Reduction of Yarn Packing Defects Using Six Sigma Methods: A Case Study

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This article originated when an Indian textile company identified packing rejection of yarn cones as its major quality problem and decided to use Six Sigma methods to correct the problem. At the end of its manufacturing process, yarn is wound into conical-shaped packages called cones, and it is shipped to customers in this format. Customers were rejecting cones due to unacceptable weight variation. Pareto charts revealed the major "counts" (a measure of yarn fineness) that were experiencing this problem. Technological deliberations led to identifying variation in yarn length, yarn count, empty yarn container weight, and moisture content of yarn as the critical parameters for this rejection. Statistical hypothesis testing established that the observed weight was significantly more than the set weight of yarn at the assembly winding stage. In addition, a significant difference in gross yarn weight between left and right sides of a machine was found at this stage. This occured despite the attachment of electronic length measuring devices (LMDs) on all assembly winding machines. The gage capability analysis of LMDs, performed on the yarn length at two assembly winding machines, revealed inadequate capability. In addition, for the polyester yarn of count $4/12^{'s}$, a relation was found between gross yarn weight and length of yarn through regression analysis. This relationship was used to arrive at the optimum parameter level.

Keywords Six sigma case study; Textile industry; Length measuring device (LMD); Two-for-one twister (TFO); Count of yarn; Pareto chart; Defects per unit (DPU); Test of hypothesis; Gage capability; Repeatability; Regression analysis; Prediction interval.

INTRODUCTION

This article originated when an Indian textile company identified packing rejection of yarn cones as its major quality problem and decided to use Six Sigma methods to correct the problem. At the end of its manufacturing process, yarn is wound into conical-shaped packages called cones, and it is shipped to customers in this format. Cones were being rejected by customers due to unacceptable weight variation. The work of the textile company to correct this problem is presented here in accordance with the standard Six Sigma DMAIC (Define-Measure-Analyze-Improve-Control) model (Pande, 2001).

DEFINE PHASE

Objective

This project reduces rejection during packing of finished yarn cones through measuring the current performance level and initiating proper remedial action thereafter.

Process

In this textile company, the final product is synthetic yarn. The company produces single and multi-fold synthetic white yarns from blends of manmade fibers for apparel and industrial applications. The process to produce yarn consists of 10 sequential steps:

1. *Mixing and conditioning*: The synthetic fibers are homogeneously mixed and conditioned with temperature and humidity.
2. *Lap formation*: The fibers are further mixed, opened, cleaned, and converted into a form that is known as "lap."
3. *Carding*: The fibers from the lap are separated into their individual elements, thereby removing short fibers. The strand of fibers is then converted into a convenient form known as "sliver."
4. *Drawing*: The fibers are straightened and parallelized to the sliver axis by means of drafting and, at the same time, "doubled" to achieve slivers of better regularity.
5. *Simplex*: This step reduces the weight per unit length of the sliver to a suitable size for spinning.

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The "roving," the output of this step, is a continuous, slightly twisted strand of synthetic fibers.

6. *Ringframe/spinning*: The roving is attenuated to the required size of single yarn; a suitable amount of twist is inserted to the strand of fibers, and the yarn is wound onto a bobbin for further use.
7. *Savio winding*: Ring frame bobbins are inputs, and yarn cheeses formed after winding are outputs. Through this winding under tension, any weak places, fluffs, snarls, and bad knots in the yarn are removed. This step is named Savio after the make of the machine that performs the operation.
8. *Assembly/doubler winding with length measuring device (LMD)*: Two cheeses are fed and wound in parallel under tension to form another cheese. While winding, weak places, fluffs, snarls, and bad knots in the yarn are further removed.
9. *Two-for-one twister (TFO)*: Final cones or cheeses are formed by twisting and winding, under tension, the parallel yarns formed by the assembly/doubler winding step.
10. *Packing*: Cones/cheeses are weighed, packed in suitable containers, and dispatched to customers.

Steps 1 to 5 are preparatory stages, whereas steps 7 to 10 are called post spinning stages. Step 6 is meant for spinning. The quality inspection functions, including weighing of cones/cheeses, are done after steps 8 and 9.

The terminology from the textile industry that is used in this article is as follows:

- Cone: A completely wound yarn package with a conical shape.
- Cheese: A completely wound yarn package with a cylindrical shape.
- Drum: The part of a winding machine that rotates the cones or cheeses while yarn is being wound onto these packages. Typical winding machines have 60 drums installed on each side, and these drums turn the cones by friction force.
- Count: The linear density of yarn, denoted in the textile industry by N_e. Specifically, count is the number of 840-yard-long segments of yarn per pound. A specialized nomenclature has been developed in the textile industry, where N_e $2/42^s$P means a two-ply polyester yarn of fineness 42^s-, implying that 42×840 yards of this yarn weigh 1 lb.

After deciding on the project and the objective, data were collected on packing rejection from December 2002 to May 2003. Based on these data, Pareto charts were drawn for defectives to give more insight to the problem.

From the Pareto chart, in Figure 1, it was evident that almost 65% of rejections were due to weight variation of cones (i.e., either over- or underweight). Because a wide range of counts was being produced and marketed by the company, a countwise Pareto chart of yarn for over- and underweight was drawn on the basis of 6 months' packing data.

From the Pareto charts in Figures 2 and 3, it was found that the major counts in terms of packing rejection due to over- and underweight were N_e $2/42^s$P, N_e $4/12^s$P, N_e $2/20^s$P, N_e $1/30^s$V, N_e $3/20^s$P, N_e $3/12^s$P.

Data was then collected from the marketing department on monthly production of yarn, as well as on the market price per kg for both the export and domestic markets. Using this information, another Pareto chart was drawn to find major counts of yarn in terms of sales volume (Figure 4).

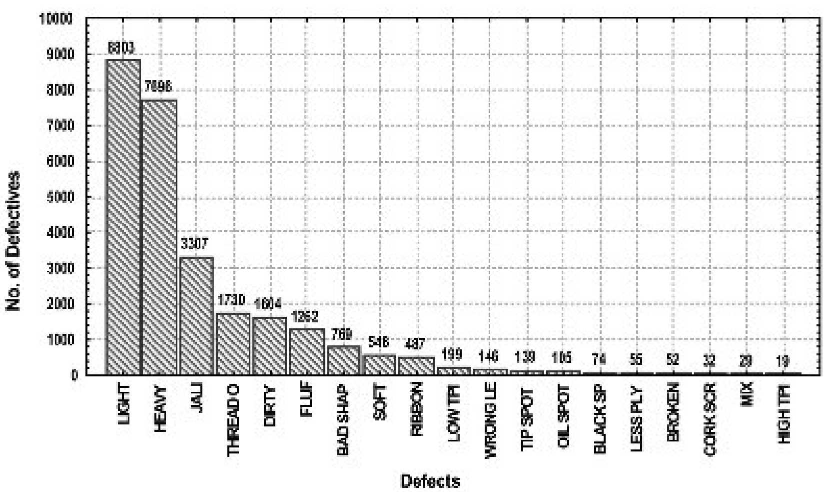

Figure 1. Pareto analysis of overall defectives.

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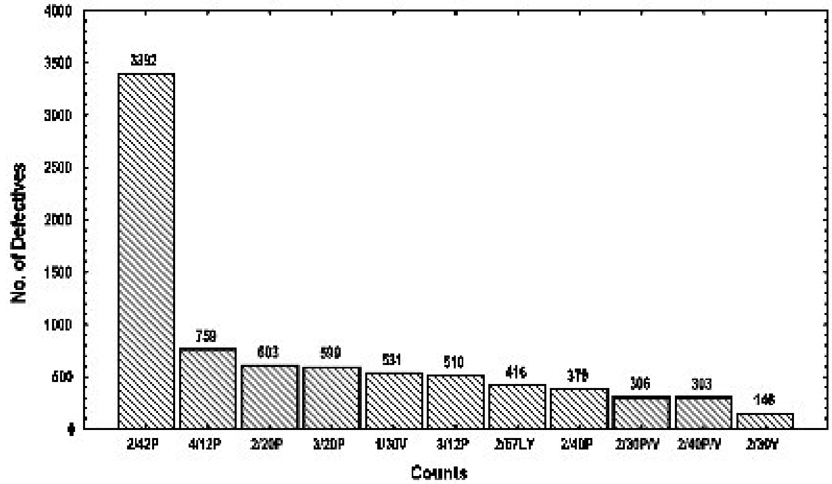

Figure 2. Pareto analysis of defectives due to underweight.

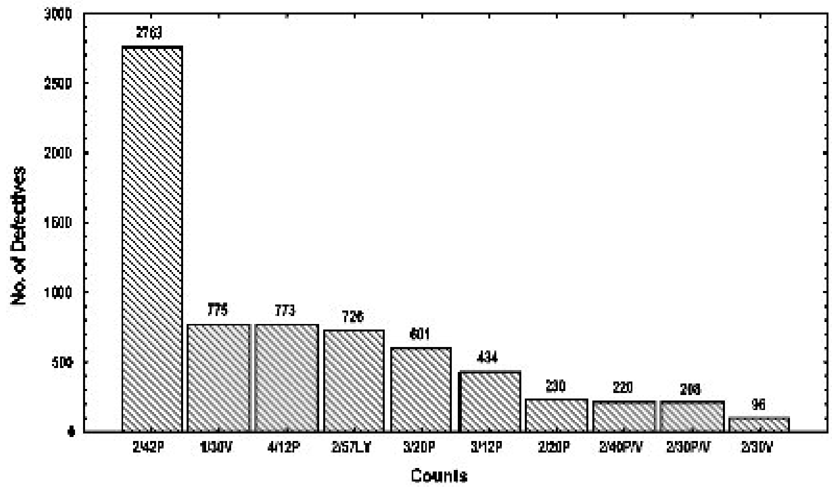

Figure 3. Pareto analysis of defectives due to overweight.

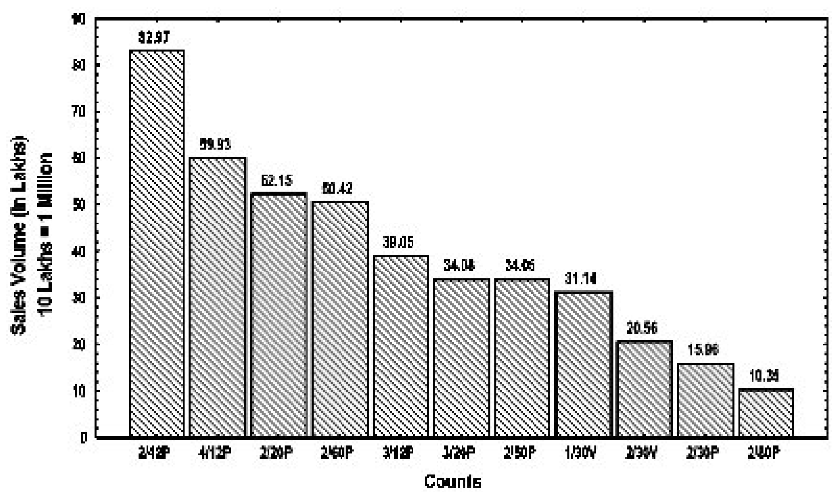

Figure 4. Pareto analysis of sales volume.

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From Figure 4, it was found that the major counts in terms of sales volume were Ne 2/42^{s}P, Ne 4/12^{s}P, Ne 2/20^{s}P, Ne 3/12^{s}P, and Ne 3/20^{s}P. These counts accounted for more than 75% of the revenue.

Because the Pareto charts of overweight and underweight and those of sales turnover converged to the same vital few counts, the analysis was narrowed to those counts.

MEASURE—PHASE I

Technical discussions concluded that the potential factors, which have a bearing on yarn weight, were as follows:

1. Count
2. Empty cheese weight
3. Moisture content % (M.C.%)
4. Length of yarn wound onto cone/cheese

Data were collected from the final two steps of post spinning (i.e., at the assembly/doubler winding step and the two-for-one twister (TFO) step). The actual count, gross cheese weight, and moisture contents were measured. The collected data are given in Appendix A.

Calculation of Current Sigma Level

From the collected data, the existing sigma level was calculated. For this calculation, the defect definitions were as follows:

1. *Defect*: A cone or cheese is defective if its gross weight (yarn weight plus empty container weight) is outside the specification limits.
2. *DPU (defect per unit)*: In DPU calculations, each drum within a machine is considered to be a unit.

The lower and upper specification limits for gross weight at the assembly winding step and those at the TFO step are given in Tables 1 and 2. The prevalent practice in the textile industry to estimate over and under weights of cones/cheeses was extended, using data in Appendix A for calculating sigma levels.

Stage I: Assembly Winding with LMD

Twenty eight drums were off-specification out of 120 that were inspected, giving a DPU = 28/120 = 0.2333 and a yield for this step of $\text{Yield}_{AW} = e^{-DPU} = 0.7919$ (Table 3).

Table 1

Specifications for gross cheese weight (kg) at the assembly winding stage

Count	LSL	Target	USL
2/10^{s}P	1.489	1.564	1.639
2/12^{s}P	0.966	1.041	1.116
3/12^{s}P	1.489	1.564	1.639
4/12^{s}P	1.489	1.564	1.639
4/12^{s}P	4.470	4.620	4.770
3/20^{s}P	0.990	1.065	1.140
2/42^{s}P	0.966	1.041	1.116

Stage II: TFO

At this step, 72 drums were off-specification out of 200 inspected, giving a DPU = 72/200 = 0.36 and a yield of $\text{Yield}_{TFO} = e^{-DPU} = 0.6977$ (Table 4).

Combining, we calculated the rolled throughput yield $= Y_{RT} = \text{Yield}_{AW} \times \text{Yield}_{TFO} = 0.7919 \times 0.6977 = 0.5525$ and the overall defective parts per million (PPM) $= -\ln(Y_{RT}) \times 10^6 = 593301.8456 \approx 593302$.

The current sigma level, $Z_{ST} = 1.3$, was obtained from the usual Six Sigma conversion table.

$$Y_{NORM} = \sqrt{\text{Yield}_{AW} \times \text{Yield}_{TFO}} = 0.7433$$

and the corresponding PPM would be $-\ln(Y_{NORM}) = 296655.5473$.

Therefore, the target sigma level, 2.017, was obtained from

$$0.8406 + \sqrt{29.37 - 2.221\ \ln(\text{PPM})} \quad \text{(Breyfogle, 1999)}$$

Table 2

Specifications for gross weight (kg) at TFO stage

Count	LSL	Target	USL
2/10^{s}P	4.350	4.500	4.650
2/12^{s}P	4.350	4.500	4.650
3/12^{s}P	4.350	4.500	4.650
4/12^{s}P	4.350	4.500	4.650
3/20^{s}P	2.050	2.100	2.200
2/42^{s}P	0.925	1.000	1.075
2/42^{s}P	2.050	2.100	2.200

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Table 3
Summary of out-of-specifications drums at assembly winding operation

Machine no.	Count	Overweight drums	Underweight drums	Total out-of-specs	Total drums
1	$2/42^{s}$P	7	0	7	120 (20)
5	$2/42^{s}$P, $2/57^{s}$LY	7	0	7	104 (20)
9	$3/20^{s}$P	0	0	0	120 (20)
10	$4/12^{s}$P, $2/10^{s}$P	2	0	2	60 (20)
11	$4/12^{s}$P	4	0	4	56 (20)
17	$3/12^{s}$P, $3/20^{s}$P, $2/12^{s}$P	8	0	8	120 (20)
Total		28	0	28	580 (120)

The figures in parentheses represent the number of drums that were inspected. Selection of the drums was random.

Table 4
Summary of out-of-specifications drums at TFO operation

Machine no.	Count	Overweight drums	Underweight drums	Total out-of-spec drums	Total drums
2	$2/42^{s}$P	7	0	7	120 (10)
5	$2/42^{s}$P, $2/57^{s}$LY	7	0	7	104 (10)
7	$3/20^{s}$P	0	0	0	120 (10)
8	$4/12^{s}$P, $2/10^{s}$P	2	0	2	60 (10)
11	$4/12^{s}$P	4	0	4	56 (10)
22	$3/12^{s}$P, $3/20^{s}$P, $2/12^{s}$P	8	0	8	120 (10)
25	$3/20^{s}$P	0	3	3	132 (10)
27	$3/20^{s}$P	0	0	0	120 (10)
33	$2/42^{s}$P	0	2	2	132 (20)
34	$2/42^{s}$P	0	0	0	144 (10)
51	$2/42^{s}$P	0	1	1	144 (10)
60	$2/42^{s}$P	1	1	2	132 (10)
64	$2/42^{s}$P	11	0	11	120 (20)
65	$2/42^{s}$P	10	0	10	120 (10)
66	$2/42^{s}$P	8	0	8	132 (10)
70	$2/42^{s}$P	7	0	7	144 (10)
71	$2/42^{s}$P	8	0	8	120 (10)
72	$2/42^{s}$P	7	0	7	132 (10)
Total		59	13	72	2,172 (200)

The figures in parentheses represent the number of drums that were inspected. Selection of drums was random.

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After the existing sigma level was calculated, analysis was initiated to investigate the cause of weight variation on the basis of the collected data.

ANALYSIS—PHASE I

Testing for Mean and Variance

Statistical hypothesis tests were performed for the gross cheese weight from assembly winding machines with attached LMDs. These tests were done in three steps:

1. The mean gross weight of cheese from each machine and each count was compared with the set target value. The results are shown in Table 5.
2. The variance of gross weight of cheese from each side of each machine for all counts was compared with the variance of gross weight of cheese from the other side of the same machine having the same count. The results are shown in Table 6.
3. The mean gross weights of cheese from the two sides of each machine having a particular count were compared. The results are shown in Table 7.

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Testing for Equality of Mean

Table 5
Testing for mean at the assembly winding stage

Machine no.	Yarn count	Target weight (kg)	Mean weight	Standard deviation	Samples	t_{CALC}	p value	Conclusion
1	2/42^{s}P	1.041	1.1091	0.0157	20	19.398	0.0000	Process not running on target.
5	2/42^{s}P	1.041	1.1042	0.0430	10	4.637	0.0006	Process not running on target.
9	3/20^{s}P	1.065	1.0960	0.0315	20	4.398	0.0000	Process not running on target.
11	4/12^{s}P	4.620	4.6861	0.0895	20	3.302	0.0020	Process not running on target.

Testing for Equality of Variances

Table 6
Comparison of variances of the two sides of assembly winding machines

Machine no.	Yarn count	n_L	n_R	S_L^2	S_R^2	$F_{CALC} = S_1^2/S_2^2$	p value	Conclusion
1	2/42^{s}P	10	10	0.0002	0.0002	1.0000	0.5000	Sides appear to have same variance.
9	3/20^{s}P	10	10	0.0015	0.0006	2.5000	0.0823	Sides appear to have same variance.
11	4/12^{s}P	10	10	0.0043	0.0053	1.2326	0.3736	Sides appear to have same variance.

Note: Because the other assembly winding machines were producing different counts at the two sides during the study period, their variances were not compared.

Testing for Equality of Means (Comparison of Two Sides)

Table 7
Comparison of means of the two sides of assembly winding machines

Machine no.	Yarn count	$\overline{X}_L$	$\overline{X}_R$	n_L	n_R	t_{CALC}	p value	Conclusion
1	2/42^{s}P	1.116	1.103	10	10	1.964	0.0250	Sides appear to have different means.
9	3/20^{s}P	1.095	1.097	10	10	0.138	0.4000	Sides appear to have same mean.
11	4/12^{s}P	4.628	4.742	10	10	3.672	0.0009	Sides appear to have different means.

Note: Because the other assembly winding machines were producing different counts at the two sides during the study period, their means were not compared. They were designed to be different.

Empty Cheese Weight Variation

To examine the variability of empty cheese weight, 50 observations were taken for each color of empty cheese. The findings are given in Table 8.

From the last two columns of Table 8, it is quite clear that the contribution of empty cheese weight variation is negligible toward the variation in gross cheese weight.

Table 8
Comparison of variation of empty cheese weight (in kg) with gross cheese weight (in kg)

Color of cheese	Count	No. of obs.	Target		Average		SD		C.V. %	
			Empty	Gross	Empty	Gross	Empty	Gross	Empty	Gross
Deep blue	4/12^{s}P	50	0.064	4.620	0.0642	4.6861	0.0014	0.0895	0.03	1.94
Yellow	4/12^{s}P	50	0.218	4.620	0.2176	4.6861	0.0021	0.0895	0.05	1.94
Lemon yellow	3/20^{s}P	50	0.064	1.065	0.0613	1.0960	0.0010	0.0315	0.09	2.96
Deep blue	2/42^{s}P	50	0.064	1.041	0.0636	1.1042	0.0014	0.0276	0.14	2.65

Note: The denominator in CV% computation is target gross cheese weight.

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Relationship between Gross Weight, Count, and Moisture Content of Yarn

To investigate the relationship between gross weight vis-à-vis count and moisture content, regression analysis was performed. Unfortunately, the analysis failed to establish count and moisture content as significant contributory factors.

CONCLUSIONS FROM THE PHASE I ANALYSIS

1. Mean gross weights of cheeses are higher than the respective target values (Table 5).
2. Variances of gross weights of cheeses at the two sides of the machines are not statistically different from each other (Table 6).
3. At machine number 11, there exists significant difference in gross weight between two sides of the machine for polyester yarn with count $4/12^{'s}$ (Table 7).
4. The contribution of empty cheese weight variation is negligible toward the gross cheese weight variation (Table 8).
5. The contribution of count and moisture content variation is negligible toward the gross cheese weight variation.
6. Variation in the length of yarn wound on to cheese appears to be the potential cause for variation in gross cheese weight.

MEASURE—PHASE II

To validate the previous findings, data were collected further from assembly winding machines with LMD attachments. This time the actual length of the yarn on the cheese, as measured by rewinding, was recorded along with set length, nominal count, actual count, moisture content percentage, empty cheese weight, and gross cheese weight. One-to-one correspondence was maintained between these parameters while collecting these data. Because the process of rewinding hampers productivity, it was decided to focus on two counts for the study—a finer variety ($2/42^{'s}$P) and a coarser variety ($4/12^{'s}$P). The corresponding data are given in Appendix B. Note that no obvious deficiency on repeatability was found for the electronic weighing balances that measure the weights of the cones/cheeses.

ANALYSIS—PHASE II

Repeatability of Set Length and Rewound Length at the Assembly Winding

From the collected data provided in Appendix B, range charts were drawn corresponding to "set length" and "actual length" for both counts ($2/42^{s}$P and $4/12^{s}$P) (Figures 5 and 6). The corresponding calculations and the range charts are provided.

For $4/12^{s}P$,

$$\mathrm{CL} = \overline{\mathrm{R}} = 350.2$$
$$\mathrm{UCL} = \mathrm{D}_4\overline{\mathrm{R}} = 1144.103 \quad [\text{for } n = 2, \mathrm{D}_4 = 3.267]$$
$$\mathrm{LCL} = \mathrm{D}_3\overline{\mathrm{R}} = 0$$

For $2/42^{s}P$,

$$\mathrm{CL} = \overline{\mathrm{R}} = 455.6$$
$$\mathrm{UCL} = \mathrm{D}_4\overline{\mathrm{R}} = 1488.445$$
$$\mathrm{LCL} = \mathrm{D}_3\overline{\mathrm{R}} = 0$$

The gage capability and repeatability of LMD were calculated to check its sensitivity on measuring yarn length for both counts. The relevant calculations are shown as follows.

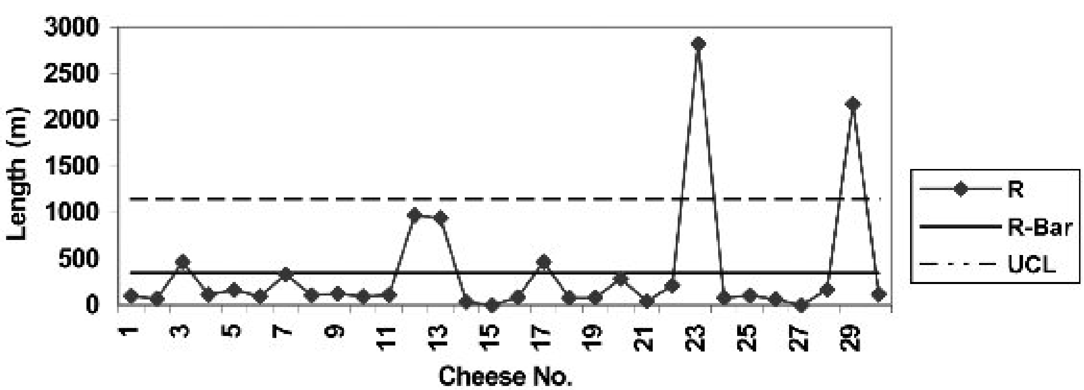

Figure 5. R-chart for repeat measurements of yarn length measured by LMD-10 (count $4/12^{'s}$P).

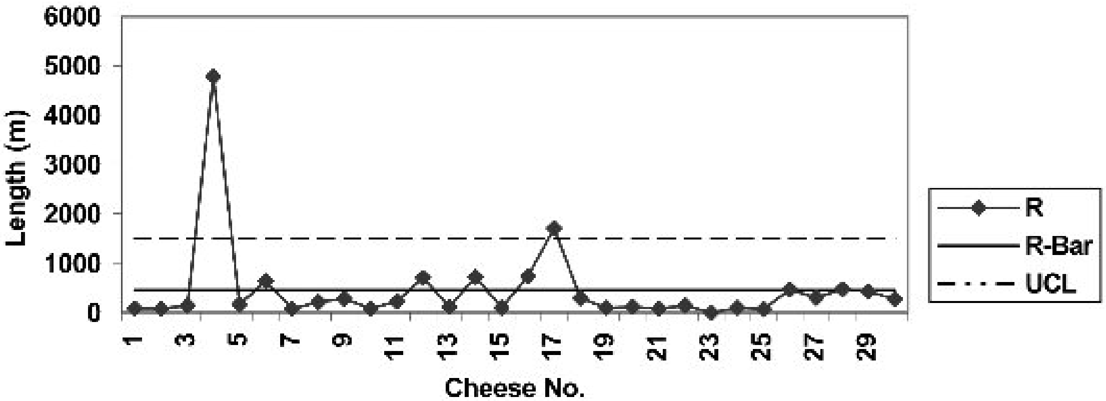

Figure 6. R-chart for repeat measurement of yarn length by LMD-5 (count 2/42's P).

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Gage Capability of LMD at the Assembly Winding Stage

The gage capability was calculated using precision-to-tolerance (P/T) percentages, where $P/T = 6\hat{\sigma}_{gage}/(USL - LSL)$ (Table 9). Values of P/T of 10% or less generally imply adequate gage capability.

The USL and LSL for length were calculated from those of gross weight using the relation, length (in meters) $= 1.693 \times$ count $(N_e) \times$ specified weight (in grams).

Gage Repeatability of LMD at the Assembly Winding Stage

The data for gage capability were used to estimate the variance components associated with total observed variability. The relation is as follows:

$$\hat{\sigma}^2_{total} = \hat{\sigma}^2_{product} + \hat{\sigma}^2_{gage}$$

$$\hat{\sigma}^2_{total} = \hat{\sigma}^2_{product} + \hat{\sigma}^2_{repeatability} \quad \text{(Montogomery, 2003)}$$

Table 9
Results of gage capability analysis

Count	$\hat{\sigma}_{gage}$	P/T %
4/12sP	310.4610 m	122.30
2/42sP	403.9007 m	45.44

Table 10
Results of gage repeatability analysis

Variability	4/12sP count	2/42sP count
$\hat{\sigma}_{total}$	700.7281 m	997.9898 m
$\hat{\sigma}_{repeatability}$	310.4610 m	403.9007 m
$\hat{\sigma}_{product}$	628.1989 m	912.6050 m
$\hat{\sigma}_{repeatability}/\hat{\sigma}_{product}$	49.42%	44.26%

(Because $\hat{\sigma}^2_{gage} = \hat{\sigma}^2_{repeatability,} + \hat{\sigma}^2_{reproducability}$, and $\hat{\sigma}^2_{reproducability}$ is nonexistent here as data are taken by a single operator.)

Here, $\hat{\sigma}^2_{total}$ is calculated for each count from the rewound lengths (Table 10).

Therefore, inconsistent measurement of yarn length by the LMDs attached with the assembly winding machines alone contributed about 44% to 49% toward the product variability. This can be considered as quite a significant amount of variation.

Regression Analysis for 4/12'sP Yarn

Using the collected data given in Appendix B, stepwise regression analysis was carried out for 4/12sP and for 2/42sP yarn to explore the relationship between gross weight vis-à-vis count, moisture content, actual yarn length, and empty cheese weight. The SPSS package was used for this purpose. Although for 2/42sP yarn no worthy relation emerged, a reasonably good relation was obtained for 4/12sP yarn. The summarized results of such regression analysis follow (Tables 11 and 12).

Table 11
ANOVA for significance of regression

Source	Sum of squares	Degrees of freedom	Mean square	*F*	*p*
Regression	0.117	1	0.117	81.985	0.000
Residual	0.039	28	0.001		
Total	0.156	29			

Table 12
Correlation matrix

	Gross cheese weight	Empty cheese weight	Moisture content	Count	Length
Gross cheese weight	1.000	−0.101	0.027	−0.233	0.863
Empty cheese weight		1.000	−0.224	0.060	−0.112
Moisture content			1.000	−0.132	−0.180
Count				1.000	−0.149
Length					1.000

The regression equation is

$$\text{Gross cheese weight} = 0.902 + 0.00009046 \times \text{Yarn length}$$

$$\text{Correlation coefficient (r)} = 0.863$$

$$\text{Coefficient of determination} = 0.745$$

$$\text{Standard error of the estimate} = 0.0377$$

This implies that about 74.5% of the variability in gross cheese weight can be explained with the variability in yarn length.

The descriptive statistics of the data for the previous regression equation are given in Table 13. Model adequacy checks were performed, and no problems were found (Montogomery, 2004).

IMPROVEMENTS ACHIEVED

1. *Rejection of cones due to being overweight (i.e., weight more than USL) lead to internal loss to the company in tangible monetary terms*. This was attributed to two factors:
   - Weights of the cheeses produced by assembly winding machines with LMDs were, in most cases, on the higher side compared with the pertinent set weight.
   - Sensitivity of the LMDs attached to the machines was inadequate, as shown using gage capability analysis through P/T percentage and $\widehat{\sigma}^2_{\text{repeatability}}$ calculations.

   Increasing the sensitivity of the performance of LMDs was achieved by implementing proper calibration procedures in some machines and by the replacement of LMDs in other machines. These corrective measures reduced cone weight variation substantially. The new P/T and $\widehat{\sigma}_{\text{repeatability}}/\widehat{\sigma}_{\text{product}}$ percentages were found to be 9.7% and 11.3%, respectively.
2. *Rejection of cones due to being underweight lead to customer dissatisfaction and hence may lead to less customer retention*. This was attributed to the lack of sensitivity of the LMDs attached to the machines and was evidenced by the gage capability analysis (using P/T ratio) and the $\widehat{\sigma}^2_{\text{repeatability}}$ calculation. The corrective measures enhanced the LMD sensitivity, and reduced its variability in length and weight measurement of yarn. Note that there existed annual maintenance contract with the suppliers of LMDs. Those suppliers were called in by the factory management to take the required corrective measures for these electronic attachments.
3. The *bottom line benefit* in monetary terms was estimated to be about Rs. 87000 per month. This was calculated as the product of the monthly production, the reduction in rework, and the cost of rework.

CONTROL

It may be recalled from Table 1 that for 4/12's polyester yarn, the specification in kg for gross weight of yarn cheeses at the assembly winding stage is LSL = 1.489, Target = 1.564, USL = 1.639. To meet the target value of 1.564 kg, the length should be set

Table 13
Descriptive statistics for 4/12's polyester yarn

	Samples	Mean	SD	Minimum	Maximum
Gross cheese weight	30	1.555	0.073	1.298	1.654
Empty cheese weight	30	64.533	1.279	62.000	66.000
Moisture content	30	0.473	0.045	0.400	0.500
Count	30	3.033	0.072	2.912	3.184
Length	30	7223.600	700.728	4576.000	7966.000

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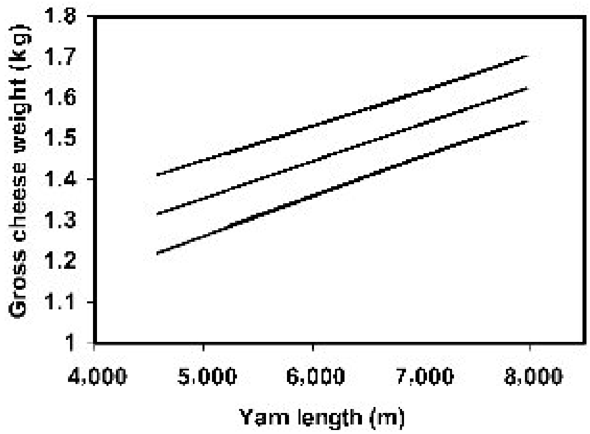

Figure 7. Fitted model and the 95% prediction interval.

at 7295.566 m, which was obtained from the X (yarn length) on Y (gross cheese weight) regression equation:

$$\text{Yarn length} = -5592.399 + 8240.387 \times \text{Gross cheese weight}$$

The 95% prediction interval for Y (gross cheese weight) on X (yarn length) regression equation at the assembly winding step was obtained as 1.486 to 1.642 kg. Note that before this study, it ranged between 1.298 and 1.654 kg. The graph showing 95% prediction interval is given in Figure 7.

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Appendix A

Sl. no.	Machine no.	Nominal count (N_e)	Actual count (N_e)	Nominal weight (kg)	Gross cheese weight (kg)	M.C.%
Data collected from assembly/doubler winding with LMD						
1	11	4/12^{s}P	3.128	4.620	4.696	0.5
2	11	4/12^{s}P	3.163	4.620	4.566	0.5
3	11	4/12^{s}P	2.922	4.620	4.568	0.5
4	11	4/12^{s}P	3.000	4.620	4.652	0.5
5	11	4/12^{s}P	2.908	4.620	4.746	0.6
6	11	4/12^{s}P	2.993	4.620	4.526	0.5
7	11	4/12^{s}P	2.929	4.620	4.608	0.6
8	11	4/12^{s}P	2.994	4.620	4.662	0.5
9	11	4/12^{s}P	2.977	4.620	4.638	0.5
10	11	4/12^{s}P	2.973	4.620	4.620	0.5
11	17	2/12^{s}P	5.762	1.041	1.485	0.7
12	17	3/12^{s}P	3.917	1.564	1.870	0.7
13	17	2/12^{s}P	5.953	1.041	1.510	0.7
14	17	2/12^{s}P	5.646	1.041	1.391	0.6
15	17	3/12^{s}P	3.924	1.564	1.502	0.6
16	17	2/12^{s}P	6.036	1.041	1.501	0.6
17	17	3/12^{s}P	3.889	1.564	1.557	0.5
18	17	2/12^{s}P	5.853	1.041	1.492	0.7
19	17	2/12^{s}P	5.658	1.041	1.481	0.6
20	17	2/12^{s}P	5.952	1.041	1.451	0.5
21	17	3/20^{s}P	6.881	1.065	1.110	0.4
22	17	3/20^{s}P	6.783	1.065	1.102	0.4
23	17	3/20^{s}P	6.728	1.065	1.111	0.4
24	17	3/20^{s}P	6.981	1.065	1.105	0.5
25	17	3/12^{s}P	4.108	1.564	1.564	0.6
26	17	3/20^{s}P	6.975	1.065	1.091	0.4
27	17	3/12^{s}P	3.514	1.564	1.557	0.5
28	17	3/12^{s}P	3.901	1.564	1.582	0.6
29	17	3/20^{s}P	6.942	1.065	1.102	0.4
30	17	3/20^{s}P	6.756	1.065	1.112	0.4
31	11	4/12^{s}P	3.298	4.620	4.862	0.6
32	11	4/12^{s}P	3.030	4.620	4.678	0.7
33	11	4/12^{s}P	2.931	4.620	4.772	0.6
34	11	4/12^{s}P	2.980	4.620	4.718	0.7
35	11	4/12^{s}P	2.881	4.620	4.700	0.7
36	11	4/12^{s}P	2.987	4.620	4.850	0.7
37	11	4/12^{s}P	2.846	4.620	4.700	0.6
38	11	4/12^{s}P	2.959	4.620	4.790	0.6
39	11	4/12^{s}P	2.993	4.620	4.700	0.7
40	11	4/12^{s}P	3.165	4.620	4.650	0.7
41	10	4/12^{s}P	2.849	1.564	1.584	0.7
42	10	4/12^{s}P	2.958	1.564	1.600	0.7
43	10	4/12^{s}P	2.885	1.564	1.662	0.7
44	10	4/12^{s}P	2.880	1.564	1.582	0.7
45	10	4/12^{s}P	2.960	1.564	1.568	0.7
46	10	4/12^{s}P	2.955	1.564	1.626	0.5
47	10	4/12^{s}P	2.938	1.564	1.590	0.7
48	10	4/12^{s}P	2.927	1.564	1.632	0.7
49	10	4/12^{s}P	3.006	1.564	1.654	0.7
50	10	4/12^{s}P	3.049	1.564	1.606	0.7

(*Continued*)

Appendix A
Continued

Sl. no.	Machine no.	Nominal count (N_e)	Actual count (N_e)	Nominal weight (kg)	Gross cheese weight (kg)	M.C.%
51	10	2/10^{s}P	4.962	1.564	1.564	0.6
52	10	2/10^{s}P	5.005	1.564	1.560	0.6
53	10	2/10^{s}P	4.877	1.564	1.552	0.6
54	10	2/10^{s}P	5.127	1.564	1.546	0.6
55	10	2/10^{s}P	5.035	1.564	1.560	0.6
56	10	2/10^{s}P	5.068	1.564	1.538	0.4
57	10	2/10^{s}P	5.137	1.564	1.562	0.6
58	10	2/10^{s}P	5.008	1.564	1.608	0.6
59	10	2/10^{s}P	4.977	1.564	1.566	0.6
60	10	2/10^{s}P	4.986	1.564	1.540	0.6
61	09	3/20^{s}P	6.552	1.065	1.120	0.5
62	09	3/20^{s}P	6.702	1.065	1.090	0.5
63	09	3/20^{s}P	6.747	1.065	1.110	0.5
64	09	3/20^{s}P	6.542	1.065	1.000	0.5
65	09	3/20^{s}P	7.155	1.065	1.140	0.5
66	09	3/20^{s}P	6.482	1.065	1.100	0.5
67	09	3/20^{s}P	7.271	1.065	1.120	0.5
68	09	3/20^{s}P	6.780	1.065	1.100	0.5
69	09	3/20^{s}P	7.134	1.065	1.070	0.4
70	09	3/20^{s}P	7.176	1.065	1.100	0.5
71	09	3/20^{s}P	6.576	1.065	1.060	0.5
72	09	3/20^{s}P	6.589	1.065	1.110	0.5
73	09	3/20^{s}P	6.898	1.065	1.130	0.5
74	09	3/20^{s}P	6.742	1.065	1.090	0.5
75	09	3/20^{s}P	6.812	1.065	1.120	0.4
76	09	3/20^{s}P	7.001	1.065	1.080	0.5
77	09	3/20^{s}P	6.415	1.065	1.120	0.5
78	09	3/20^{s}P	6.813	1.065	1.090	0.5
79	09	3/20^{s}P	7.019	1.065	1.060	0.4
80	09	3/20^{s}P	6.810	1.065	1.110	0.5
81	05	2/42^{s}P	21.658	1.041	1.124	0.5
82	05	2/42^{s}P	21.080	1.041	1.118	0.5
83	05	2/42^{s}P	21.281	1.041	1.028	0.4
84	05	2/42^{s}P	21.464	1.041	1.022	0.5
85	05	2/42^{s}P	21.723	1.041	1.106	0.5
86	05	2/42^{s}P	20.591	1.041	1.136	0.5
87	05	2/42^{s}P	21.478	1.041	1.118	0.5
88	05	2/42^{s}P	21.586	1.041	1.146	0.5
89	05	2/42^{s}P	20.256	1.041	1.124	0.5
90	05	2/42^{s}P	20.483	1.041	1.120	0.5
91	05	2/57^{s}LY	27.645	0.600	0.656	9.3
92	05	2/57^{s}LY	28.711	0.600	0.662	9.6
93	05	2/57^{s}LY	28.736	0.600	0.656	9.6
94	05	2/57^{s}LY	27.847	0.600	0.658	9.3
95	05	2/57^{s}LY	28.211	0.600	0.664	9.6
96	05	2/57^{s}LY	28.409	0.600	0.666	9.6
97	05	2/57^{s}LY	27.931	0.600	0.662	9.6
98	05	2/57^{s}LY	28.864	0.600	0.660	9.6
99	05	2/57^{s}LY	28.993	0.600	0.666	9.6
100	05	2/57^{s}LY	27.967	0.600	0.666	9.6
101	01	2/42^{s}P	21.450	1.041	1.140	0.5

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Appendix A
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Sl. no.	Machine no.	Nominal count (N_e)	Actual count (N_e)	Nominal weight (kg)	Gross cheese weight (kg)	M.C.%
102	01	2/42^{s}P	21.107	1.041	1.080	0.5
103	01	2/42^{s}P	21.478	1.041	1.040	0.5
104	01	2/42^{s}P	21.025	1.041	1.134	0.5
105	01	2/42^{s}P	21.365	1.041	1.092	0.5
106	01	2/42^{s}P	21.485	1.041	1.108	0.5
107	01	2/42^{s}P	20.964	1.041	1.128	0.5
108	01	2/42^{s}P	21.114	1.041	1.124	0.5
109	01	2/42^{s}P	21.330	1.041	1.102	0.5
110	01	2/42^{s}P	20.709	1.041	1.116	0.5
111	01	2/42^{s}P	21.073	1.041	1.118	0.5
112	01	2/42^{s}P	22.291	1.041	1.100	0.5
113	01	2/42^{s}P	21.135	1.041	1.122	0.5
114	01	2/42^{s}P	21.679	1.041	1.102	0.5
115	01	2/42^{s}P	21.571	1.041	1.102	0.5
116	01	2/42^{s}P	21.665	1.041	1.090	0.5
117	01	2/42^{s}P	21.358	1.041	1.086	0.5
118	01	2/42^{s}P	21.274	1.041	1.120	0.5
119	01	2/42^{s}P	21.848	1.041	1.102	0.5
120	01	2/42^{s}P	21.372	1.041	1.084	0.5
Data Collected from TFO						
1	33	2/42^{s}P	19.963	2.100	2.18	0.6
2	33	2/42^{s}P	20.604	2.100	2.16	0.5
3	33	2/42^{s}P	21.309	2.100	2.10	0.5
4	33	2/42^{s}P	20.923	2.100	2.02	0.5
5	33	2/42^{s}P	21.239	2.100	2.12	0.5
6	33	2/42^{s}P	21.156	2.100	2.10	0.5
7	33	2/42^{s}P	20.212	2.100	2.16	0.5
8	33	2/42^{s}P	20.087	2.100	2.02	0.6
9	33	2/42^{s}P	20.703	2.100	2.08	0.6
10	33	2/42^{s}P	21.365	2.100	2.12	0.6
11	33	2/42^{s}P	20.617	2.100	2.12	0.5
12	33	2/42^{s}P	20.870	2.100	2.12	0.5
13	33	2/42^{s}P	21.136	2.100	2.12	0.5
14	33	2/42^{s}P	21.730	2.100	2.12	0.5
15	33	2/42^{s}P	20.856	2.100	2.14	0.5
16	33	2/42^{s}P	21.578	2.100	2.10	0.5
17	33	2/42^{s}P	20.250	2.100	2.14	0.5
18	33	2/42^{s}P	21.803	2.100	2.06	0.6
19	33	2/42^{s}P	21.709	2.100	2.10	0.5
20	33	2/42^{s}P	21.372	2.100	2.10	0.5
21	64	2/42^{s}P	20.352	1.000	1.08	0.5
22	64	2/42^{s}P	20.506	1.000	1.14	0.4
23	64	2/42^{s}P	20.461	1.000	1.10	0.5
24	64	2/42^{s}P	21.114	1.000	1.08	0.5
25	64	2/42^{s}P	21.593	1.000	1.06	0.5
26	64	2/42^{s}P	20.789	1.000	1.08	0.5
27	64	2/42^{s}P	20.480	1.000	1.08	0.5
28	64	2/42^{s}P	21.053	1.000	1.08	0.5
29	64	2/42^{s}P	19.951	1.000	1.06	0.4

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Appendix A
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Sl. no.	Machine no.	Nominal count (N_e)	Actual count (N_e)	Nominal weight (kg)	Gross cheese weight (kg)	M.C.%
30	64	2/42^{s}P	20.910	1.000	0.98	0.5
31	64	2/42^{s}P	21.436	1.000	1.10	0.5
32	64	2/42^{s}P	21.840	1.000	1.06	0.5
33	64	2/42^{s}P	21.246	1.000	1.04	0.5
34	64	2/42^{s}P	21.032	1.000	1.06	0.5
35	64	2/42^{s}P	20.105	1.000	1.10	0.5
36	64	2/42^{s}P	21.066	1.000	1.02	0.6
37	64	2/42^{s}P	20.212	1.000	1.06	0.5
38	64	2/42^{s}P	21.855	1.000	1.02	0.5
39	64	2/42^{s}P	21.351	1.000	1.08	0.5
40	64	2/42^{s}P	21.557	1.000	1.08	0.5
41	72	2/42^{s}P	20.657	1.000	1.12	0.5
42	72	2/42^{s}P	20.870	1.000	1.10	0.5
43	72	2/42^{s}P	20.552	1.000	1.10	0.6
44	72	2/42^{s}P	20.836	1.000	1.12	0.5
45	72	2/42^{s}P	20.930	1.000	1.02	0.5
46	72	2/42^{s}P	20.294	1.000	1.10	0.5
47	72	2/42^{s}P	21.163	1.000	1.08	0.5
48	72	2/42^{s}P	21.309	1.000	1.12	0.5
49	72	2/42^{s}P	21.046	1.000	1.02	0.5
50	72	2/42^{s}P	20.896	1.000	1.02	0.5
51	60	2/42^{s}P	20.558	2.100	2.08	0.6
52	60	2/42^{s}P	20.769	2.100	2.16	0.6
53	60	2/42^{s}P	21.344	2.100	2.10	0.5
54	60	2/42^{s}P	21.379	2.100	2.14	0.6
55	60	2/42^{s}P	21.756	2.100	2.14	0.6
56	60	2/42^{s}P	21.012	2.100	2.04	0.7
57	60	2/42^{s}P	20.736	2.100	2.12	0.7
58	60	2/42^{s}P	21.005	2.100	2.06	0.8
59	60	2/42^{s}P	21.039	2.100	2.12	0.7
60	60	2/42^{s}P	21.884	2.100	2.24	0.6
61	27	3/20^{s}P	6.520	2.100	2.14	0.6
62	27	3/20^{s}P	6.467	2.100	2.14	0.5
63	27	3/20^{s}P	5.221	2.100	2.12	0.5
64	27	3/20^{s}P	7.041	2.100	2.10	0.6
65	27	3/20^{s}P	6.785	2.100	2.08	0.6
66	27	3/20^{s}P	6.658	2.100	2.14	0.6
67	27	3/20^{s}P	6.316	2.100	2.14	0.6
68	27	3/20^{s}P	6.930	2.100	2.10	0.6
69	27	3/20^{s}P	6.806	2.100	2.08	0.5
70	27	3/20^{s}P	6.430	2.100	2.12	0.5
71	22	3/20^{s}P	6.272	2.100	2.14	0.6
72	22	3/20^{s}P	6.452	2.100	2.14	0.6
73	22	3/20^{s}P	6.727	2.100	2.16	0.6
74	22	3/20^{s}P	6.644	2.100	2.14	0.5
75	22	3/20^{s}P	7.025	2.100	2.08	0.7
76	22	3/20^{s}P	6.280	2.100	2.14	0.5
77	22	3/20^{s}P	6.689	2.100	2.14	0.6
78	22	3/20^{s}P	6.339	2.100	2.08	0.6
79	22	3/20^{s}P	6.159	2.100	2.18	0.6
80	22	3/20^{s}P	6.459	2.100	2.16	0.6

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Appendix A
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Sl. no.	Machine no.	Nominal count (N_e)	Actual count (N_e)	Nominal weight (kg)	Gross cheese weight (kg)	M.C.%
81	71	2/42^{s}P	21.135	1.000	1.10	0.5
82	71	2/42^{s}P	21.344	1.000	1.08	0.6
83	71	2/42^{s}P	22.531	1.000	1.10	0.6
84	71	2/42^{s}P	21.260	1.000	1.10	0.6
85	71	2/42^{s}P	20.716	1.000	1.10	0.5
86	71	2/42^{s}P	21.059	1.000	1.08	0.5
87	71	2/42^{s}P	20.513	1.000	1.10	0.6
88	71	2/42^{s}P	20.591	1.000	1.04	0.5
89	71	2/42^{s}P	20.843	1.000	1.04	0.6
90	71	2/42^{s}P	20.663	1.000	1.10	0.6
91	11	2/42^{s}P	20.591	2.100	2.04	0.7
92	11	2/42^{s}P	20.263	2.100	2.16	0.7
93	11	2/42^{s}P	21.443	2.100	2.16	0.7
94	11	2/42^{s}P	20.896	2.100	2.12	0.6
95	11	2/42^{s}P	20.442	2.100	2.08	0.5
96	11	2/42^{s}P	21.302	2.100	2.14	0.6
97	11	2/42^{s}P	20.749	2.100	2.08	0.6
98	11	2/42^{s}P	20.716	2.100	2.10	0.7
99	11	2/42^{s}P	20.250	2.100	2.16	0.7
100	11	2/42^{s}P	20.657	2.100	1.82	0.7
101	66	2/42^{s}P	20.422	1.000	1.08	0.6
102	66	2/42^{s}P	20.571	1.000	1.18	0.6
103	66	2/42^{s}P	21.288	1.000	1.12	0.5
104	66	2/42^{s}P	21.478	1.000	1.08	0.5
105	66	2/42^{s}P	21.032	1.000	1.18	0.6
106	66	2/42^{s}P	20.856	1.000	1.06	0.6
107	66	2/42^{s}P	21.436	1.000	1.04	0.6
108	66	2/42^{s}P	21.032	1.000	1.08	0.6
109	66	2/42^{s}P	21.796	1.000	1.08	0.5
110	66	2/42^{s}P	21.478	1.000	1.08	0.5
111	25	3/20^{s}P	6.136	2.100	2.18	0.5
112	25	3/20^{s}P	6.216	2.100	2.14	0.6
113	25	3/20^{s}P	6.666	2.100	2.12	0.5
114	25	3/20^{s}P	6.496	2.100	1.82	0.5
115	25	3/20^{s}P	6.116	2.100	2.18	0.5
116	25	3/20^{s}P	6.387	2.100	2.10	0.7
117	25	3/20^{s}P	6.257	2.100	2.08	0.7
118	25	3/20^{s}P	6.624	2.100	1.52	0.5
119	25	3/20^{s}P	6.343	2.100	2.14	0.6
120	25	3/20^{s}P	6.787	2.100	1.54	0.5
121	65	2/42^{s}P	21.156	1.000	1.10	0.5
122	65	2/42^{s}P	21.094	1.000	1.08	0.6
123	65	2/42^{s}P	21.745	1.000	1.10	0.6
124	65	2/42^{s}P	20.591	1.000	1.14	0.5
125	65	2/42^{s}P	20.062	1.000	1.16	0.5
126	65	2/42^{s}P	21.493	1.000	1.10	0.5
127	65	2/42^{s}P	21.818	1.000	1.08	0.5
128	65	2/42^{s}P	21.101	1.000	1.12	0.6
129	65	2/42^{s}P	21.295	1.000	1.08	0.5
130	65	2/42^{s}P	21.309	1.000	1.08	0.5
131	34	2/42^{s}P	21.344	2.100	2.18	0.6

(*Continued*)

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Appendix A
Continued

Sl. no.	Machine no.	Nominal count (N_e)	Actual count (N_e)	Nominal weight (kg)	Gross cheese weight (kg)	M.C.%
132	34	$2/42^s$P	21.281	2.100	2.18	0.6
133	34	$2/42^s$P	22.146	2.100	2.06	0.5
134	34	$2/42^s$P	21.500	2.100	2.16	0.6
135	34	$2/42^s$P	22.222	2.100	2.06	0.6
136	34	$2/42^s$P	20.957	2.100	2.10	0.6
137	34	$2/42^s$P	21.877	2.100	2.08	0.7
138	34	$2/42^s$P	20.676	2.100	2.18	0.5
139	34	$2/42^s$P	20.598	2.100	2.10	0.7
140	34	$2/42^s$P	21.302	2.100	2.08	0.6
141	51	$2/42^s$P	21.344	2.100	2.10	0.5
142	51	$2/42^s$P	21.622	2.100	2.16	0.5
143	51	$2/42^s$P	20.487	2.100	2.16	0.5
144	51	$2/42^s$P	20.736	2.100	2.14	0.6
145	51	$2/42^s$P	21.478	2.100	2.04	0.6
146	51	$2/42^s$P	21.012	2.100	2.18	0.6
147	51	$2/42^s$P	21.218	2.100	2.14	0.6
148	51	$2/42^s$P	20.545	2.100	2.20	0.7
149	51	$2/42^s$P	21.414	2.100	2.14	0.6
150	51	$2/42^s$P	20.883	2.100	2.20	0.6
151	70	$2/42^s$P	21.066	1.000	1.08	0.6
152	70	$2/42^s$P	21.826	1.000	1.06	0.5
153	70	$2/42^s$P	20.910	1.000	1.08	0.5
154	70	$2/42^s$P	21.528	1.000	1.08	0.6
155	70	$2/42^s$P	21.907	1.000	1.10	0.5
156	70	$2/42^s$P	21.204	1.000	1.06	0.5
157	70	$2/42^s$P	21.211	1.000	1.08	0.6
158	70	$2/42^s$P	21.204	1.000	1.08	0.5
159	70	$2/42^s$P	21.571	1.000	1.06	0.6
160	70	$2/42^s$P	20.282	1.000	1.08	0.6
161	07	$4/12^s$P	2.903	4.500	4.75	0.7
162	07	$4/12^s$P	2.922	4.500	4.55	0.8
163	07	$4/12^s$P	3.000	4.500	4.50	0.8
164	07	$4/12^s$P	2.949	4.500	4.50	0.8
165	07	$4/12^s$P	2.923	4.500	4.50	0.8
166	07	$4/12^s$P	2.967	4.500	4.70	0.8
167	07	$4/12^s$P	3.005	4.500	4.65	0.8
168	07	$4/12^s$P	2.894	4.500	4.60	0.8
169	07	$4/12^s$P	2.993	4.500	4.60	0.7
170	07	$4/12^s$P	3.010	4.500	4.70	0.8
171	02	$3/12^s$P	3.951	4.500	4.70	0.6
172	02	$3/12^s$P	3.860	4.500	4.65	0.6
173	02	$3/12^s$P	3.820	4.500	4.70	0.5
174	02	$3/12^s$P	4.061	4.500	4.65	0.6
175	02	$3/12^s$P	3.668	4.500	4.60	0.5
176	02	$3/12^s$P	3.775	4.500	4.55	0.5
177	02	$3/12^s$P	4.042	4.500	4.65	0.5
178	02	$3/12^s$P	3.857	4.500	4.60	0.5
179	02	$3/12^s$P	3.718	4.500	4.70	0.6
180	02	$3/12^s$P	3.834	4.500	4.55	0.6
181	05	$4/12^s$P	2.887	4.500	4.50	0.6
182	05	$4/12^s$P	2.960	4.500	4.55	0.6

(*Continued*)

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Appendix A
Continued

Sl. no.	Machine no.	Nominal count (N_e)	Actual count (N_e)	Nominal weight (kg)	Gross cheese weight (kg)	M.C.%
183	05	4/12^{s}P	2.952	4.500	4.75	0.6
184	05	4/12^{s}P	3.077	4.500	4.65	0.6
185	05	4/12^{s}P	2.888	4.500	4.65	0.6
186	05	4/12^{s}P	3.092	4.500	4.45	0.7
187	05	4/12^{s}P	3.077	4.500	4.55	0.6
188	05	4/12^{s}P	3.082	4.500	4.45	0.6
189	05	4/12^{s}P	2.997	4.500	4.50	0.6
190	05	4/12^{s}P	2.972	4.500	4.45	0.7
191	08	4/12^{s}P	3.178	4.500	4.15	0.6
192	08	4/12^{s}P	3.025	4.500	1.05	0.6
193	08	4/12^{s}P	2.990	4.500	4.30	0.7
194	08	4/12^{s}P	2.997	4.500	4.40	0.7
195	08	4/12^{s}P	3.003	4.500	4.30	0.6
196	08	4/12^{s}P	3.061	4.500	4.60	0.7
197	08	4/12^{s}P	3.088	4.500	4.50	0.7
198	08	4/12^{s}P	2.993	4.500	4.45	0.7
199	08	4/12^{s}P	2.916	4.500	4.60	0.8
200	08	4/12^{s}P	2.890	4.500	4.55	0.6

Appendix B
Data on cheese weight at the assembly winding stage after rewinding

Serial no.	Gross weight (kg)	Nominal count (N_e)	Actual count (N_e)	Set length (m)	Actual length (m)	M.C.%	Empty cheese weight (g)
1	1.098	2/42^{s}P	21.855	36,500	36,418	0.5	64
2	1.084	2/42^{s}P	21.344	36,500	36,417	0.5	60
3	1.096	2/42^{s}P	21.267	36,500	36,360	0.5	64
4	1.092	2/42^{s}P	21.840	36,500	31,724	0.5	64
5	1.102	2/42^{s}P	21.803	36,500	36,667	0.5	62
6	1.112	2/42^{s}P	21.636	36,500	37,134	0.5	62
7	1.106	2/42^{s}P	21.774	36,500	36,425	0.5	64
8	1.056	2/42^{s}P	21.687	36,500	36,714	0.4	64
9	1.104	2/42^{s}P	21.450	36,500	36,778	0.5	62
10	1.118	2/42^{s}P	21.988	36,500	36,583	0.5	64
11	1.104	2/42^{s}P	21.789	36,500	36,724	0.5	64
12	1.084	2/42^{s}P	21.636	36,500	35,793	0.5	64
13	1.082	2/42^{s}P	21.716	36,500	36,613	0.5	64
14	1.136	2/42^{s}P	21.281	36,500	37,224	0.5	64
15	1.134	2/42^{s}P	20.611	36,500	36,594	0.5	64
16	1.122	2/42^{s}P	21.018	36,500	37,234	0.5	62
17	1.200	2/42^{s}P	21.302	36,500	38,213	0.5	64
18	1.112	2/42^{s}P	21.884	36,500	36,793	0.5	64
19	1.118	2/42^{s}P	21.302	36,500	36,405	0.5	64
20	1.100	2/42^{s}P	21.730	36,500	36,614	0.5	64
21	1.400	2/42^{s}P	21.101	36,500	36,584	0.5	64
22	1.134	2/42^{s}P	20.162	36,500	36,640	0.4	62
23	1.174	2/42^{s}P	20.763	36,500	36,500	0.5	64
24	1.122	2/42^{s}P	22.003	36,500	36,594	0.4	66
25	1.072	2/42^{s}P	21.066	36,500	36,574	0.5	64
26	1.086	2/42^{s}P	20.624	36,500	36,965	0.5	64

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Appendix B
Continued

Serial no.	Gross weight (kg)	Nominal count (N_e)	Actual count (N_e)	Set length (m)	Actual length (m)	M.C.%	Empty cheese weight (g)
27	1.130	$2/42^s$P	21.855	36,500	36,795	0.4	64
28	1.112	$2/42^s$P	22.268	36,500	36,974	0.4	62
29	1.102	$2/42^s$P	21.386	36,500	36,074	0.5	64
30	1.106	$2/42^s$P	22.071	36,500	36,773	0.4	64
31	1.618	$4/12^s$P	3.018	7,500	7,400	0.5	66
32	1.568	$4/12^s$P	2.936	7,500	7,432	0.5	64
33	1.550	$4/12^s$P	3.054	7,500	7,966	0.4	64
34	1.572	$4/12^s$P	2.944	7,500	7,386	0.5	66
35	1.548	$4/12^s$P	2.965	7,500	7,336	0.5	66
36	1.614	$4/12^s$P	2.912	7,500	7,402	0.4	64
37	1.654	$4/12^s$P	3.078	7,500	7,832	0.5	64
38	1.572	$4/12^s$P	3.000	7,500	7,393	0.4	66
39	1.584	$4/12^s$P	3.184	7,500	7,377	0.4	66
40	1.640	$4/12^s$P	2.929	7,500	7,406	0.5	64
41	1.570	$4/12^s$P	3.093	7,500	7,610	0.5	64
42	1.514	$4/12^s$P	3.011	7,500	6,531	0.5	66
43	1.570	$4/12^s$P	3.082	7,500	6,559	0.5	62
44	1.558	$4/12^s$P	2.972	7,500	7,533	0.5	64
45	1.614	$4/12^s$P	2.972	7,500	7,500	0.5	64
46	1.614	$4/12^s$P	2.974	7,500	7,413	0.5	66
47	1.448	$4/12^s$P	3.089	7,500	7,034	0.4	64
48	1.588	$4/12^s$P	3.165	7,500	7,581	0.5	64
49	1.568	$4/12^s$P	2.945	7,500	7,581	0.5	62
50	1.584	$4/12^s$P	3.083	7,500	7,788	0.5	64
51	1.582	$4/12^s$P	3.081	7,500	7,457	0.4	66
52	1.524	$4/12^s$P	3.045	7,500	7,289	0.4	64
53	1.298	$4/12^s$P	3.040	7,500	4,576	0.5	66
54	1.570	$4/12^s$P	3.137	7,500	7,322	0.5	66
55	1.552	$4/12^s$P	2.997	7,500	7,296	0.5	64
56	1.544	$4/12^s$P	3.065	7,500	7,334	0.5	64
57	1.568	$4/12^s$P	3.066	7,500	7,400	0.5	64
58	1.572	$4/12^s$P	3.006	7,500	7,231	0.5	62
59	1.358	$4/12^s$P	3.129	7,500	5,227	0.5	64
60	1.542	$4/12^s$P	3.024	7,500	7,516	0.4	66

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