INTER-PHASE CONTROL OF DEFECTS AND REASONS FOR THEIR OCCURRENCE IN THE PROCESS OF SEWING WOMEN'S TROUSERS

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Abstract: *Quality is the best investment to strengthen the competitiveness of enterprises in the international market. Achieving quality is the responsibility of every worker in the organization. The role of quality control is to detect defects by constantly monitoring the production process, analyzing the defects, find the source of their occurrence and take appropriate corrective measurements.*

In this paper, are presented some factors that have influence on defects occurrence in the process of sewing one model of female trousers. The obtained results during the inter-phase control in two production lines in the four week period are analyzed. Possible reasons for detected defects are indicated by: Working days in the week, the structure of the employees in the production lines, their work experience, their age and difficulty of operations. The influence of each of these factors is discussed separately.

Keywords: Quality, monitoring, defect, operator.

MEĐU-FAZNA KONTROLA DEFEKTA I RAZLOGA ZA NJIHOVO POJAVLJIVANJE U PROCESU ŠIVENJA ŽENSKIH PANTALONA

Apstrakt: *Kvalitet je najbolja investicija za jačanje konkurentnosti preduzeća na međunarodnom tržištu. Postizanje kvaliteta je odgovornost svakog radnika u organizaciji. Uloga kontrole kvaliteta je otkrivanje nedostataka, konstantnim praćenjem proizvodnog procesa, analiziranjem defekata, pronalaženjem izvora njihove pojave i preduzimanjem odgovarajućih korektivnih mera.*

U ovom radu su predstavljeni neki faktori koji utiču na pojave defekata u procesu šivenja jednog modela ženskih pantalona. Analizirani su dobijeni rezultati tokom međufazne kontrole u dve proizvodne linije u u periodu od četiri nedelja ili četvoronedeljnom periodu. Mogući razlozi za otkrivanje nedostataka obuhvataju: Radne dane u nedelji, strukturu zaposlenih u proizvodnim linijama, njihovo radno iskustvo, njihovu starost i teškoće izvođenja operacija. Uticaj svakog od ovih faktora se razmatra odvojeno.

Ključne reči: Kvalitet, monitoring, defekt, operator.

1. INTRODUCTION

The main goal of every textile company is to create production without defects, because it is the only way to enter into the race with the great competitiveness of the market.

Quality by definition means "superiority" or "superior." At a minimum, this means "better than average", but in practice achieving quality is very complicated task because it depends of every single worker in the company. Only with good organized team work, high quality results can be obtained. Quality is a duty for every working individual, but it is necessary to make the right choice of specialists who are well-organized and motivated to provide the services that are needed in quality assurance.

In the clothing (textile) industry, there are many factors that affects to the quality of the product, usually the final control misses 10-15% of the defects that appear on the market. For these reasons, inter-phase control has a big influence on the percentage of defects of the final product. The task of this control is to serve as a filter that will detect defects on time and enable their timely prevention [1,2,3].

Determination of the control positions in a production line is usually a matter of assessment, and the following factors are important and should be taken into account:

- Achieving minimum percentage of defects in the production process.
- Quick check of the work for critical product features.
- Control of the new features and increased control of newly employment workers.
- Control of operations in which the required quality is close to the control limits, because of the condition of the machines or the operators work.
- Detect the operations where the most of the defects occurs.
- Control of workplaces where different parts of the garment are interconnected [4,5,6].

Usually defects may not be detected for several days, which will be reflected in further stages of production. The large number of garment with defects leads to economic losses, problems in balancing the process and wasted time for their correction. It is considered that the analysis of reports about defects from previous weeks or months can contribute to a better perception of the cause of their occurrence. If in due time the defects are detected than appropriate corrective actions can be taken [7, 8].

One of the most important factor that has a major impact on quality are employees. Significant for every company is to succeed in the goal of changing the perception of the employees about quality. That means that primarily the management staff should understand the value and meaning of the quality, and then to find a best way to share it with other employees, especially with operators who work in production lines [9].

In order to achieve high quality, the company should strive to:

- Develop employee conscience that quality is crucial for all workers, because quality assures sales, and sales assures work/profit.
- Every employer on his working position can contribute to quality.
- Any idea of quality improvement is helpful and can lead to a better quality.

The most important goal of all is employers to understand and accept the fact that "quality is a matter of everyone" [10,11, 12, 13].

In this paper are presented causes that lead to reduced quality and occurrence of defects in the production of one modern model of women's trousers. Factors that have impact on the quality are clearly presented: Working days in the week, the structure of the employees in the production lines, their work experience, their age and difficulty of operations. The analysis was made in two production lines in a four-week period. Defects were detected by the inter-phase control, which controlled the operators in production lines twice a day.

2. EXPERIMENTAL

The model of women trousers that is subject to this analysis is shown below (Fig. 1). The model is fashionable and modern. It is composed of two pockets on the front and two pockets on the back side. This model has decorative leather accessories, which makes the model more sporty. The belt has loops, and the fastening is made by zipper and one button. The model is made of cotton material in beige color. The leather accessories are in brown color. For sewing the model was made list of operations which lead to its completion.

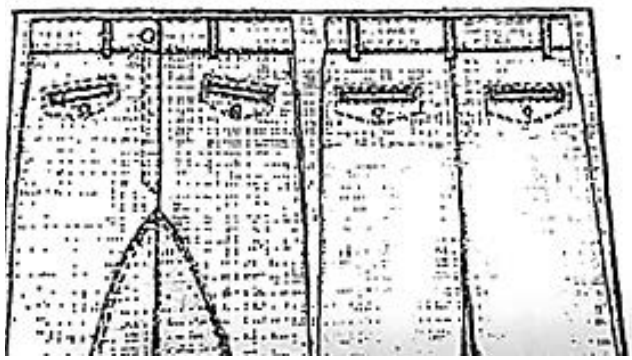

Figure 1: Front and rear part of the women trousers

The obtained results from inter-phase control in four weeks period are shown in Tables (1-4).

For the first week defects that were detected from the inter-phase control, with the reasons for their occurrence are given bellow.

The model in this week was produced in production line II, with the number of operators 27, their age ranges is 20 to 48 years, and the operators work experience vary from 6 months to 14 years. The total number of defects in the first week is 1.65% (Table 1). The highest number of defects (19) in this week occurs in operations of sewing zipper and bar-tack. The reason for the occurrence of a large number of defects in this two operations was noticed in the short work experience (1 year) of the operators who performed the operation. The operation proved to be quite complicated and it requires operators with more work experience. The obtained results according to the days of the week indicated that the highest percentage of defects was made on Wednesday (2.31%) and the lowest in Friday (1.08%). The big percentage of defects at the beginning of the week was expected, due to the complexity of the model that requires operators adapt to the new model. At the end of the week (Friday), it was noted that the percentage of defects was significantly reduced (1,08%), which means that the operators are beginning to adapt to to the new operation plan.

In the second week the sewing of the model was performed in the production line II. Defects that were detected from the inter-phase control with the reasons for their occurrence are given as follows. In this week the total number of defects decreased to 1.37% (Table 2). The largest number of defects was recorded in the operation with number 1. This operation was performed by 3 operators of different age and different work experience. The results of the analysis of the three operators showed that work experience has a major impact on the quality and the number of defects. The operator with 1 year work experience made 13 defects, the operator with 5 years of work experience made 7, while the operator with the greatest working experience of 14 years did only 4. The operation proved to be highly complicated for this type of model and it requires greater experience and skill for it's performance by the operator. According to the days of the week, most of the defects were recorded on Monday (1.94%), and the smallest number of defects was recorded on Thursday (0,94%).

In the third week the sewing of the model was performed in the production line I (Table 3). In this production line operates 26 operators, their age ranges is 21 to 52 years, of which 10 are with working experience of 14 years (in the production line II this number was only 2). The number of operators is lower (26) compared to production line II (27), but in this case work experience has influenced the reduction of the percentage of incurred defects. The largest number of defects this week was detected in the operation with number 6 (12 defects), and the number of operations where no defect was recorded was even 8, which indicates that by constant monitoring and timely reaction, inter-phase control managed to reduce the number of defects from the first to the third week for 0,95%. The obtained results according to the days of this week indicated that the highest percentage of defects was recorded on Monday (1.31%) and Wednesday (0.45%). The total number of defects this week was reduced to 0.70%.

For the fourth week the sewing of the model was performed in the production line I. Defects that were detected from the inter-phase control with the reasons for their occurrence are also shown (Table 4). The obtained results for this week indicated that the highest number of defects was reduced to 7 (in the operation of sewing leather accessories on front middle side), and the lowest percentage of errors (0) was observed in the operation of sewing button hole. The results from the number of the defects according to the days of this week, indicated that in this week the highest percentage of defects was recorded on Monday (1.18%) and Tuesday (0.45%), but the total percent of defects was significantly lower than the previous weeks (from 1,65 % first week to 0.73% in the fourth week). The total number of occurred defects in period of four weeks as for comparison is shown on diagram (Figure 2).

The obtained results according to the operations plan for sewing the model in the period of four weeks, indicated that the greatest number of defects occurred in operations with number 2, 3, 5 and 8.

Number of operation 2 (sewing and closing the belt): Detected defects were as a result of puffed belt,

twisted belt or belt gloss. A problem with a puffed belt occurred because of the stretching of the belt, and the crease of the trousers or inversely. The problem was solved by unstitching the belt and removing the spare. This defect may also occur as a consequence of a tightened selvage. This problem was resolved by stretching the selvage with simultaneous ironing. A problem with a twisted belt occurs when notches on the belt didn't correspond with the notches of the trousers. The problem was solved by unstitching the belt, his correction and sewing over again.

Number of operation 3 (sewing zipper): Detected defects where result of inappropriate sewn zipper that causes stretching the material or pleat occurrence. In this case operator unstitched the zipper, took the corrective measures and sewn the zipper all over again.

Number of operation 5 (sewing pocket): This defect usually occurs as a result of a sloping pocket and an inadequate height on both pockets. For correction of this defect the operator should carefully sew the pocket of exactly marked positions. In some cases the problem can be partially resolved by ironing the pocket.

Number of operation 8 (Inter-phase ironing): Detected defects are result of material gloss, that negatively reflects on the final look of the model. Correction of his defect is very hard, so the operator should be very careful while performing the operation, also taking care to not use high pressure with the iron.

Table 1: Number of defects in inter-phase control in the first week

Number of operation	Type of operation	Number of operators	Working experience (years)	Age (years)	I (first) week, quality check in production line II twice per day first check/second check					Total number of pieces	Total number of defects
					Monday	Tuesday	Wednesday	Thursday	Friday		
1	Overlock of pocket and sides	1	1	29	2/0	4/0	0/2	0/0	0/1	**285**	**9**
		2	14	34	0/3	1/0	0/0	0/1	0/0	**285**	**5**
		3	5	20	0/1	1/1	3/0	0/2	0/1	**285**	**9**
2	Sewing and closing the belt	4	3	41	0/3	0/1	1/1	1/3	1/2	**140**	**13**
		5	3	29	0/2	0/1	0/0	0/1	0/0	**140**	**4**
		6	3	39	0/0	0/0	0/1	0/0	0/1	**140**	**2**
		7	3	23	0/0	0/1	0/0	0/0	0/2	**140**	**3**
		8	3	33	0/0	0/1	1/2	0/0	0/1	**140**	**5**
		9	1	26	4/0	1/0	2/1	3/0	0/0	**140**	**11**
3	Sewing zipper	10	3	31	0/0	1/1	3/1	½	0/1	**425**	**10**
		11	1	22	3/4	½	3/2	1/1	0/2	**425**	**19**
4	Sewing loops and labels	12	3	46	0/0	0/1	0/2	0/0	0/0	**425**	**3**
		13	1	32	0/1	0/0	0/0	0/1	0/2	**425**	**4**
5	Sewing pocket	14	3	42	0/0	0/1	0/1	0/2	1/0	**285**	**5**
		15	2	34	1/1	2/2	3/2	0/2	2/0	**285**	**15**
		16	1	27	1/0	3/0	3/2	0/1	0/0	**285**	**10**
	Sewing leather accessories on front middle side	17	½	27	0/0	0/0	0/0	0/0	0/0	**425**	**0**
		18	½	27	0/0	0/0	0/0	0/0	0/0	**425**	**0**
6	Sewing side (leg) seams with chain stitch	19	2	31	0/0	0/0	0/1	0/1	0/0	**425**	**2**
		20	1	28	2/0	0/2	0/0	4/0	0/1	**425**	**9**
	Making basil	21	3	40	0/0	0/0	0/2	2/3	0/0	**750**	**7**
7	Interphase ironing of side seams	22	14	34	0/0	0/0	0/1	0/0	0/0	**750**	**1**
8	Interphase ironing of flap and pocket	23	2	21	0/0	1/1	5/0	3/0	0/1	**750**	**11**
	Interphase ironing of belt	24	1	48	1/1	½	3/2	3/3	3/0	**750**	**19**
9	Sewing bar-tack	25	3	32	0/0	0/0	0/1	0/0	0/0	**750**	**1**

10	Sewing button	26	7	38	1/0	1/1	0/0	0/0	2/0	**750**	**5**
11	Sewing button hole	27	7	34	0/0	0/0	0/0	0/0	0/0	**750**	**0**
	Total number of defects				**31**	**35**	**51**	**41**	**24**		**182**
	Total number of pieces				**2210**	**2210**	**2210**	**2210**	**2210**	**11010**	
	Percentage of defects (%)				**1,41**	**1,58**	**2,31**	**1,85**	**1,08**		**1,65**

Table 2: Number of defects in inter-phase control in the second week

Number of operation	Type of operation	Number of operators	Working experience (years)	Age (years)	**II (second) week, quality check in production line II twice per day first check/second check**					Total number of pieces	Total number of defects
					Monday	Tuesday	Wednesday	Thursday	Friday		
1	Overlock of pocket and sides	1	1	29	2/0	2/2	2/0	2/2	0/1	**285**	**13**
		2	14	34	0/1	0/0	0/1	0/0	0/2	**285**	**4**
		3	5	20	0/0	2/0	0/3	0/1	1/0	**285**	**7**
2	Sewing and closing the belt	4	3	41	0/3	0/0	1/0	½	1/3	**140**	**11**
		5	3	29	0/3	0/0	0/2	0/0	0/1	**140**	**6**
		6	3	39	0/2	0/1	0/0	0/1	1/0	**140**	**5**
		7	3	23	4/0	0/1	0/2	1/0	2/2	**140**	**12**
		8	3	33	0/0	1/1	0/0	½	0/0	**140**	**5**
		9	1	26	3/2	½	0/1	0/0	0/2	**140**	**11**
3	Sewing zipper	10	3	31	0/0	0/1	1/0	0/0	0/1	**425**	**3**
		11	1	22	2/0	0/2	1/1	1/0	0/0	**425**	**7**
4	Sewing loops and labels	12	3	46	0/0	0/0	0/0	0/0	0/0	**425**	**0**
		13	1	32	0/0	0/0	0/1	0/0	0/0	**425**	**1**
5	Sewing pocket	14	3	42	0/1	0/0	0/0	0/1	1/0	**285**	**3**
		15	2	34	1/1	0/0	0/1	0/0	1/1	**285**	**5**
		16	1	27	2/0	0/1	0/0	0/0	0/1	**285**	**4**
	Sewing leather accessories on front middle side	17	1/2	27	3/1	0/0	0/0	0/1	0/0	**425**	**5**
		18	1/2	27	2/2	0/1	0/0	0/0	1/0	**425**	**6**
6	Sewing side (leg) seams with chain stitch	19	2	31	0/0	0/0	1/0	0/0	0/0	**425**	**1**
		20	1	28	0/2	0/1	0/0	0/0	0/1	**425**	**4**
	Making basil	21	3	40	0/0	0/1	3/0	0/0	0/1	**750**	**5**
7	Interphase ironing of side seams	22	14	34	0/0	0/0	0/0	0/0	0/1	**750**	**1**
8	Interphase ironing of flap and pocket	23	2	21	2/0	0/2	0/1	1/1	0/0	**750**	**7**
	Interphase ironing of belt	24	1	48	0/1	0/2	1/1	0/0	0/1	**750**	**6**
9	Sewing bar-tack	25	3	32	0/0	0/1	1/0	2/0	0/0	**750**	**4**
10	Sewing button	26	7	38	½	0/0	0/1	0/0	0/2	**750**	**6**
11	Sewing button hole	27	7	34	0/0	0/0	0/1	0/0	0/0	**750**	**1**
	Total number of defects				**43**	**25**	**27**	**20**	**28**		**151**
	Total number of pieces				**2210**	**2210**	**2210**	**2210**	**2210**	**11010**	
	Percentage of defects (%)				**1,94**	**1,13**	**1,22**	**0,94**	**1,27**		**1,37**

Table 3: Number of defects in inter-phase control in the third week

Number of operation	Type of operation	Number of operators	Working experience (years)	Age (years)	III (third) week, quality check in production line I twice per day first check/second check					Total number of pieces	Total number of defects
					Monday	Tuesday	Wednesday	Thursday	Friday		
1	Overlock of pocket and sides	1	14	36	1/0	0/0	0/0	0/0	0/0	**285**	**1**
		2	14	35	0/1	0/1	0/0	0/0	0/0	**285**	**2**
		3	5	42	0/0	0/0	0/0	0/1	0/1	**285**	**2**
2	Sewing and closing the belt	4	14	42	0/0	0/0	0/0	0/0	0/0	**170**	**0**
		5	14	34	0/0	0/1	0/0	0/0	0/0	**170**	**1**
		6	14	37	0/0	0/0	0/0	0/0	0/0	**170**	**0**
		7	5	31	0/1	0/0	0/0	0/0	0/1	**170**	**2**
		8	3	32	0/1	0/0	0/0	0/0	0/0	**170**	**1**
3	Sewing zipper	9	10	31	0/0	0/0	0/0	0/0	0/0	**425**	**0**
		10	5	22	0/0	0/0	0/0	0/0	0/0	**425**	**0**
4	Sewing loops and labels	11	14	46	0/0	0/0	0/0	0/0	0/0	**425**	**0**
		12	5	52	0/0	0/0	0/1	0/0	0/0	**425**	**1**
5	Sewing pocket	13	14	34	3/1	0/0	0/0	1/1	1/1	**285**	**8**
		14	14	34	½	0/1	1/1	0/0	½	**285**	**9**
		15	14	41	0/0	0/1	0/0	0/0	0/0	**285**	**1**
	Sewing leather accessories on front middle side	16	8	27	5/0	1/0	1/1	½	0/0	**425**	**11**
		17	5	27	3/1	0/1	0/0	0/1	0/0	**425**	**6**
6	Sewing side (leg) seams with chain stitch	18	7	31	0/0	0/0	0/1	0/0	0/1	**285**	**2**
		19	4	21	0/0	0/0	0/0	0/0	0/0	**285**	**0**
	Making basil	20	3	28	2/1	1/1	3/1	0/1	1/1	**285**	**12**
7	Interphase ironing of side seams	21	8	29	1/0	1/1	0/0	0/0	1/1	**850**	**5**
8	Interphase ironing of flap and pocket	22	3	22	½	1/1	0/0	0/1	0/1	**850**	**7**
	Interphase ironing of belt	23	2	24	0/0	0/0	0/0	0/0	0/0	**850**	**0**
9	Sewing bar-tack	24	3	44	1/0	1/0	0/0	0/2	0/0	**850**	**4**
10	Sewing button	25	2	26	1/0	0/0	0/0	0/0	0/1	**850**	**2**
11	Sewing button hole	26	14	35	0/0	0/0	0/0	0/0	0/0	**850**	**0**
	Total number of defects				**29**	**13**	**10**	**11**	**14**		**77**
	Total number of pieces				**2210**	**2210**	**2210**	**2210**	**2210**	**11050**	
	Percentage of defects (%)				**1,31**	**0,59**	**0,45**	**0,50**	**0,63**		**0,70**

Table 4: Number of defects in inter-phase control in the fourth week

Number of operation	Type of operation	Number of operators	Working experience (years)	Age (years)	IV (fourth) week, quality check in production line I twice per day first check/second check					Total number of pieces	Total number of defects
					Monday	Tuesday	Wednesday	Thursday	Friday		
1	Overlock of pocket and sides	1	14	36	2/2	0/0	1/1	0/1	1/1	**285**	**7**
		2	14	35	0/0	0/0	0/1	0/0	1/0	**285**	**2**
		3	5	42	1/0	1/0	0/0	0/0	0/0	**285**	**2**
2	Sewing and closing the belt	4	14	42	0/2	0/0	1/0	0/0	0/1	**170**	**4**
		5	14	34	2/1	0/0	0/1	1/1	0/0	**170**	**6**
		6	14	37	0/0	0/0	0/0	0/0	1/0	**170**	**1**
		7	5	31	1/0	0/1	0/0	0/0	2/0	**170**	**4**
		8	3	32	2/1	0/0	0/1	0/0	0/1	**172**	**5**
3	Sewing zipper	9	10	31	1/0	0/0	1/0	0/1	0/0	**425**	**3**
		10	5	22	0/0	0/0	2/0	0/0	1/0	**425**	**3**
4	Sewing loops and labels	11	14	46	0/1	1/0	0/0	1/1	1/0	**425**	**5**
		12	5	52	0/2	2/0	0/0	1/0	0/0	**425**	**5**
5	Sewing pocket	13	14	34	1/0	0/1	0/0	0/0	0/1	**285**	**3**
		14	14	34	0/0	0/0	0/0	1/0	0/0	**285**	**1**
		15	14	41	1/0	1/1	0/0	1/0	0/0	**285**	**4**
	Sewing leather accessories on front middle side	16	8	27	2/2	0/0	0/1	2/0	0/1	**425**	**8**
		17	5	27	0/0	0/0	2/1	0/1	1/0	**425**	**5**
6	Sewing side (leg) seams with chain stitch	18	7	31	0/0	0/1	0/0	0/0	0/0	**285**	**1**
		19	4	21	0/0	0/0	1/0	0/0	0/0	**285**	**1**
	Making basil	20	3	28	0/0	0/0	0/0	2/0	0/0	**285**	**2**
7	Interphase ironing of side seams	21	8	29	0/0	0/1	0/0	0/0	0/1	**850**	**2**
8	Interphase ironing of flap and pocket	22	3	22	0/0	0/0	0/0	0/1	1/1	**850**	**3**
	Interphase ironing of belt	23	2	24	0/1	0/0	0/0	0/0	0/0	**850**	**1**
9	Sewing bar-tack	24	3	44	1/0	0/0	0/0	0/0	0/0	**850**	**1**
10	Sewing button	25	2	26	1/1	0/0	0/0	0/0	0/0	**850**	**2**
11	Sewing button hole	26	14	35	0/0	0/0	0/0	0/0	0/0	**850**	**0**
	Total number of defects				**26**	**10**	**13**	**15**	**17**		**81**
	Total number of pieces				**2210**	**2210**	**2210**	**2210**	**2210**	**11050**	
	Percentage of defects (%)				**1,18**	**0,45**	**0,59**	**0,68**	**0,77**		**0,73**

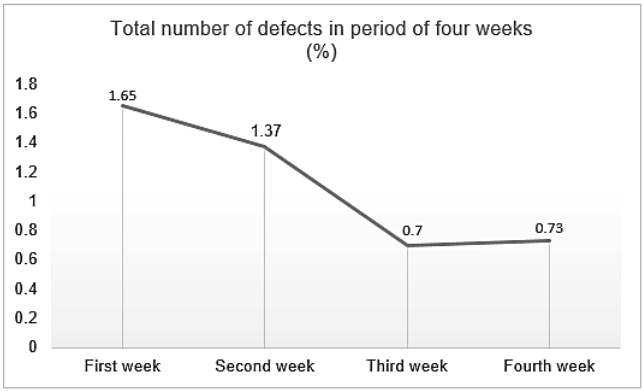

Figure 2: Total number of defects for all four weeks

3. CONCLUSION

From the obtained results can be concluded that the inter-phase control had a big and positive influence on the percentage of defects of the new model. This control enabled the timely detection of the defects, and therefore timely correction and prevention of the appearance of new ones. As a result of this control, the number of defects began to decline in the second week, and it has been drastically reduced in the third and fourth week.

The inter phase control detected that the highest number of defects occurred in Monday (in second, third and fourth week), because operators need time to adapt to the work after the weekend. The number of defects was higher in the first week (the model was new, and the operation plan was unfamiliar for the operators), and the number of defects decrease in the next three weeks.

Operators working experience was proven to be very important, especially in complicated operations, where a higher level of operator skills was needed to perform the required operation. According to the age of operators inter-phase control didn't detect significant results.

According to the operations plan for sewing the model the obtained results had also shown the operations that are hard for perform. The reasons for their occurrence and the possible ways for their prevention where also discussed, and a practical solution was offered. With timely prevention of defects inter–phase control had shown great impact, which led to obtain product with high quality and lower number of defects.

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