comber < 1.6%, head-to-head < 5% - Inside to outside lap weight control

Benchmarks		
Process	Product	Process
Combing	- Sliver short fiber $< 2\%$ - AFIS neps/trash count per 5 grains < 15 - Sliver Analyzer defects per pound < 1.5 - Uster CV $< 3\%$ - Sliver weight Vo (3-yd lengths) $\leq 1.2\%$ - Full cans with no sliver breaks or splices 80% +	30-50% noils removed by top comb
Finisher Drawing	- Uster CV $< 3\%$ - Weight Vo (3-yd lengths) $\leq 1\%$ - Sliver Analyzer defects per pound ≤ 4 - Uster inert range (3-yd lengths) $\leq 3\%$ points - AFIS neps/trash count per 5 grains ≤ 25 - Full cans with no sliver breaks or splices 90% +	480 grains maximum fed per delivery - no sliver crossing or dragging in creel - perfect can builds - random creeling (no channelling)
Roving	- Uster CV $\leq 4\%$ - Uster inert range (3-yd lengths) $\leq 3\%$ points - Weight Vo on 12-yd lengths $\leq 1\%$ - Zero visible slubs/bobbin - Critical draft from ITT Draftometer 1.40-1.45	- No piece cans processed - Ends down/doff ≤ 1 - Power creel operating - No crossed ends in creel - Maximum flyer speed: 14 x 7 = 1000 rpm 16 x 6 = 1000 rpm 12 x 6 = 1300 rpm

Cotton Cleaning

The product benchmarks for effective cotton cleaning prior to the card are that minimal fiber damage occur and that 50% to 60% of the visible trash in the cotton be removed. There must be cleaning machines in the line that are capable of removing seed coat particles. If truly consistent opening, cleaning, and blending are to occur, there should be zero unscheduled machine downtime in the opening/cleaning department.

Cotton Carding

Product benchmarks at carding are numerous and each one shown in Table 3 is very important if World - Class yarn quality is to be achieved. There are several of these measurable indicators that the average yarn spinner fails to accomplish. Control of card-to-card mat weight variability to under 5% is a major opportunity for these average manufacturers. Another is sliver as measured on the ITV tester. Frequently noticed process improvement opportunities include a stop rate target of less than one per 700 pounds produced and nep removal efficiency at 80% or higher. Can builds with adequate coil spacing so no sliver stripping occurs when removing stock from the can and a consistent crown height of 12 inches maximum are two additional process opportunities often available in the cotton carding operation.

Cotton Lap preparation

Nominal linear lap weight needs to be optimal for effective combing. A guide to consider is that the lap weight in grains/yard be within 5% of 80 grains per inch of lap width. This would make the weight between 800 and 880 grains/yard for the older lappers and 910 and 1010 grains/yard for the newer lappers producing the 12-inch wide lap. ITT and other researchers have shown that best combing and best yarn quality result if total draft at predrawing and lapping is between 8 and 12. this is relatively new

research information and many combed yarn plants have not as yet investigated this process detail.

Cotton Combing

The major objective of combing is to remove short fiber from the cotton stork fed to the comber. It is reasonable then that a most important product benchmark would pertain to the percent short fiber remaining in the combed sliver. Less than 2% is the suggested benchmark as compared to the 3% to 4% levels normally observed. It is also believed that most effective combing is accomplished with 30% to 50% of the noils removed by the top comb.

Finisher Drawing of Cotton Slivers

Cotton finisher sliver should have a Uster CV of under 3%, overall weight variation on 3-yarn lengths of 1% or less, Sliver Analyzer defects/ pound at 4 or less, and full cans with no sliver breaks or splices at 90% or more. Two process opportunities often observed are reflected in the benchmark suggestions that no more than 480 gains of sliver be fed per delivery and that the creeled can positioning allow the sliver to be pulled directly vertically out of the can 100% of the time.

Cotton Roving

A 1.0 Hank cotton roving can have a Uster CV of 4% or less, weight variation on 12-yard lengths at 1% or less, a Uster inert plot range of 3 percentage points or less, and zero visible slubs. In addition, the roving that will spin the best and produce the highest consistent quality will have a critical draft of 1.40 to 1.45 as measured on the ITT Draftometer. Ends down/doff will be one or less and the benchmark roving operation will process no piece cans of sliver.

Summary

In order for World-Class cotton yarn quality to be achieved, there must be World-Class performance in product and process at each step in manufacturing. For spinning to be superior, so must roving or drawing. For drawing to be superior, so must combing or carding. For combing to be the best, so must predraw and lapping. And, carding can only be superior if the opening room processes of bale selection, blending, opening, and cleaning are accomplished in a superior fashion.

Reaching the benchmarks provided in this paper will allow the production of certifiable World-Class quality cotton yarns. These measurable product and process performance descriptors do not represent a menu from which choices are made for emphasis. All benchmarks are interdependent and should be considered as a unit when goals are set for improving cotton yarn quality to the world-Class level. As these product and process benchmarks are reached, the labor content benchmarks provided in Table 3 become possible to achieve or surpass.

<Table 3> ITT LABOR CONTENT BENCHMARKS FOR OPERATORS AND
PROCESS SUPPORT LABOR IN COTTON YARN MANUFACTURING
PROCESSES

Labor Category	Man-Hours/100,000 Pounds Produced			
	Carded Ring	Combed Ring	Carded Open-End	Carded Air-Jet
<u>Operators:</u>				
Opening Room	30	30	30	30
Card	50	50	50	50
Predraw/Lap/Comber	-	200	-	-
Drawing	70 (2)	35 (1)	70 (2)	105 (3)
Roving 1.0 HK	125	125	-	-
Spinner/Doffer (Linked) 30/1	450	400	125	N/A
<u>Department Support:*</u>				
Card Room	100	150	85	90
Spinning	250	300	325**	N/A
<u>Total Department:</u>				
Card Room	375	440	150	185
Spinning	700	700	450	360
* Maintenance, cleaning, service, utility, transport.				
** Includes inspection and packing.				