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Effect of standard operating procedure on the Whisker and Hand Brush process of denim garments

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ABSTRACT

Denim industry is one of the emerging sectors in the world among all woven garments industry. The rapid changing monetary conditions like as global challenge, declining overall revenue, client interest for high quality item, variety of product and diminished lead–time and so on had a crucial impact on manufacturing plants. The interest for higher incentive at lower cost is expanding and to endure, clothing makers need to enhance their operation through-delivering right first-time quality and reduction of waste or reworks. Defects are the main concern in quality assurance of denim garments. Most of the defects are visualize in denim washing. This research emphasizes the cause effect and remedy of washing defects of denim garments. This research initiated by collecting quality inspected data of consecutive three months for the Whisker and Hand Brush process to have an overview of the defects of the washing plant and then analyzed the root causes and effects of the defects to provide a recommended solution both for Whisker and Hand Brush process on which standard operating procedure (SOP) is introduced to reduce the level of defects. After ensuring the standard operating procedure both for dry and wet process, quality inspected data was recorded for the following three months for Whisker and Hand Brush process. Finally, a significant level of defects is reduced in Whisker and Hand Brush process.

***Keywords*:** Denim, Whisker, Hand Brush, Reworks, SOP, Quality, Defects, Cause effect

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1. INTRODUCTION

Denim is a rough cotton twill fabric with weft yarn passing under two or more warp threads which is also called warp faced fabric. It is noticed that, blue denim garments are well documented among the customers of the world as a modern fashion trend which is made by indigo dyes. Indigo undergoes a complex heterogeneous processes during dyeing which take place at the solid-liquid interface [1, 2]. The outlook of warp face twill is blue on one side and the other side is remain white [3]. Bleaching is a process which apply to the denim to promote the value of denim but it only it can not develop the reqired object [4]. In the denim washing industry the manufacturers use pumic stone in the wash bath to attain a decent wearing effect [5], but as a result of stone washing it has a rough hand feel and emits huge effluent to pollute the environment [6].

Right now, four types of frequently used bleaching process is applied to the denim garments to attain a smooth and required soft hand feel [7-9]. An eco-friendly aprroach is enzymatic treatment to advance the pusuance of color-fading of denim garments and about 80% of bleaching is now done in this way [10-12]. The vintage look of the denim is achieved by the synergistic action of enzymes and mechanical action to irregularly removal of indigo dyes from the garments [13]. To achieve wearing effect on the denim, Whisker and Hand Brush are well known technique of dry process of washing technology. These techniques are used to create vintage look design as per pattern or requirements of the buyer which are frequently asked as a fashion trend.

As the world economic situation is changing in a swift motion, usually in an industry more focal point is given on revenue margin, consumer interest for high trait product and enhanced productivity. In denim washing industry, it is usual few rejected garments after shipment. Because, most of the manufacturers believe that garments are soft goods and non-repairable defect may occur due to low quality raw materials or faulty process or employee casual behavior. However, factory must have check points to control over this crucial issue. There is no used up solution that can decrease rejection rate overnight. Each order is unique. But this research works suggests how to handle this issue and bring down rejection rate and reworks to minimum.

We see a lot of rejected garment after shipment. Most of the organization termed these garments as rejected because those garments can’t be repaired by any means. Reworks in the denim washing industry is a common works that hampers the smooth production rate and focus poor quality products having an impact on overall factory economy. Minimization of reworks and defects is a must in quality and productivity improvement. Reworks and defects are an important issue for poor quality product and low production rate. Alters are the non -productive activities concentrate on any activity that consumers are not prone to pay for. Non-productive actions interpret that the consumer does not acknowledge as enumerate value to his product. By performing immediate in reduction of alter to make a product as per consumer satisfaction with expected quality, the company can devote less money and more costs savings [14]. Therefore, a study has carried out in the renowned washing plant located at Nishat Nagar, Tongi, Gazipur in quality section to identify reworks and defects so as to reduce them for saving time, cost and improved product quality.

Murat Tarhan et al. [5] investigated the loss of weight, color abrasion and loss of tensile strength of denim fabrics were measured after washing. Action of enzymes during the degradation of cellulose are analyzed by Artur Cavaco-Paulo [8].

Patrick et al. [15] scrutinized reproducible laboratory test system that evaluates garment breakdown due to denim wash methods. Ortiz-Morales et al. [16] presented a comparative study of the experimental results obtained in laser fading using different types of lasers. C. W. Kan et al. [9] explored the optimum condition for the enzyme treatment.

Ayanna Card et al. [17] checked the effects of laundering on physical properties of washed denim fabrics. S. Yesilpinar et al. [18] studied by following the consequence of different seam types and wet process of denim washing on the seam strength of denim garments which helps the manufacturers to determine the seam type acknowledging the finishing processes to be practiced to the garments.

Vildan Sular et al. [19] researched on sewn denim products to investigate the effect of washing, special treatment processes and bleaching on mechanical properties, hand feel and physical properties and got significant results on desired study. Joy Sarkar et al. [20] researched the impact of bleach wash and subsequent softening treatment on 100% cotton denim dyed with indigo dye. Md Ibrahim H Mondal et al. [21] measured the effect of process parameters on the physical and mechanical properties of cotton denim garment.

C.W. Kan et al. [22] investigated the fabric performance of various percentage of elastane in the stretch denim fabric following repeated home laundering practice. Wei Du et al. [23] investigated the physical properties of indigo Kapok/Cotton denim fabrics focusing on laser bleaching and conventional bleaching. No research work is noticed regarding denim garments washing quality.

Md. Anwar Jahid et al. [24] studied some potential steps follow to reduce fabric fault through process control parameters analysis and reliable measurements for optimizing defects in knitted finished fabrics to scrutinize quality of finished fabrics. The root causes for all types of defects of knit fabric were analyzed and their improvement technique was discussed by Md. Shak Sadi et al. [25].

Md. Tahiduzzaman et al. [26] studied the cause-effect diagrams to show the root cause, effect, and 5S & PDCA which are used to minimize the defects effectively.

Ms.N.S. Patil et al. [27] studied on identification of reworks at sewing and finishing sections so as to eliminate them for saving time, cost and improved product quality. Many researchers are studied on defects type and rate, root causes of the defects and made suggested solution on the knit fabric, woven fabric, dyenig, sewing etc. but no researcher is focused on the denim washing defects type, causes and solution of the defects.

As denim washing sector is emerging and prospective sector and the analysis of denim washing defects are not investigated yet that's why we are focused on this field.

2. MATERIALS AND METHODS

2. 1. Instrument used through the research works

There are several types of instruments which were used as follows.

- Light box at the inspection room with light TL-83, D-65, & "A" light, light box size 130 cm × 130 cm (1000 lux).
- Template or Whisker pattern.
- Scale.

- Tally Book to record inspection data per hour.
- Smart phone

2. 2. Workplace description

The study has been done in a renowned washing industry a sister concern of Hameem group located at Nishat Nagar, Tongi, Gazipur. This washing industry mainly deals with denim pant and other products are washed in others factory of the group. This washing industry works for many world class buyer and the production is running at a stretch about 12 years of same buyers. Both types (Dry and Wet) of washing is present in the industry. There are 47 wash machine 42 dryer machine and 10 extractor machines used in wet process of washing besides there are 20 Hand Brush machine, 4 Whisker table, 24 Whiskers stand, 3 grinding machine, 10 3D crinkle machine, 12 iron machine, 1 oven machine, 3 laser machine, 2 thread sucker machine, 6 tagging machine and 5 PP chamber with 24 dummies. ETP is running in the factory. There are about 1100 employee in the factory. The monthly capacity of the factory is 1650000 pcs. About 2.5-4 lac pcs denim washed pants per month are delivered to the buyer. The industry is segmented about 4 units for being dry process. The inspected data is collected from unit -1.

2. 3. Task sequence

2. 3. 1. Product Analysis

In the beginning of the factory visit the observation was done on a running order of denim pant (only) of VF Asia buyer and the order will be continued till minimum upcoming 1 years and 6 months acknowledged by discussion with the manager. That's the reason behind for finalized the product on which research study will do. The product was lady's denim pant. There were different styles of denim pant like long, short etc. but same fabric construction. The fabric is 64% cotton, 34% polyester, 2% spandex and 8.7oz indigo denim.

EPI = 170, PPI = 75, Warp count = 20 Ne, Weft count = 200D, Spandex = 40D and 56/57".

2. 3. 2. Process Analysis

There are mainly two types of washing process such as wet process and dry process. Available dry processes are Whiskering, Laser Whiskering, Hand Scraping or Hand Brush, Grinding, Destroy, Overall crinkle, 3D crinkle, Tagging and PP spray. Except Laser Whiskering process all other process are done on the garments. From above mentioned process we focused on Whisker and Hand Brush process in this study.

2. 3. 3. Defect Analysis

After completing each and individual dry process the garments are inspected per hour and recorded on a format sheet as total inspected quantity, total passed quantity, total defected quantity then calculates the defect % of the garments. Besides, in the same sheet the individual defect types are also recorded to know the degree of frequency of a certain defect.

2. 3. 4. Cause Effect Analysis and remedies of the defects

Collected the inspected data of July 2018 from dry process then analyzed the defects by pareto analysis to observe the degree of frequency of each defect and how many percentages of

defective garments. Observing the defects then started to analyze the causes and effect of the defects through Ishikawa diagram and tried to generate or suggest a solution of the problem till 30 September 2018 and at the same time inspected data are collected.

2. 3. 5. SOP Establishment and implementation

From 01 August 2018 to 31 December 2018 the for being dry processes it was trying used to operator to the suggested solution of the problem and then created a SOP for each process and given operator to maintain SOP checklist.

2. 3. 6. Result observation

By implementing the suggested solution of the problem against the causes then the processes are monitored and recorded the quality inspected data from August 2018 to 31 December 2018 and finally compared with the initial observed data to show the effect of suggested solution.

2. 4. Methods of analysis

2. 4. 1. Bar Diagram

Bar diagram is used to show comparisons between categories of data. It has two axis. One axis described the types of defects being compared and the other has numerical values that represent the degree of frequency of defects. The descriptions are on the horizontal axis and the bars are oriented vertically.

2. 4. 2. Pareto Analysis

Pareto chart is a bar graph. The lengths of the bars represent frequency and are arranged with longest bars on the left and the shortest to the right. In this way the chart visually depicts which situations or problems are more significant. Acknowledging from pare to chart it is concentrated firstly to the most significant problem to analyze and reduce.

2. 4. 3. Cause Effect Analysis

Ishikawa diagram, is also known as a cause and effect diagram or a fishbone diagram are used to deepen the understanding of the causes that generate a specific problem of the process. As a result, a suggested solution is developed on the basis of the specific problem.

3. RESULT AND DISCUSSION

3. 1. Defects frequency for dry process

At the very beginning of study initial data had been recorded for the selected product from the in-process QC table which are described as follows.

Table1. Initial observation on the dry process quality and defects.

Initial Observation of Whisker and Hand Brush Quality Defects (Ins. = Inspection, DGs = Defected Garments)									
Dry Process	**July**		**August**		**September**		**Ins.**	**DGs**	**DGs %**
	Ins.	**DGs**	**Ins.**	**DGs**	**Ins.**	**DGs**			
Whisker	97675	15197	84023	14111	81421	11552	263119	40860	15.53%
Hand Brush	91897	12048	84667	10667	81692	9732	258256	32447	12.56%

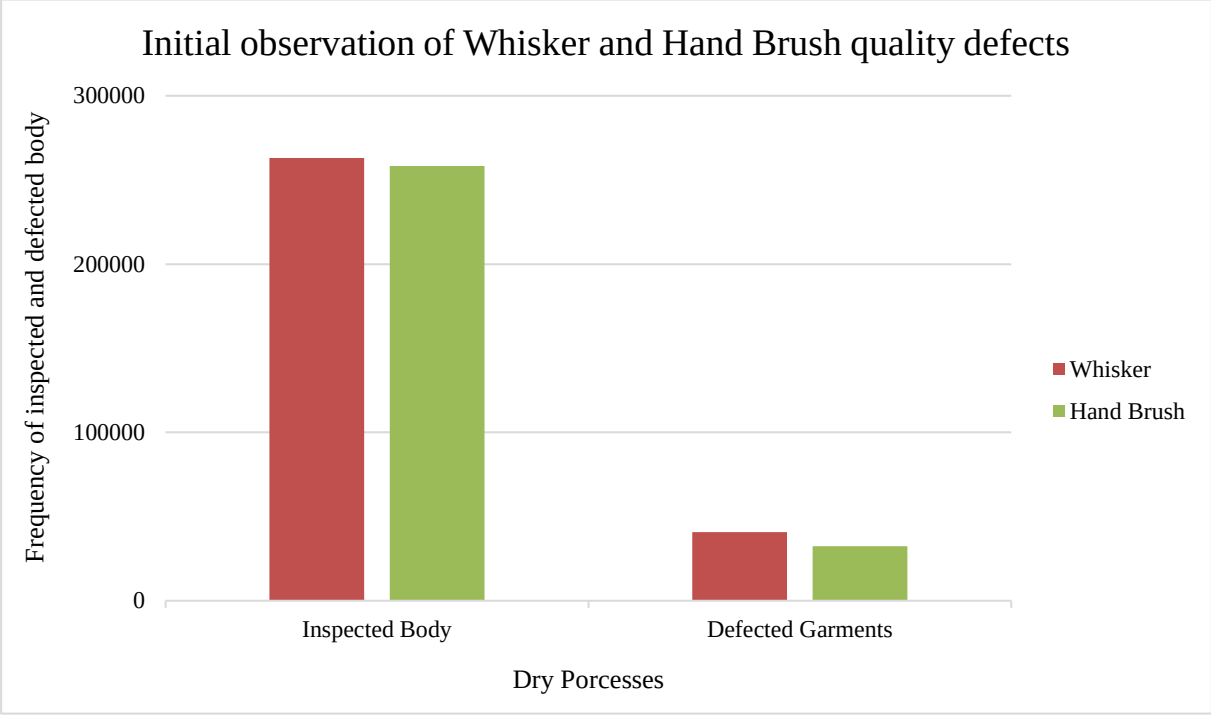

Figure 1. Initial observation on the dry process quality and defects

3. 2. Cause effect analysis & recommended solution for Whisker

3. 2. 1. Defects Frequency of Whisker

Initially it was observed the defects record taken from the QC table for three months from July 2018 to September 2018 to find out the defects of Whisker and analyzing the frequency of defects.

Table 2. Defects frequency of Whisker process.

Process Name	Defects	July		August		September	
		Defects Qty	Defects %	Defects Qty	Defects %	Defects Qty	Defects %
Whisker	Inconsistent	6932	45%	6812	48%	5092	44%
	Intensity less	2923	19%	2542	18%	2282	20%
	Intensity over	2980	20%	2495	18%	2122	18%
	Crease Mark	1228	8%	1102	8%	1152	10%
	Placement Up/Down	1178	8%	1193	8%	1005	9%
	Total	15241		14144		11653	

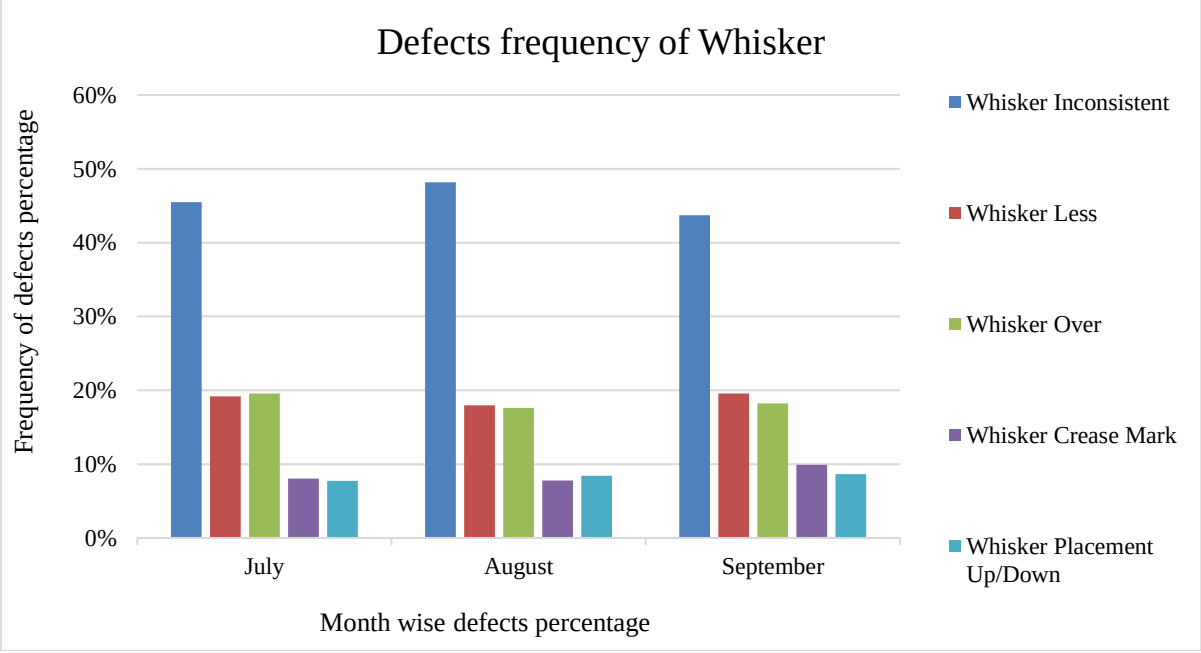

Figure 2. Comparing study of Whisker defects

The Figure 2, illustrates the no of defects in percentage to visualize the defects frequency of Whisker. The diagram identifies that Whisker inconsistent, less and over are the most significant defects of Whiskering process.

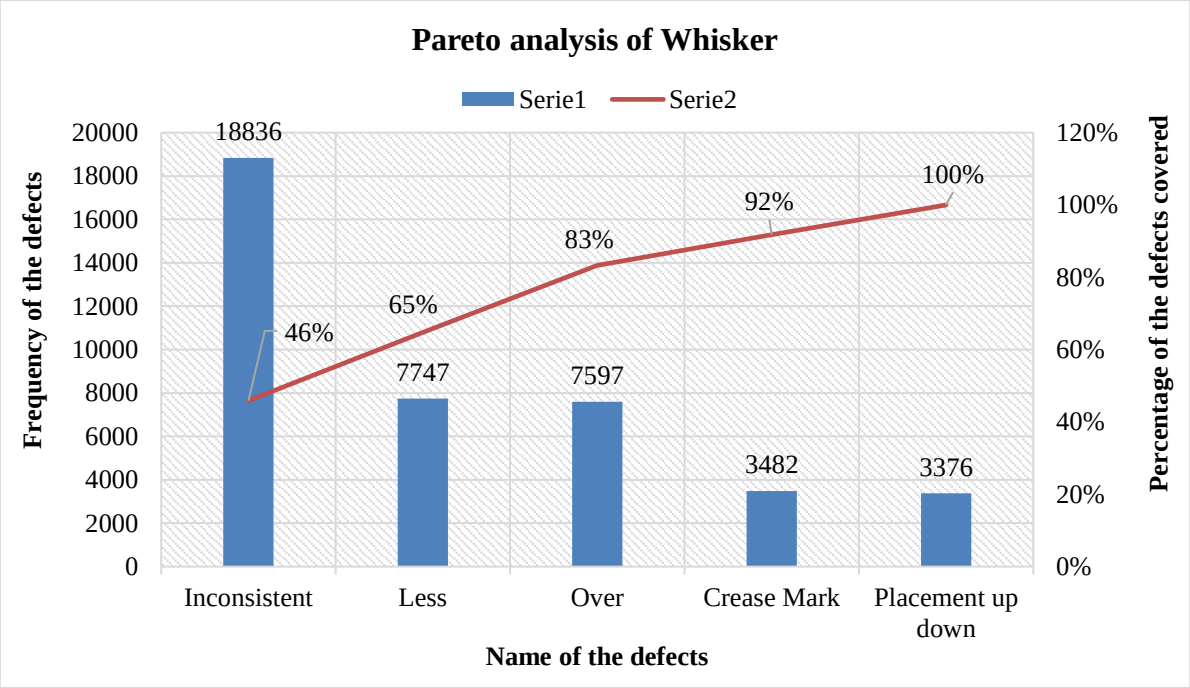

Figure 3. Pareto analysis of Whisker defects

From Figure 3, it is seen that 83% defects are covered by Whisker inconsistent, less and over that's why our investigation is focused on those defects which are occurred frequently.

3. 2. 2. Cause effect analysis of Whisker inconsistent

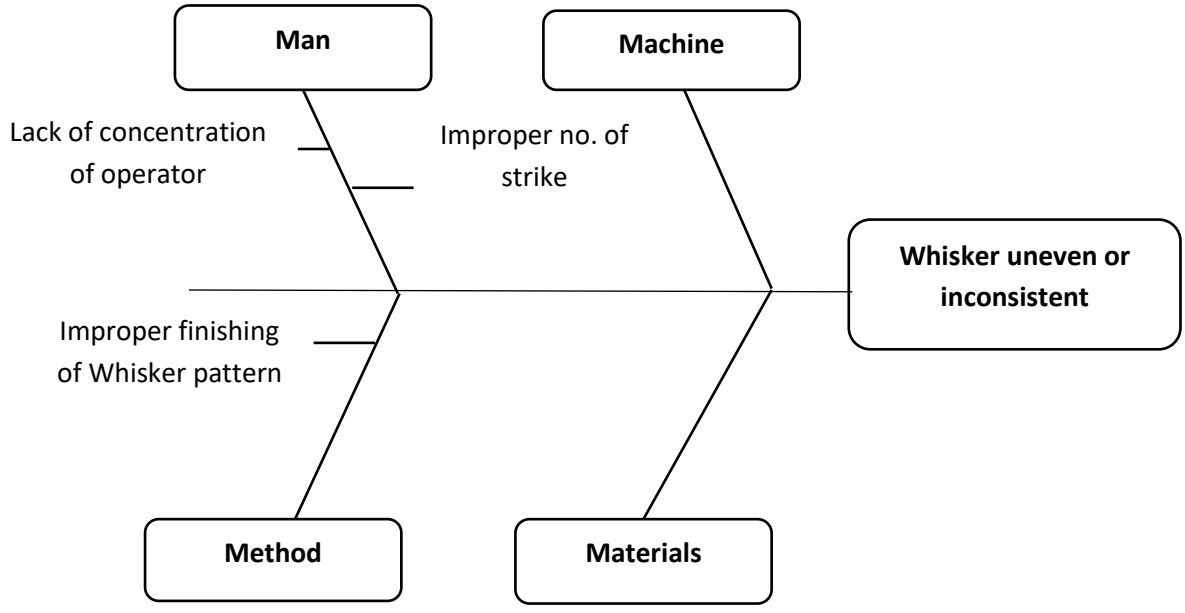

Figure 4. Cause-effect diagram of Whisker inconsistency

The root cause of Whisker inconsistency can be identified from below cause effect diagram.

Table 3. Causes and recommended solutions for Whisker inconsistency.

Causes	Recommended solution
Lack of concentration of operator	Given 10 minutes' rest or refreshment to the operators in each interval of two hours.
Improper finishing of Whisker pattern	Precise finishing of Whisker pattern checking before starting Whisker.
Improper no. of strike	Set proper no. of strike to meet the buyer standard design.
	Use of laser machine instead of manual process

3. 2. 3. Cause effect analysis of Whisker intensity more or less

The root cause of Whisker more or less can be identified from below cause effect diagram.

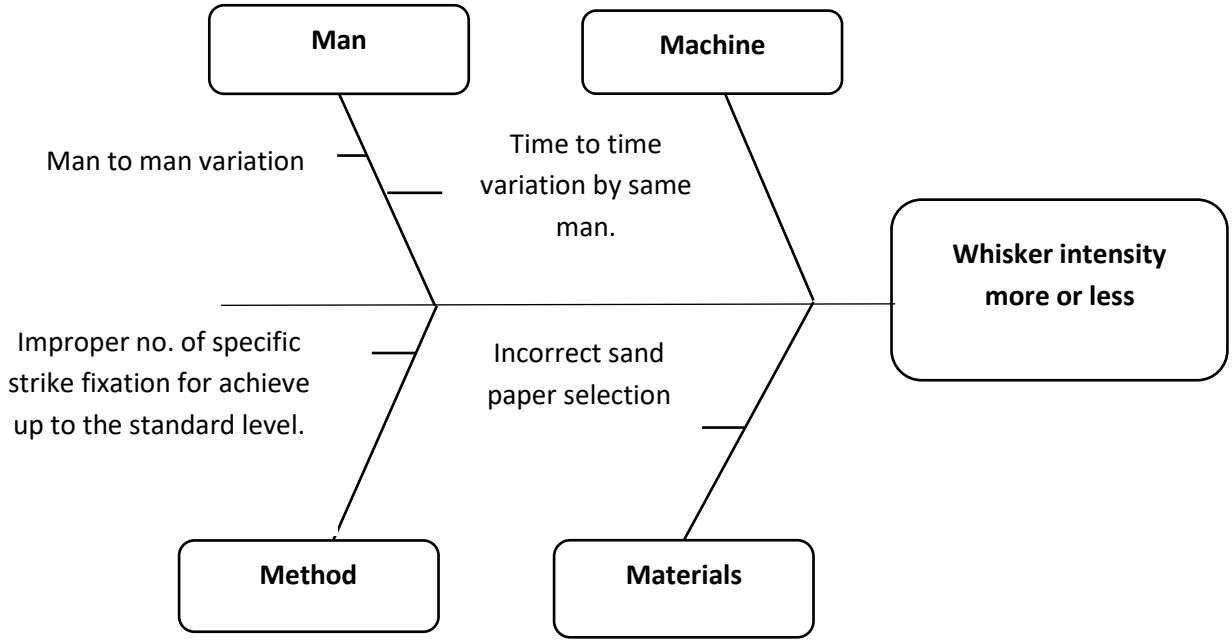

Figure 5. Cause-effect diagram of Whisker intensity more or less

Table 4. Causes and recommended solutions for Whisker intensity more or less.

Causes	Recommended solution
Man to man variation.	All operators are called together and trained them how to make the effect uniformly.
Time to time variation by same man.	Ensure inline quality system to minimize intensity variation and warn to the operator
Improper no. of specific strike fixation for achieve up to the standard level.	Set proper strike.
Incorrect sand paper selection.	Select correct sand paper.
	Whisker can be done by laser light or laser flame.

3. 3. Cause effect analysis & recommended solution for Hand Brush

3. 3. 1. Defects Frequency of Hand Brush

Initially it was observed the defects record taken from the QC table for three months from July 2018 to September 2018 to find out the defects of Hand Brush and analyzing the frequency.

Table 5. Defects frequency of Hand Brush.

Process Name	Defects	July		August		September	
		Defects	Defects %	Defects	Defects %	Defects	Defects %
Hand Brush	Inconsistent	6758	56%	6015	56%	5215	53%
	Intensity less	2138	18%	1880	18%	1893	19%
	Intensity over	997	8%	979	9%	892	9%
	Crease Mark	878	7%	859	8%	767	8%
	Placement Up/Down	1304	11%	1007	9%	1080	11%
	Total	12075		10740		9847	

Above table data are represented as in following bar diagram:

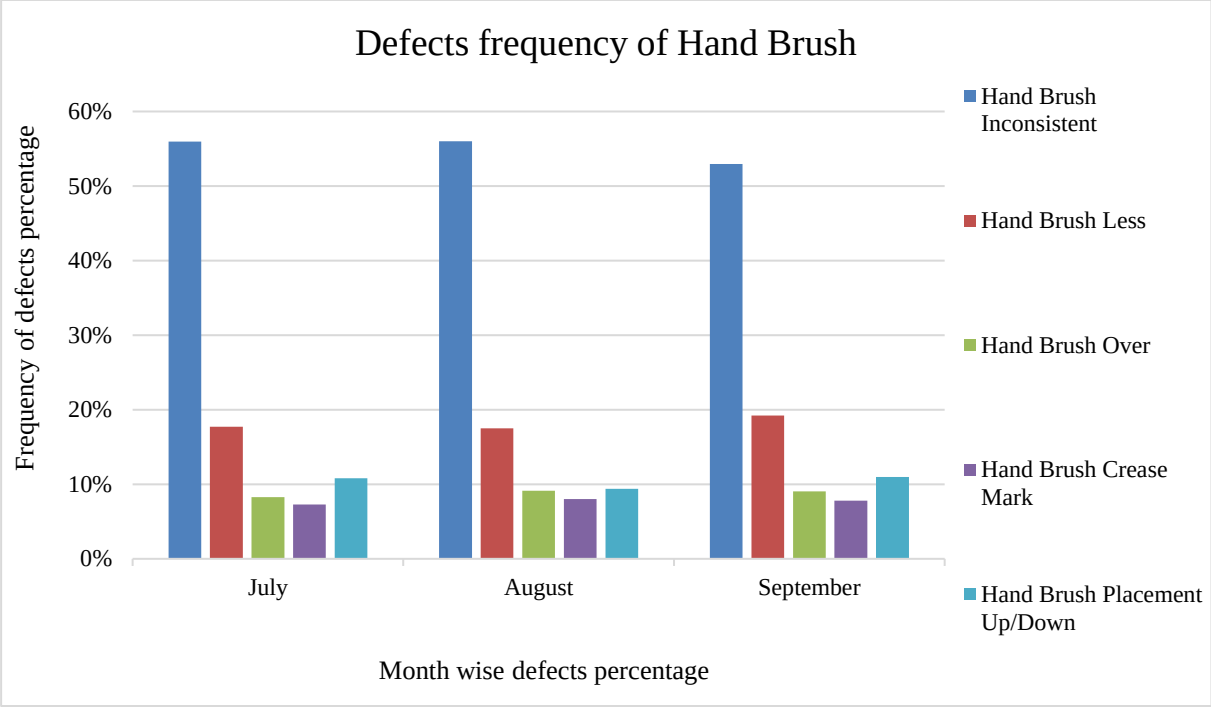

Figure 6. Comparing study of Hand Brush defects

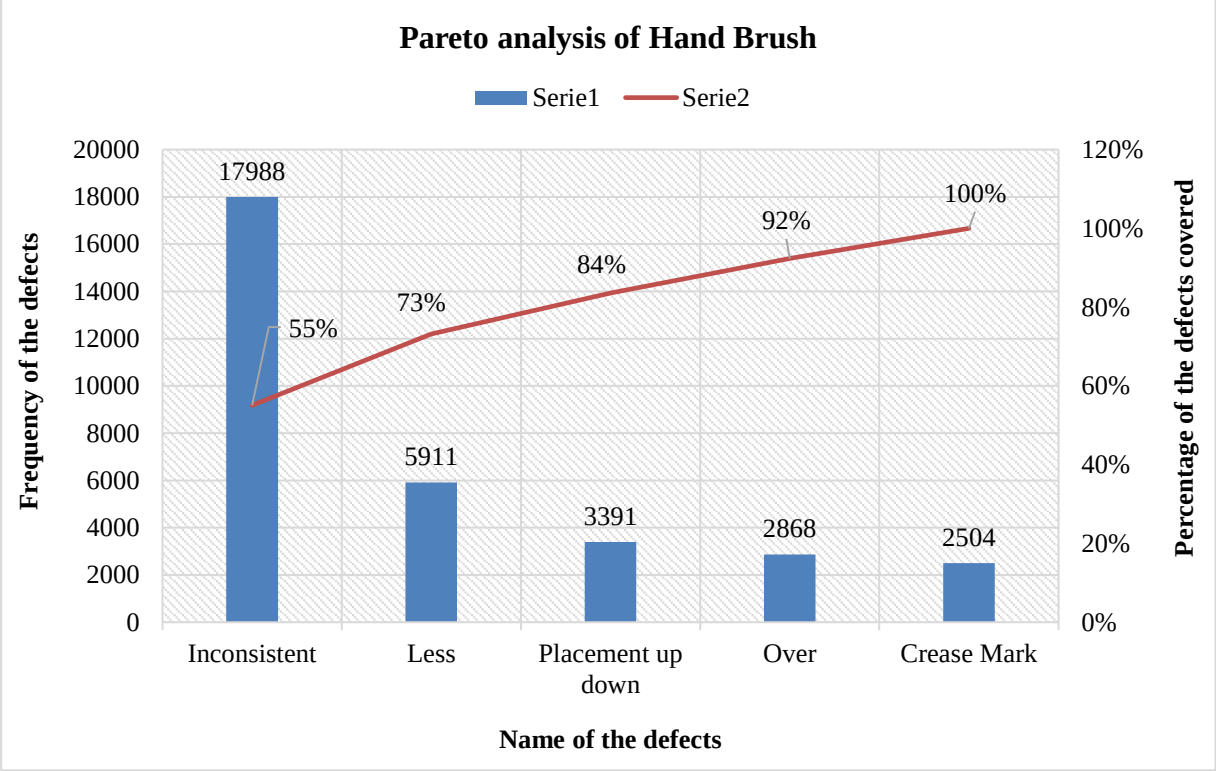

Figure 7. Pareto analysis of Hand Brush defects

Above bar diagram illustrates the no of defects in percentage to visualize the defects frequency of Hand Brush. The diagram identifies that Hand Brush inconsistent, less and over are the most significant defects of Hand Brush. After that we have analyzed which defects are covered around 80 % by pareto analysis. From the above figure it is seen that 84% defects are covered by Hand Brush inconsistent, less and placement up down thats why our investigation is focused on those defects which are occured frequently.

3. 3. 2. Cause effect analysis of Hand Brush inconsistent

The root cause of Hand Brush inconsistent can be identified from below cause effect diagram.

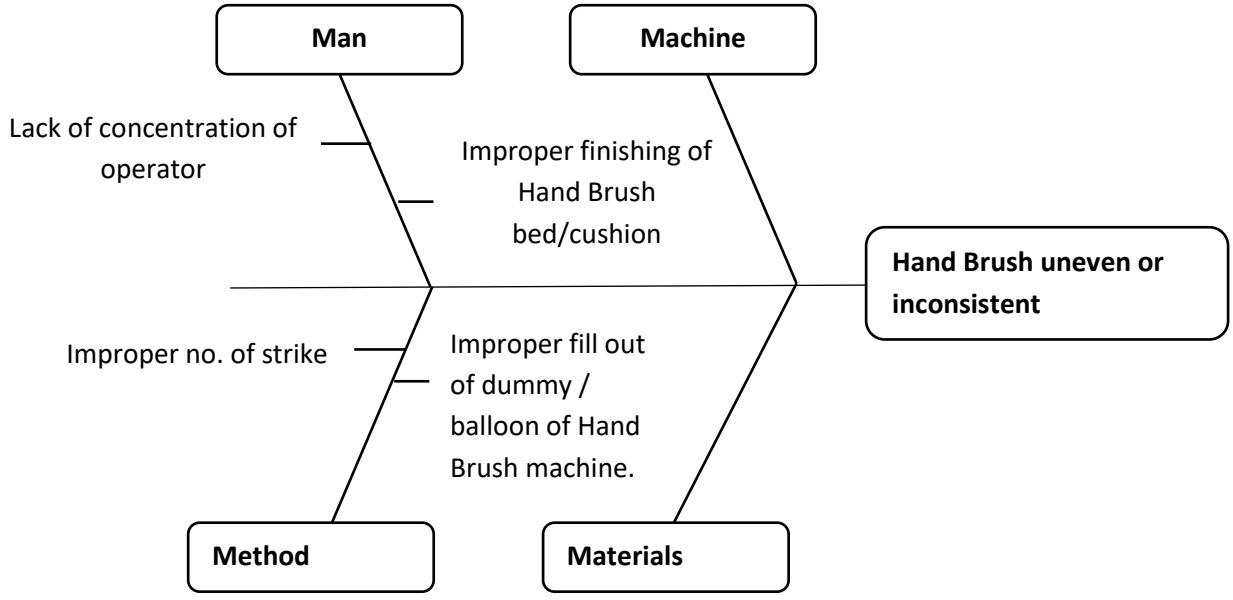

Figure 8. Cause-effect diagram of Hand Brush inconsistent

Table 6. Causes and recommended solutions for Hand Brush inconsistent

Causes	Recommended solution
Improper finishing of Hand Brush bed/cushion	Replaced Hand Brush bed with precise finished bed.
Improper no. of strike	Set specific no. of strike to meet the standard.
Improper fill out of dummy / balloon of Hand Brush machine.	Use of laser machine instead of manual process
	Proper and smooth fill out of dummy or balloon of Hand Brush machine.

3. 3. 3. Cause effect analysis of Hand Brush placement or measurement up or down

The root cause of Hand Brush placement up/down can be identified from below cause effect diagram.

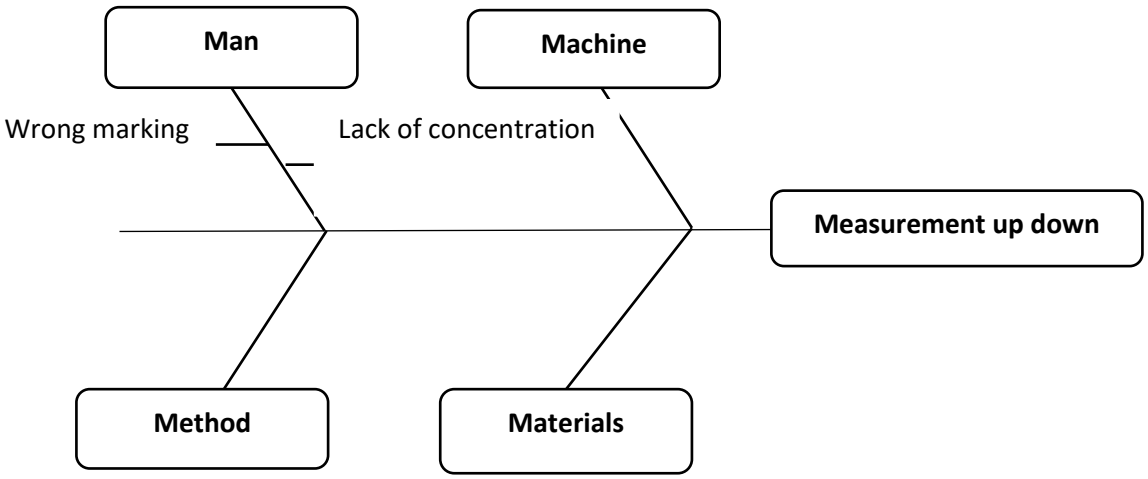

Figure 9. Cause effect diagram of Hand Brush placement up/down

Table 7. Causes and recommended solutions for Hand Brush placement up/down

Causes	Recommended solution
Wrong marking	Marked the Hand Brush by following strictly the sample measurement.
	Use of laser machine

3. 3. 4. Cause effect analysis of Hand Brush crease mark

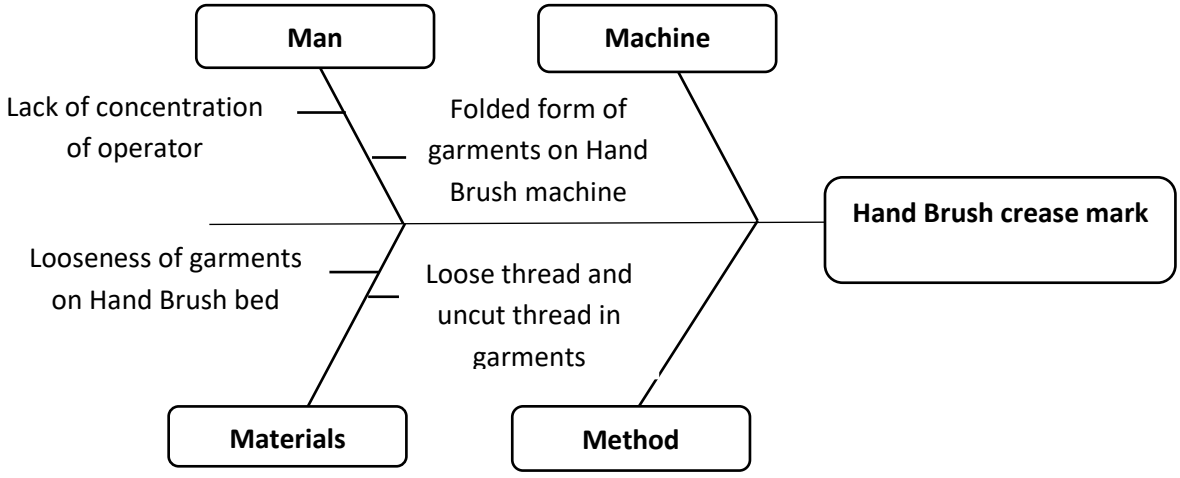

Figure 10. Cause-effect diagram of Hand Brush crease mark

The root cause of Hand Brush crease mark can be identified from below cause effect diagram.

Table 8. Causes and recommended solutions for Hand Brush placement up/down.

Causes	Recommended solution
Looseness of garments on Hand Brush bed	Garments should be tight on Hand Brush bed
Folded form of garments on Hand Brush machine	Should be flat form of garments on Hand Brush machine
Loose thread and uncut thread in garments	Loose thread removing by thread sucker machine and cutting uncut thread in garments

It is noticeable that for both process lack of concentration of the operators is the very crucial causes of the defects. To concentrate the operators on their task it was given them 10 minutes break after every two hours for the refreshment during production.

3. 4. SOP establishment

3. 4. 1. Standard operating procedure (SOP) of Whisker

- At first loose thread need to be blown out by thread sucker machine from the garments and uncut thread must be cut prior to start the Whisker process.
- Prepare Whisker pattern as per size of the garments by following inseam measurement.
- Before start the production it should be done a trial lot and make option which one is ok or not. After wash check Whisker pattern with standard and set inspection standard with ok option.
- Size segregation should be done of the garments.
- Marking should be done on the position of the garments the Whisker design is acheived.
- Hanging Whisker standard in front of every operator so that the exact design is kept in mind and uniform quality of the production is achieved.
- Numbering of the garments as per operator so that we can detect the operator when we get any defect in quality inspection.
- After finish Whisker all garments should be send to next process.
- Good quality garments send to next process by checking with inspection standard.

3. 4. 2. Standard operating procedure (SOP) of Hand Brush/ Hand Scraping

- At first loose thread need to be blown out by thread sucker machine from the garments
- and uncut thread must be cut before starting hand scraping.
- Prior to start production it should be make option, indicate by rope. After wash match with standard which option is ok and set inspection standard.
- Marking should be done properly.
- Machine number & operator number must indicate at every garment.
- Be careful about bladder crease, thread erase & allowance crease.
- Hanging the standard in front of every operator.
- Good quality garments send to next process by checking with inspection standard.

3. 5. Comparison of defects before and after SOP establishment

Standard Operating Procedure has been established through analyzing the root causes of defects and their suggested solutions. The established SOP was maintained for the next following three months from October 2018 to December 2018 and a significant change defects was found for individual process of Whisker and Hand Brush.

3. 5. 1. Comparison of Whisker defects before & after SOP

Table 9. Comparing the defects of Whisker before and after SOP establishment

Monthwise data of Whisker defects (before & after SOP establishment)							
Process Name	**Defects**	**Before SOP**			**After SOP**		
		July	**August**	**September**	**October**	**November**	**December**
Whisker	Inconsistent	6932	6812	5092	4315	1825	1166
	Less	2923	2542	2282	2033	1249	836
	Over	2980	2495	2122	1895	908	630
	Crease Mark	1228	1102	1152	902	843	600
	Placement Up/Down	1178	1193	1005	739	986	674

Above comparison can be illustrated as in below bar diagram to get an overview about the quality after implementation of SOP for Whisker process.

The above figure represents the comparison of defects level before after SOP implementation. The defects level of Whisker is decreased significantly in the November and December.

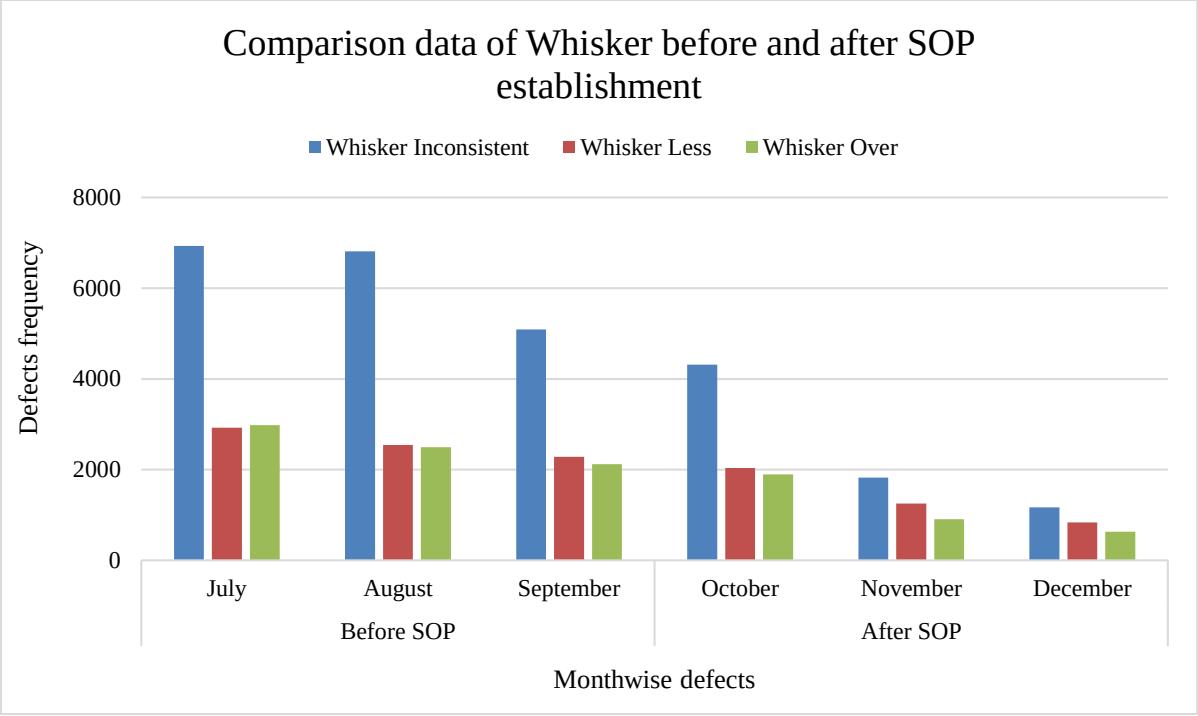

Figure 11. Comparing the defects of Whisker before and after SOP establishment

3. 6. Comparison of Hand Brush defects before & after SOP

Table 10. Comparing the defects of Hand Brush before and after SOP establishment

Monthwise data of Hand Brush defects (before & after SOP establishment)							
Process Name	**Defects**	**Before SOP**			**After SOP**		
		July	**August**	**September**	**October**	**November**	**December**
Hand Brush	Inconsistent	6758	6015	5215	4881	923	874
	Less	2138	1880	1893	1458	1120	919
	Over	997	979	892	721	727	601
	Placement Up/Down	1304	1007	1080	992	766	615
	Crease Mark	878	859	767	689	815	630

Above comparison can be illustrated as in below bar diagram to get an overview about the quality after implementation of SOP for Hand Brush process.

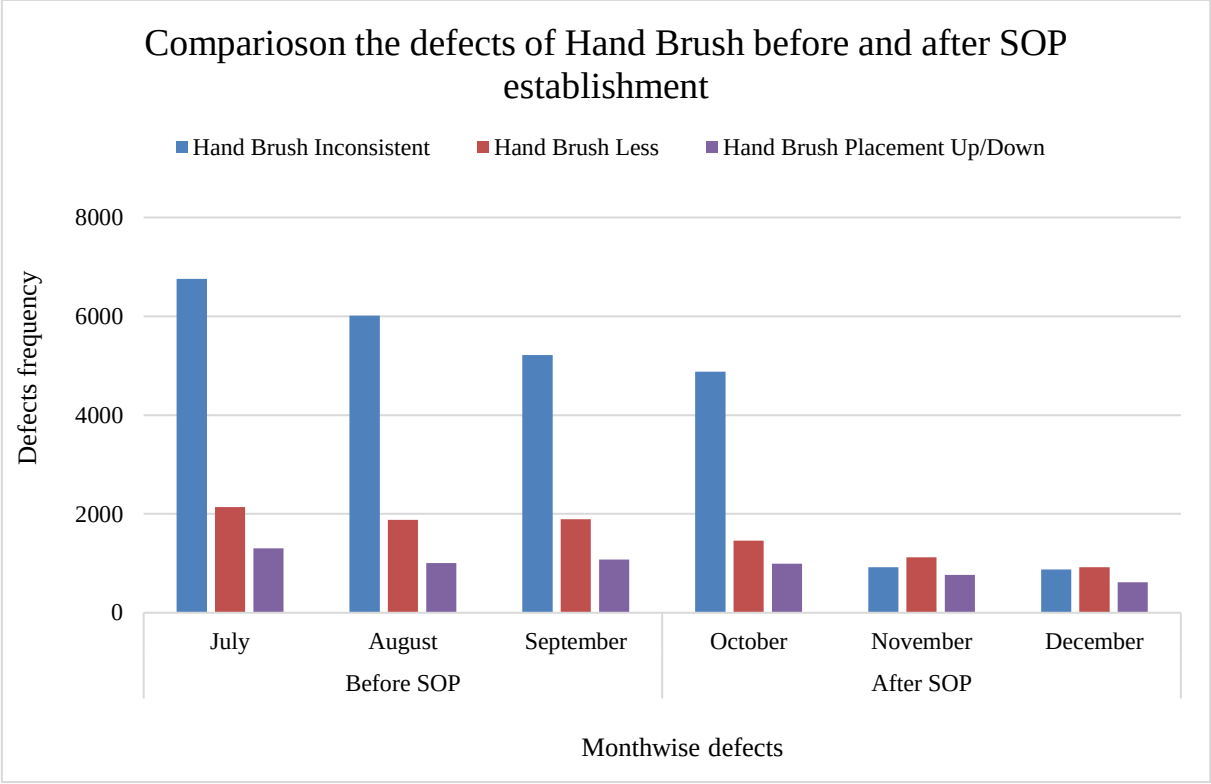

Figure 12. Comparing the defects of Hand Brush before and after SOP establishment

The above figure represents the comparison of defects level before after SOP implementation. The defects level of Hand Brush is also decreased significantly in the November and December.

3. 7. Outcome of the study

Table 11. Comparison results of dry process before and after SOP checklist maintained.

Process Name	Before SOP			After SOP		
	Inspection	Defected Garments	Defected Garments Percentage	Inspection	Defected Garments	Defected Garments Percentage
Whisker	263119	40860	16%	267205	19401	7%
Hand Brush	258256	32447	13%	275718	16687	6%

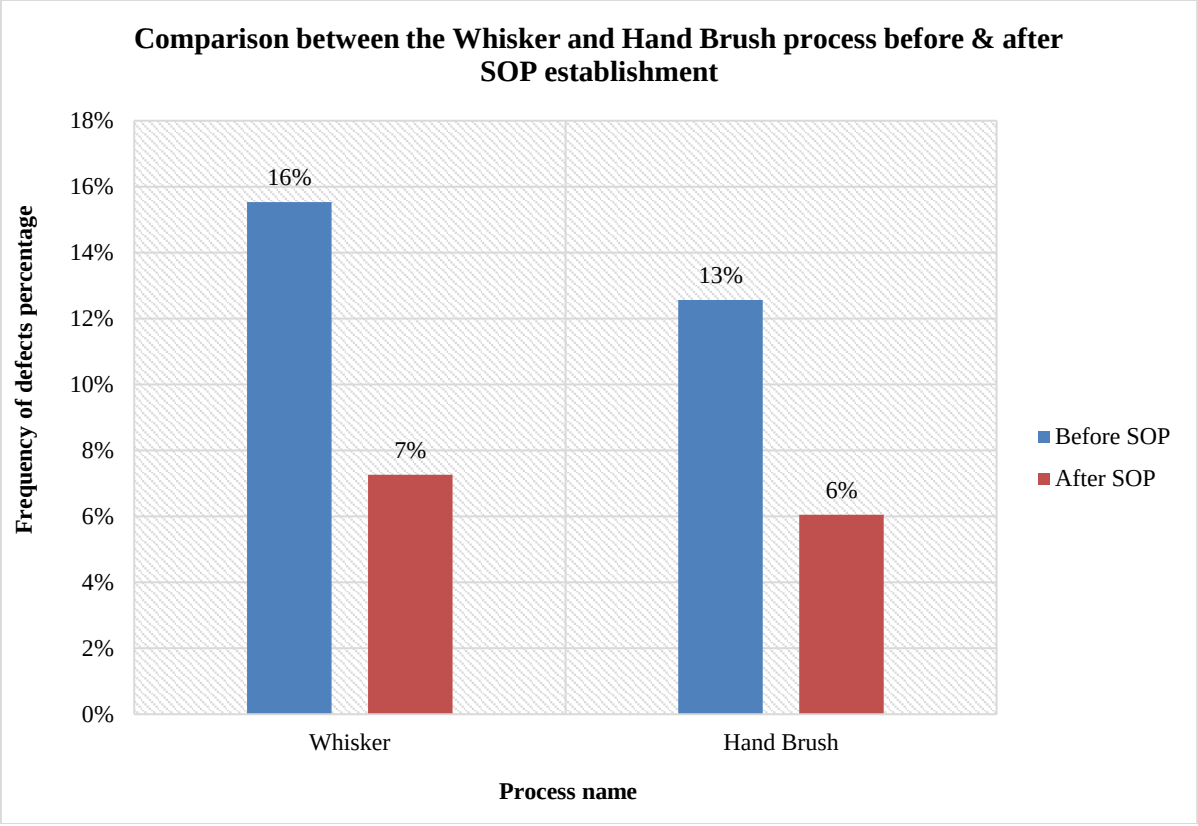

Figure 13. Final outcome of the study for Whisker and Hand Brush process

From the Figure 13, it is noticed that after maintaining SOP checklist and suggested solution, the defected garments of Whisker process is decreased from 16% to 7%, Hand Brush process is decreased from 13% to 6%. Finally, 9% and 7% defects are decreased from Whisker and Hand Brush process.

4. CONCLUSIONS

According to results and discussions it is noticed that the objects of this study is achieved significantly for Whisker and Hand Brush process of denim washing. After SOP implementation the defects level has decreased to the 7% and 6%, for the process of Whisker and Hand Brush respectively, which are mostly within and near the tolerance limit (3-5%) in denim washing process.

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