Loss Function And Satistical Control In The Measurement Of Knitted School Sweater Canvases

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***Abstract*—The present work of investigation is about the quality in the fabric of knitting for the manufacture of textile sweaters in the municipality of Moroleón, Guanajuato, México, whit the main purpose to make known to the organization in question which is in fact the loss suffered for not having quality in its products, this investigation was carried out whit the help of the statistical control and the function of loss established by Taguchi, this statistical control was used for the linens both of the body and the sleeves for the manufacture of the textile sweater, the measurements of both the width and the length of the canvases in question were taken as a basis, these measurements of the both the width and the length of the canvases in question were taken as a basis, these measurements were taken with the tape measure, which is the unit of measurement used by custom in the region, which allows us to have the data that we want to collect, once we have this data we will begin to develop the formula to obtain the loss function and once obtained combine it with the statistical control to cover more branches about the quality, and give more detailed information about the quality that we have in the manufacture of school sweaters. 100 samples of both width and length of sleeves and bodies were taken in order to have a better visualization of the statistical control and the loss function when graphing them.**

Keywords—Loss function; statistical control; textile; Taguchi; quality

I. Introduction (*Heading 1*)

The textile industry is an important source of income and employment for many countries, particularly developing countries. In 2001, this industry accounted for 2.5% of world trade in goods and 3.3% of world trade in manufactures. The region in which it is most relevant is Asia, whose textile exports represent 4.3% of total merchandise exports and 5.3% of the region’s total manufactured exports. The regions that receive the most textile imports are Africa whit 8% and Eastern Europe with 5.8% of the region’s total imports[1].

The textile activity has become one of the main generators of employment and foreign exchange in Latin America. This region has positioned itself as the second largest international supplier of clothing to the U.S. market – after Asia – with 32.8% of the volume of imports made by this country in 2003. In the last decade, export quantities have quadrupled from 1,542 million SME1 in 1992 to 6,193 million in 2003, an average annual growth of 13.5%. The textile sector became in many countries a key sector for diversifying exports, which in 1980s were almost entirely concentrated in traditional agricultural products [2].

In the European context, in 2000, 54% of European exports in the sector were concentrated in what is known as the high-quality segment, compared to only 26% of European imports for the same segment, In recent years, the development of the high-tech textile sector with high levels of investment and development (the application of synthetic fibres to production processes, for example) is becoming an increasingly important percentage in the European textile industry, contributing 27% of all European textile production in 1993 [3].

Today, textiles are perhaps the sector of the global economy in which the production and commercialization structure of the capitalist economic system in its phase of globalization is more graphically reproduced. Cotton and other fibers travel to the textile workshops of Southeast Asia, India or Morocco where the workers, the vast majority of whom are women, sew the garments in deplorable working, safety and hygiene conditions. The owners of the workshops sell the garments to the big international fashion companies, which sell their exclusive designs in the shop windows of Paris, Madrid or Milan, in a chain that often puts high economic profitability above any other social or environmental consideration [4].

The textile, clothing and leather industry is currently the fourth most important activity of the manufacturing sector in Mexico (in 2002 it contributed 7.5% of the manufacturing GDP) despite the fact its share in the manufacturing GDP has decreased in recent years [5].

The Mexican textile sector is mainly integrated by micro and small companies (85.9%). In 2006, the national production of chemical fibers was centered on synthetic fibers (93.1%) more than on artificial fibers (6.9%). Compared to the manufacture of textile supplies (69.5%) compared to the manufacture of textile products (15.5%). In 2006, total textile exports and imports amounted to 24,610.2 and 73, 217.5 million pesos; the main products exported by the Mexican textile industry are synthetic and artificial fibers and filaments (24.1%). In 2006, Mexico participated with 1.0% of world textile exports, while textile imports made by our country represented 2.6% of the world total [6].

In the 80's, the State of Guanajuato had based its economy on the agricultural and commercial sector, but from the 90's, industry and service increased significantly; taking actions to attract investments and businesses to the state. From this total of companies in the state, the clothing industry and apparel is concentrated in 8 municipalities: Irapuato, León, Moroleón, Uriangato, San Francisco del Rincón, Celaya, San José Iturbide and Acámbaro. In these municipalities, 80% of the state's clothing companies are located, in which 90% of the employed personnel work and 95% of the production value of this industry is generated. The municipalities of Moroleón and Uriangato are characterized by being almost completely textile, and being the source of income for most of the population and its surroundings. Most of the businesses are family businesses of micro and small size. The push of industrialists and artisans in the area, in terms of knitting, for its volume, design and quality, has led to this region to be called the "National capital of the sweater" [7].

As mentioned above in both places, Moroleón and Uriangato, the companies that are dedicated to the textile industry are micro and small enterprises, which have been cleared thanks to the low costs of production and sale of these products with good "quality", however, not all companies have run with this luck as many have remained in the attempt to excel the rest of the others. This is largely due to the lack of internal process control when manufacturing the garments. It is in the producer's interest to finish the order on time and to generate profits. These companies do not have a control system to help them manage production processes and inventory management of both raw materials and finished products. A factor that does not help clear the companies in the region is the lack of quality at the time of making their products, most companies generate their products systematically without conducting a thorough analysis of whether or not the product meets the measures and standarbs that should have and how to reduce waste generated at the time of making their products.

To achieve quality there has to be a flow of information between what the customer expects and what is provided. If this process of communication is not correct, it will be incurred due to lack of quality. Throughout industrial development there have been many contributions to quality. Among these contributions, the following stand out: Walter Shewart. I develop the statistical process control SPC, whose objective is to dominate the process. Edwards Deming. I promote the use of statistical process control and make numerous contributions that are in full force. Joseph M. Juran. Wrote his trilogy: planning, control and quality improvement. His philosophy was: that quality is achieved by mentalization and not by inspection. Genichi Taguchi. I am researching a methodology to reduce costs and improve quality (Taguchi DDE method of statistical design of experiments) [8].

Genichi Taguchi made a great effort to bring the experimental design to a practical level. He also introduced revolutionary concepts that affected the way quality is measured and its cost. For Taguchi, quality, rather than the satisfaction of specifications, must be measured in terms of the loss that society suffers as a result of poor quality. For the customer, a quality product is one that meets performance expectations every time it is used, without failure and in any condition or circumstance. Products that do not meet these expectations cause losses, both for customers and producers, and eventually for the res of society. This is why, for Taguchi, quality must be measured in terms of the loss it causes: the greater the loss, the lower the quality [9].

One of Dr. Taguchi's most important achievements is to associate the concept of the loss function. This function makes it possible to determine the financial loss caused to the consumer when there is a deviation from the target, as the variation due to noise increases. The basic activities of quality engineering are aimed at reducing losses caused by variation [10]. Dr. Taguchi's quality loss function quantifies monetarily the costs of performing a process where the product does not meet the customer´s specification [11].

For Taguchi, quality, rather than the satisfaction of specifications, must be measured in terms of the so-called loss function, which establishes the loss that society suffers as a result of poor quality. For the customer, a quality product is one that meets performances expectations every time it is used, without failure and in any condition or circumstance. Products that do not meet these expectations cause losses, both for customers and producers, and eventually for the rest of society [12].

The issue described above has consequences that seriously affect the region's textile industry, since many companies have been forced to close down because of losses generated by the lack of quality in their product; in the case of returning an order due to lack of quality, the company would be losing everything from the purchase of raw material (if it were the case that the raw material was purchased) to the expenses generated by labor and all its derivatives, which has caused companies in the region to be unable to rise from such a shock.

That is why the following paper will be aimed at making an analysis of the loss function and statistical control based on a knitting textile production company in the southern zone of state of Guanajuato, in which it will be observed whether the measurements of the canvases for the creation of a school sweater, meets or not the rage values to which it should be subject, and if this is not the case it will generate an eventual loss for the company.

II. State of the Art

Vendor selection is a multi-criteria decision-making process. It encompasses a variety of tangible and intangible factors. Both risks and benefits of using a supplier in the supply chain are identified for inclusion in the evaluation process. The Taguchi loss function is used to measure the performance of each candidate supplier against the risks and benefits. The combination of the Taguchi loss function and the hierarchy process (AHP) provides a novel approach to ranking potential suppliers for outsourcing purposes [13]. A supplier evaluation and selection system using the Taguchi loss function aims to address the issue of how to measure overall supplier performance on the basis of quality, on-time delivery, price and service. As purchasing organizations continue to secure long-term supplier relationships, this evaluation program can address purchasing needs by monitoring and evaluating supplier on their actual performance, communicating purchasing priorities to the supplier in a situation that is easy to understand [14]. The analytic hierarchy process is a useful method for adding group preferences. However, judgments are often inconsistent and in reality, peer comparison matrices rarely meet the criterion of inconsistency. In this situation, we suggest a new method, called the loss function approach, which uses an inconsistency relationship as the quality of group evaluation. The Taguchi loss function was introduced for this method. An evaluation reliability function was also developed to derive the weight of the group. Finally, a step-by-step numerical example of loss function approach was provided [15]. The application of the robust design concept, based on the Taguchi loss function, to the formulation and solution of non-linear optimization problems is investigated. The effectiveness of the approach is illustrated whit two examples. The first example is a machining parameter optimization problem in which the cost of production, the second example is a weld life design problem where the weld and beam dimensions are within the stated limitations of the shear stress in the weld [16]. An integrated method of the Taguchi loss function proposes an analytical hierarchy process model (AHP) and multiple choice target scheduling (MCGP) to solve the problem of vendor selection. First, the Taguchi loss function is applied to evaluate the loss of each criterion. Finally, based on tangible and intangible constraints with respect to vendors an MCGP model is formulated and solved to identify the best supplier [17]. Recently, Taguchi loss function have been applied to other non-manufacturing fields. Quigley and McNamara implemented such functions to evaluate product quality as an aid in supplier selection. Kethley applied them to improve customer service in the real estate industry. Li used them to measure service quality [18].Taguchi's loss function is applied to various industry problems, such as healthcare, real estate and manufacturing application [19]. Mahalonobis promoted statistical quality control and operations research techniques in the industrial sector to increase productivity and improve the quality of manufacturing goods [20].

The relationship between the loss function and statistical control was sought in the literature and nothing was found, therefore, this paper will cover the relationship between the loss function and statistical control.

III. Methodology

In this section a description of the process that was carried out to obtain the loss function and the statistical control is made, in which the following methodology will be applied, which will be described in order to obtain the results that will allow us to see which is the loss in the production of school sweaters, its most important stages can be observed in the following scheme:

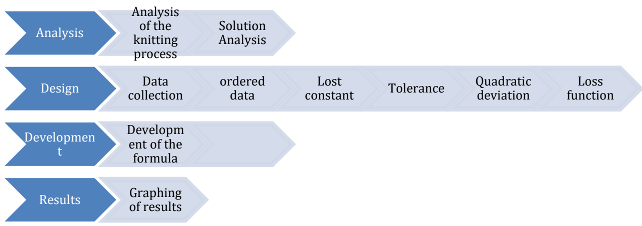

Fig. 1. Diagrama data

Figure 1 shows each of the processes followed in the methodology, from the analysis to the results. Next, the activities that were carried out in each of the processes and sub-processes are developed.

A. Analysis

De objective of this stage is to analyze the process that takes place in the elaboration of the school sweaters. It will also analyze how to find the loss function and the statistical control for the textile manufacturing process.

B. Design

- At this stage of the process, data was collected on the canvases from which the sweaters are made, both bodies and sleeves. This data will allow the Taguchi model to be made in order to obtain the results of the loss incurred in the manufacturing process. We also looked for the loss caused by this in the company, the tolerance the company gives to canvases so that they do not generate loss, the quadratic deviation of the data and finally find the loss function.

- In the same design stage, the design of the formula that will allow us to obtain the loss function and the statistical control was carried out. There are 3 types of quality charactetistics:

- Nominal is better: where values can be close to the target value, ideally all values should be at the target value and thus the loss function would be 0.

- Higher is better: Where the value found is as high as possible.

- Lower is better: Where you look for the lowest value found.

- The formula for finding the loss function is as follow:

- $\iota = \frac{A}{\Delta^2}(r^2)$ (1)

- Were:

- L = Loss function

- A = Loss of organization by defective product

- r2 = variance

- Δ = Tolerance

IV. Development

At this stage, the formula chosen to carry out the loss function and the statistical control will be carefully developed, which will allow us to know whether or not the appropriate quality for the manufacture of school sweaters is being fulfilled. Once the formula has been developed and the expected results have been obtained, we will proceed to develop the graph which will allow us to observe how data are behaving and see which date are between the limits and which are not.

V. Results

At this stage, the results obtained in the previous stages will be shown in order to make a general conclusion about the state of the quality of the clothing process in that company.

A. *Results of the analysis stage*

At the time of the analysis of the textile manufacturing, the whole process of the school sweaters manufacturing, which can be made as body or sleeves until the moment of arriving at the packing of the same.

The manufacturing or the canvas is done in a straight line machine, gauge 10, where the parameters of how we want to obtain the canvas are programmed. These parameters are the width, length and hardness of the canvas, among others. In illustration 2 is a picture of the rectilinear machine in charge of manufacturing the canvas.

After the canvases are taken out of the straight machine we proceed to measure their width and length to see that they are within the established limits in which the canvas waste is no more or no less than expected or necessary strict. After checking the measurements, the mold is put on which has the design of the body and the sleeve and proceeds to cut it.

Fig. 2. Straight knitting machine

B. *Results of the design stage.*

The data collection was taken in the following way: first the measurements of the patterns were taken, which have the standard measurements for the manufacture of the sweaters; both the sleeves and the bodies were measured, the measurements of the sleeves were:

TABLE I. Sleeve Measurements

Width	Length
13 cm	38 cm

TABLE II. Body Measurements

Width	Length
16 cm	43 cm

The data was stored in an Excel sheet both the values of the sleeves and the bodies, this sheet will act as a data repository in which they will be extracted to give them the treatment we need.

Fig. 3. *Pattern of a body*

Then we proceeded to measure the width and length of the canvases of both the sleeves and the bodies with a tape measure, we built 4 tables which data are in a disorderly manner which helped us to give an adequate treatment to them. The following tables show the data taken from the bodies and the sleeves of the sweaters:

TABLE III. BODY LENGTH DATA

45	***46***	***45***	***46***	***47***	***44***
45	46	44	45	47	48
45	46	44	46	47	45
45	46	47	48	45	46
44	46	43	47	45	46
48	45	44	49	45	46
47	44	45	46	44	45
46	44	46	45	47	46
44	46	45	45	48	47
44	46	43	47	45	46
48	45	45	46	45	46
47	44	45	46	44	45
47	48	45	48	45	44
49	45	46	47	44	45
44	45	46	44	46	45
47	46	44	46	46	44
45	43	47	45		

TABLE IV. BODY LENGTH DATA

16.5	***16.6***	***16.5***	***16.8***	***16.7***	***16.5***
16.4	16.3	16.5	16.8	16.7	16.9
16.3	16.9	16.4	16.6	16.3	16.8
16.4	16.7	16.5	16.7	16.2	16.5
16.8	16.2	16.8	16.7	16.5	16.9
16.7	16.3	16.9	16.5	16.7	16.9
16.4	16.8	16.9	16.3	16.9	16.4
16.6	16.3	16.8	16.4	16.7	16.5
16.7	16.2	16.5	16.8	16.2	16.8
16.7	16.5	16.6	16.5	16.8	16.7
16.5	16.4	16.3	16.5	16.8	16.7
16.8	16.7	16.5	16.9	16.7	16.3
16.9	16.5	16.7	16.9	16.4	16.8
16.9	16.3	16.9	16.4	16.6	16.4
16.3	16.5	16.8	16.7	16.8	16.7
16.5	16.9	16.9	16.3	16.9	16.4
16.6	16.3	16.4	16.9		

TABLE V. SLEEVE LENGTH DATA

40	***42***	***40.5***	***43***	***41***	***40.5***
42	43.5	42.5	40.5	43.5	43
40.5	42	42.5	44	43.5	42.5
41.5	40.6	41.6	44	45.6	45.5
43.6	41.5	42.5	40	42	42.5
44.5	43.6	46.5	44.3	42.5	44.5
44	40.5	40	42	42.5	44
43.5	42.5	41.5	40.6	41.6	44
45.6	40	42	40.5	43	41
40.5	42	43.5	42.5	40.5	40.5
42	42.5	44	43.5	42.5	41.5
40.6	41.6	41.5	42.5	40	42
42.5	44.5	43.6	46.5	44.3	42.5
44.5	44	40.5	40	40	42
40.5	43	41	40.5	42	43.5
42.5	40	42.5	41	43	44
44.5	46	45	46		

TABLE VI. SLEEVE LENGTH DATA

13.3	***13.4***	***13.4***	***13.6***	***13.5***	***13.5***
13.4	13.2	13.6	13.7	13.8	13.9
13.5	13.7	13.6	13.4	13.1	13.4
13.6	13.7	13.8	13.9	13	13.6
13.7	13.1	13.9	13.2	13.9	13.6
13.4	13.6	13.7	13.8	13.6	13.4
13.5	13.3	13.4	13.4	13.6	13.5
13.5	13.4	13.2	13.6	13.7	13.8
13.9	13.5	13.7	13.6	13.4	13.1
13.4	13.6	13.7	13.8	13.9	13
13.6	13.7	13.1	13.9	13.2	13.9
13.6	13.3	13.4	13.4	13.6	13.5
13.4	13.4	13.2	13.6	13.7	13.8
13.9	13.5	13.7	13.6	13	13.6
13.7	13.1	13.9	13.2	13.9	13.6
13.3	13.4	13.5	13.4	13.2	13.6
13.9	13.8	13.6	13.4		

After the unordered data was obtained, the value of loss caused to the company by the canvases that have measurements outside the tolerance ranges was introduced. The loss generated establishes the cost in the length of the canvases of: $1.25 pesos and the price of width is: $0.25 cents. The tolerance established for the length of the bodies is 2cm, while for the width of these is 0.9cm. Tolerance for the length of the sleeves is 3cm and the width is 0.9cm.

The square deviation of the data was obtained by squaring the data obtained, while the loss function was obtained by developing the formula for nominal is better. Tables 7, with the results obtained, are show below.

C. Development Results

To obtain the results of the paper, the characteristic of nominal is better, since it is better suited for the realization of the knitted fabric, therefore, the following formula was used to calculate the loss function:

$$\iota = \frac{A}{\Delta^2}\,(r^2) \quad (2)$$

When the formula was broken down, it was necessary to find the constant value of A resulting form the loss suffered by the organization when faults were found. Table 7 show the value of A with a value of 1.25. In the same way we need to know the value of the tolerance allowed for the canvases, where the tolerance for the length of the bodies is 2cm, but it is must be squared given as a result a final tolerance of 4. The square deviation was obtained by squaring the data obtained from the measurement of the canvases, for example if one of the data is 45cm it is squared giving as a result* 2025 and so on with the other data (see table 7, to see the results of all the data) after obtaining the data we need we substitute the values of the formula. Where we divide the value of by the square tolerance, then we squared the square deviation and obtained this value we multiplied it by the value we obtained form the division and the value obtained from this multiplication is the function of loss the obtained data.

Length of the body	Data	a	Tolerance	Square deviation	Loss of function
1	45	1.25	4	2025	632.8125
2	46	1.25	4	2116	661.25
3	45	1.25	4	2025	632.8125
4	46	1.25	4	2116	661.25
5	47	1.25	4	2209	690.3125
6	44	1.25	4	1936	605
7	45	1.25	4	2025	632.8125
8	46	1.25	4	2116	661.25
9	44	1.25	4	1936	605
10	45	1.25	4	2025	632.8125
11	47	1.25	4	2209	690.3125
12	48	1.25	4	2304	720
13	45	1.25	4	2025	632.8125
14	46	1.25	4	2116	661.25
15	44	1.25	4	1936	605
16	46	1.25	4	2116	661.25
17	47	1.25	4	2209	690.3125
18	45	1.25	4	2025	632.8125
19	45	1.25	4	2025	632.8125
20	46	1.25	4	2116	661.25
21	47	1.25	4	2209	690.3125
22	48	1.25	4	2304	720
23	45	1.25	4	2025	632.8125
24	46	1.25	4	2116	661.25
25	44	1.25	4	1936	605
26	46	1.25	4	2116	661.25
27	43	1.25	4	1849	577.8125
28	47	1.25	4	2209	690.3125
29	45	1.25	4	2025	632.8125
30	46	1.25	4	2116	661.25
31	48	1.25	4	2304	720
32	45	1.25	4	2025	632.8125
33	44	1.25	4	1936	605
34	49	1.25	4	2401	750.3125
35	45	1.25	4	2025	632.8125
36	46	1.25	4	2116	661.25
37	47	1.25	4	2209	690.3125
38	44	1.25	4	1936	605
39	45	1.25	4	2025	632.8125
40	46	1.25	4	2116	661.25
41	44	1.25	4	1936	605
42	45	1.25	4	2025	632.8125
43	46	1.25	4	2116	661.25
44	44	1.25	4	1936	605
45	46	1.25	4	2116	661.25
46	45	1.25	4	2025	632.8125
47	47	1.25	4	2209	690.3125
48	46	1.25	4	2116	661.25
49	44	1.25	4	1936	605
50	46	1.25	4	2116	661.25
51	45	1.25	4	2025	632.8125
52	45	1.25	4	2025	632.8125
53	48	1.25	4	2304	720
54	47	1.25	4	2209	690.3125
55	44	1.25	4	1936	605
56	46	1.25	4	2116	661.25
57	43	1.25	4	1849	577.8125
58	47	1.25	4	2209	690.3125
59	45	1.25	4	2025	632.8125
60	46	1.25	4	2116	661.25
61	48	1.25	4	2304	720
62	45	1.25	4	2025	632.8125
63	45	1.25	4	2025	632.8125
64	46	1.25	4	2116	661.25
65	45	1.25	4	2025	632.8125
66	46	1.25	4	2116	661.25
67	47	1.25	4	2209	690.3125
68	44	1.25	4	1936	605
69	45	1.25	4	2025	632.8125
70	46	1.25	4	2116	661.25
71	44	1.25	4	1936	605
72	45	1.25	4	2025	632.8125
73	47	1.25	4	2209	690.3125
74	48	1.25	4	2304	720
75	45	1.25	4	2025	632.8125
76	48	1.25	4	2304	720
77	45	1.25	4	2025	632.8125
78	44	1.25	4	1936	605
79	49	1.25	4	2401	750.3125
80	45	1.25	4	2025	632.8125
81	46	1.25	4	2116	661.25

82	47	1.25	4	2209	690.3125
83	44	1.25	4	1936	605
84	45	1.25	4	2025	632.8125
85	44	1.25	4	1936	605
86	45	1.25	4	2025	632.8125
87	46	1.25	4	2116	661.25
88	44	1.25	4	1936	605
89	46	1.25	4	2116	661.25
90	45	1.25	4	2025	632.8125
91	47	1.25	4	2209	690.3125
92	46	1.25	4	2116	661.25
93	44	1.25	4	1936	605
94	46	1.25	4	2116	661.25
95	46	1.25	4	2116	661.25
96	44	1.25	4	1936	605
97	45	1.25	4	2025	632.8125
98	43	1.25	4	1849	577.8125
99	47	1.25	4	2209	690.3125
100	45	1.25	4	2025	632.8125

D. Results

The results in this stage was to develop the formula of nominal is better and obtain the statistical control, then the graphs that were generated from the statistical control are show.

Figure 4 show the statistical control of the body length in which we can observe that the data are within the established ranges, we can notice that no data fall in the target value to which these measures should be subject. The loss function that can be seen in blue control we see its behavior according to the data in a disordered way.

Fig. 4. *Statistical control and body length loss function*

In the illustration 5 we can see the statistical control of the body width in which we can observe that the values are within the established ranges, although some of them are rising the zone of the inferior limits, in difference of the statistical control of the length of the sleeves we can observe that there are values that fall in the target value and its function of loss is joint with the values of the data.

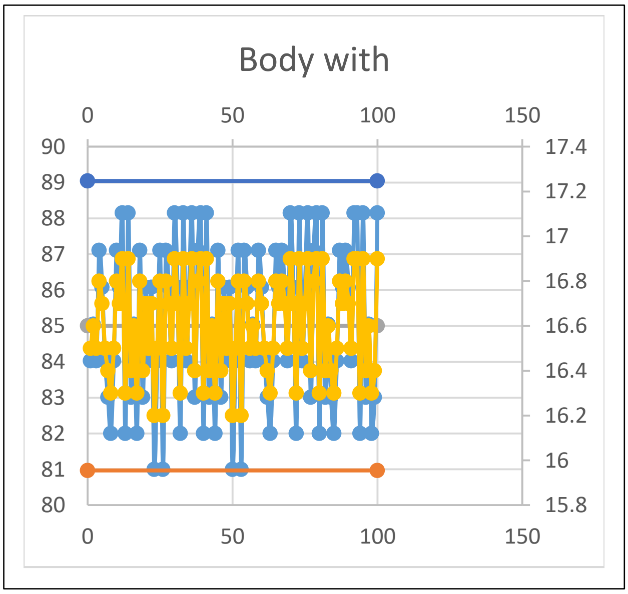

Fig. 5. *Statistical control and body width loss function.*

In the illustration 6 we can observe the statistical control of the width of the beam in which we can observe that the data are within the established limits, although some of the data manage to get out of the limits in a little way, just as some of the data fall within the target value in the same way we can observe its loss function.

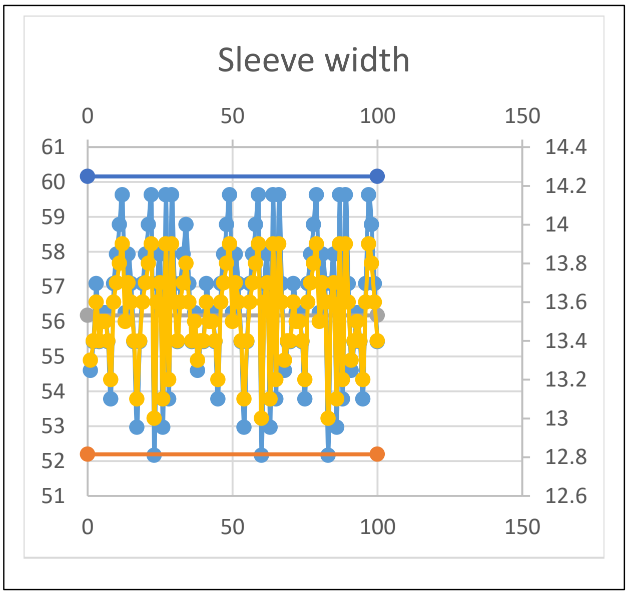

Fig. 6. Statistical control and Sleeve width loss function

In the illustration 7 we can see the statistical control of the length of the sleeves in which we can observe that the data are withing the established ranges, as well as we can also observe that some of their values fall within the target value, in the same way we can observe the function loss of these values.

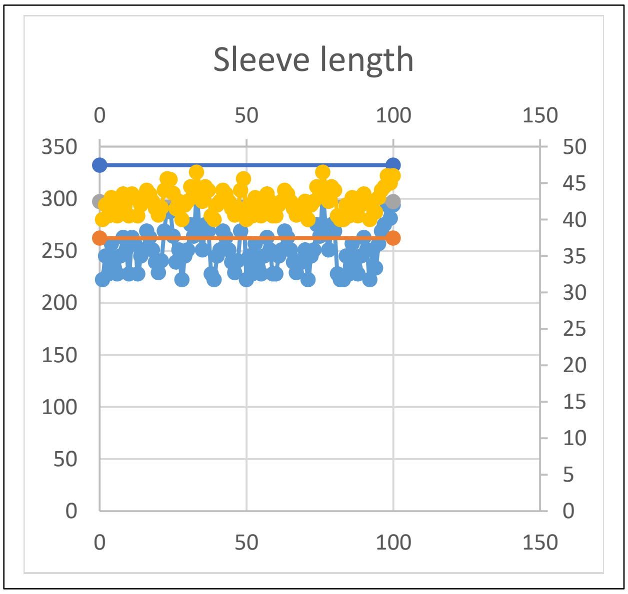

Fig. 7. Statistical control and Sleeve length loss function

E. Conclusions

At the time of collecting the data we realized that we have limitations when measuring the canvases, since the tape measure for this type of cases is not very accurate because the values found were repeated more than once which at the time of making the graphs of the loss function, the data showed us a perpendicular line, so we chose to graph the values in a disorderly manner to have a better perspective of these. The process of making the textile garments is not at all easy to do since at the moment of making a bad measurement the loss that can cause to the company can be enormous, that is why we realized that the data obtained are within the established ranges but this does not mean that the loss exists, since only some fall in the target value, which guarantees the total quality. This research will serve to make known that even though during the manufacturing process there is no loss for the owners, the result is different because the loss continues to exist since it causes the quality of their products not to be as expected, which can have consequences with the client, who can return their products and generate a great loss for the company.

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