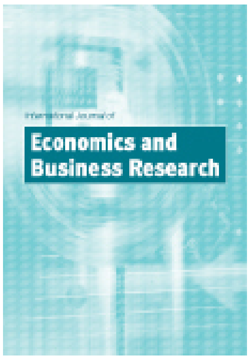

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Productivity improvement in the stitching process: a Six Sigma case study of the footwear industry

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Abstract: This paper introduces the concept of Six Sigma in the footwear industry. Various Six Sigma tools and techniques have been applied for measuring and analysing the reasons for defects in the shoe-making process. DMAIC was applied in the footwear manufacturing industry and sigma level observed was 3.77. The efforts have been made to reduce the defects and improve the sigma level with the help of Six Sigma DMAIC methodology. However, further improvements in the process are subject to following the various control measures suggested in the paper. With the help of general factorial design and Taguchi's experiments, the key influence factors of the optimal combination for cooling time, temperature, viscosity have been obtained to analyse their effect on adhesive strength of the material used in the shoe-making process. Key techniques used in the analysis are Pareto analysis, cause and effect diagram, nested ANOVA, Duncan's test and Taguchi's design of experiments (DoE).

Keywords: DMAIC; process improvement; Six Sigma; Pareto analysis; Duncan's test; nested ANOVA; Taguchi's design of experiments; design of experiments; DoEs.

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Biographical notes: Indu Uprety has been an academician for the last 20 years and has industrial and research background in the field of stochastic modelling, Six Sigma and data analysis. Currently, she is an Associate Professor at Gautam Buddha University, Greater Noida, UP, India. She has been awarded IIM-Kozhikode Gold Medal for her scholarly performance in Executive Education Program in Operations Management. She has published articles in journals, conferences of national and international repute. Her main research interests include stochastic modelling, quality management, multivariate data analysis and Six Sigma.

1 Introduction

Six Sigma is a highly structured process improvement framework that uses both statistical and non-statistical tools and techniques to eliminate process variation and thereby improve process performance and capability (Anthony and Banuelas, 2002). It is a proven method for improving profits by pursuing perfection. For non-Six Sigma companies, the costs of not meeting desired quality may prove significant. There is a huge cost to operating between three to four sigma as one might have to spend between 25% and 40% of their revenues on fixing problems. This is known as the cost of quality on the part of manufacturer and is the cost of poor quality. Companies operating at Six Sigma typically save more than 95% of their revenues because of not spending on fixing problems/repair/rework.

An 'opportunity' is defined as various possibilities of failure for not meeting the required specifications. For the manufacturing systems that still depends heavily on labour work and where process automatisation is not intensively utilised, the concept of Six Sigma should be applied differently. The industries like footwear, sewing, which largely depend on the people activity, the work should be planned keeping in view the employee skills and the level of automation required to have an effective production plan and productivity. The small incremental changes when routinely applied using Six Sigma philosophy can result in significant improvements. This paper aims at providing insight in implementing Six Sigma as a manufacturing practice in labour-intensive industry by conducting a case study.

2 Literature survey

The adoption of advanced manufacturing technologies and associated management and quality philosophies to achieve manufacturing excellence has long been widely prevalent in all industrial sectors. Various applications of lean, Six Sigma, BPR and Kaizen have been reported across a number of public services. Many authors recognised that business process improvement methodologies are based on established tools and techniques, and therefore could be argued to merely draw on "any good practice of process/operations improvement that allows reduction of waste, improvement of flow and better customer satisfaction and process view" (Radnor et al., 2006). In this regard, Mia et al. (2017) worked on waste management of footwear manufacturing industry using Lean Sigma tools and presented a framework for the industry.

To achieve quality, it is critical to understand voice of customers and meet customer specifications (Ishikawa, 1985; Hackman and Wageman, 1995). Productivity is an important measure to ensure efficient production. Maximum productivity can be ensured with the effective use of resources since productivity is the ratio of output to inputs used in the production process. Labour productivity, for example, is usually expressed as output per hour. Typical partial productivity measures such as worker hours, materials or energy per unit of production can be used to gauge the efficiency of a production unit/system in an industrial environment (Mathew et al., 2017).

Obtaining efficiency in productivity is imperative to any economy as it leads to optimum utilisation of resources. For example, employee productivity can be improved through an effective performance monitoring system and managing the dynamics of performance hour by hour, shift by shift, day by day or month by month. It is very important to see and understand the various performance measures so that appropriate action can be taken to make high performance an everyday reality. Umble et al. (2003) in their paper suggested implementation procedures and critical success factors for enterprise resource planning. The shoe industry need to produce momentous quantities in shorter lead times as production of footwear product is highly correlated with high level of productivity (Parthiban and Razu, 2008). Some earlier authors like Coronado and Antony (2002) and Henderson and Evans (2000) pointed out the critical success factors for the successful implementation of Six Sigma projects in organisations.

Methinee and Prasad (2014), in this context worked on reducing defects in the shoe manufacturing process. Define-measure-analyse-improve-control (DMAIC) approach was followed to identify the current process and areas for improvement. Senapati (2004) suggested DMAIC approach through Deming's cycle, TQM, MBNQA and Dorian Shanin's statistical engineering. He has suggested different methodologies as an improvement initiative. Antony et al. (2005) presented the application of DMAIC methodology to reduce engine- overheating problem in an automotive industry.

Six Sigma approach has been found to be an important cost saving technique in a variety of industries with a considerable focus on financially measurable results. Any Six Sigma implementation aims at improving customer satisfaction, by means of improved product quality (Bhote, 2002; Caulcutt, 2001). Six Sigma DMAIC methodology attempts to remove non-value adding activities from the process making it more balanced and leading to reduction in cost and improving productivity of the process. The DMAIC framework utilises various tools and techniques like control charts, quality function deployment (QFD), failure mode and effect analysis (FMEA), regression analysis, design of experiments (DoEs), response surface methodology, statistical process control (SPC), etc. for identification and reduction of variation in the process to drive out defects in operations. Among the available collection of tools and techniques, application of DoE is at the heart of DMAIC cycle (Breyfogle, 1999). DoE helps to create and design minimum number of experiments with the help of orthogonal arrays and helps in identifying key process parameters to finally optimise them for best outcome through a robust process (Pande et al., 2002; Tanco et al., 2009). A study was conducted by Kwon et al. (2016) to find out the optimum condition of the rotary cutter used in the footwear outsole process. Taguchi method was used to identify the robust condition of the cutter using L_{18} orthogonal array. It was found in the study that the most important factors to reduce maximum stress in the cutter were supported angle and diameter and the optimised levels of these parameters resulted in reduction of 70% cycle time and 9% raw material compared to the traditional methods. In another study carried out by Anggoro et al. (2021), Taguchi's response surface methodology was adopted to optimise the parameters of the CNC milling process (cutting speed, feed rate, tool path strategy and step over). Ethylene-vinyl acetate (EVA) foam with varying surface hardness and the tolerance of the wide fit insoles corresponding to the surface roughness were analysed.

Footwear industry has gone through significant changes in the recent years with the rapidly developing computer-aided design (CAD) technology and other three-dimensional (3D) design and printing techniques. A 3D design of orthotic insoles is proposed by Ye et al. (2008) for various foot contours with optimal fit and minimum design time and production cost. It is possible to design and fabricate various insole designs according to the requirements of the feet of diabetic patients using CAD technology. Innovative approaches like artificial neural network (ANN) and the optimal design procedure have also been developed in shoe manufacturing, e.g., a model is developed to predict and optimise the rate of deformation from the raw materials used in the composition of the adhesive joint (Paiva et al., 2016). Thus, with the newer technological advancements and defect reduction techniques like Six Sigma along with lean manufacturing tools have paved way for the shoe making process to produce more customised products as per market demand. Lean Six Sigma (LSS) has been found very effective and a strong strategy in process management with the aim to eliminate defects and reduce variations in product manufacturing and service processes leading to business process excellence (Antony et al., 2007; Snee, 2010; Laureani and Antony, 2012). The advantages and critical success factors of implementing LSS tools are well acknowledged in many case study papers in both the manufacturing and the service sectors (Akbulut-Bailey et al., 2012; Pickrell et al., 2005; Hardeman and Goethals, 2011).

Process reengineering and simulation have also been practiced in footwear industry to analyse the root causes of the problems (Rubén et al., 2020). A study was conducted by Nguyen (2015) to improve an electronic assembly line and combination of reengineering and lean manufacturing was practiced and a significant 40% decrease in the number of workers and 30% savings in production plant space were attained as evident from the study.

The study described below in Section 4 was implemented in an industrial shoe company in India. The company was trying to expand its market and therefore, it was necessary to increment its productivity to attain the required quality. DMAIC problem solving methodology along with general factorial design and Taguchi's DoE methods have been adopted in the study to reduce number of defects in the process, increase productivity, maintain proper operation sequence and identify key process parameters to analyse their effect on adhesive strength of the material used in the shoe-making process.

3 Case study review

3.1 Six Sigma in banking services (Uprety, 2009)

The use of Six Sigma methodology has increased significantly in financial institutions now than it has ever been and companies are now reaping true savings and revenue growth. It follows the DMAIC approach to problem solving and to identify the areas for improvement.

The case was taken up to answer the following questions:

- Why Six Sigma in services?
- How Six Sigma in financial services is different from manufacturing Six Sigma?
- Financial sector challenges and possible solutions.
- How Six Sigma can benefit the banking sector?
- Six Sigma project management methodology.
- Business improvement now and in future.

Unlike manufacturing operations, defining a service defect is quite challenging and a matter of subjective assessment and therefore, the critical to quality attributes are more difficult to derive. The case study was designed with a view to improve key performance indicators, reduce defects in the process and increase customer satisfaction using Six Sigma DMAIC methodology. The tools and techniques used in the study included process map, Pareto analysis, Kruskal-Wallis test, chi-square test, etc.

The goal was to identify the feeble areas in overall transaction and improve upon those which would be of maximum benefit to the company.

3.2 Six Sigma in manufacturing industry (Shanmugaraja et al., 2011)

The authors presented a case study from a die casting company demonstrating how the effective introduction and implementation of a Six Sigma program can lead to a breakthrough in profitability, incorporating change management and gaining customer loyalty. The subject company is a south Indian SME who produces many automobile aluminium components for their various clienteles in India and abroad. Among the various components produced in lots, two stroke engine oil pump body was selected for this analysis. The organisation was encountering blow holes defect in oil pump body casting.

This research study proposed an innovative approach to controlling the defects in aluminium die casting business. Six Sigma DMAIC (define, measure, analyse, improve, control) methodology was used to analyse the problem. Process validation was done with Taguchi's DoE. Analysis of variance (ANOVA) analysis at 95% confidence showed that the metal temperature is the vital process parameter causing defects. Confirmation experiment at optimum process parameter level showed defect level reduced from 17.22% to 4.8%. Since aluminium die casting is one of the most widely used process for producing automobile components, this study attempted to provide a methodology for improving the die casting process.

4 Executive summary of the present business case

ABC India Ltd. is one of the largest footwear manufacturing companies in India and has been in operation since 1966 with nine companies located at different parts of India. The range of their products includes stuck-on-sports shoes, canvas vulcanised shoes, PVC injected sports shoes and leather shoes.

This study is carried out at the main production unit of Lakhani India Ltd. The shoe making process can be broken in two steps:

1 sole preparation

2 preparation of upper shoe part.

For upper shoe preparation, there are two main processes:

1 cutting and preparation of shoe components

2 stitching of components.

After this comes the lasting and assembly process, which assembles the sole part and upper part of the shoe followed by inspection. Finally comes into picture the packing of shoes.

This paper is based on the productivity study of stitching process. The study is initiated with a view to identify the weak areas in overall process and improve upon those which would be of the maximum benefit to the company. DMAIC approach is followed to identify the current process and areas for improvement. Systems have been identified to initiate the improvements through training, monitoring and motivational methods for employees.

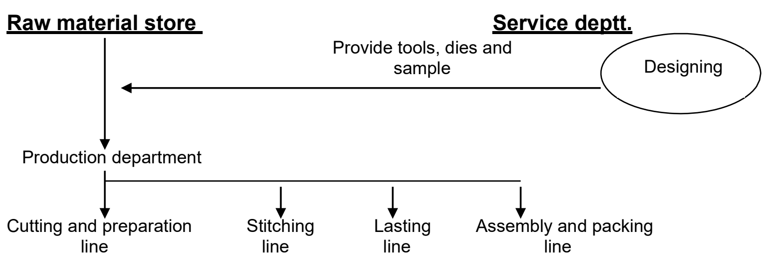
5 Case explanation

5.1 Business case: the define phase

This study is carried out to find the ways and means to improve the productivity in stitching process, as the deviations are more than expected in this process. In the stitching process, there are five identical production lines, i.e., any shoe article can be put on any of these lines but output from these lines vary significantly due to the efficiency and skills of employees. There are three categories of workers: skilled, semi-skilled and unskilled.

Flow diagram of the process is as shown in Figure 1.

Figure 1 Flow diagram of shoe-making process



During final inspection at each process end, the shoes are divided into three categories – A, B and C. There are 14 types of defects, which may be seen in a shoe or shoes. Apart from the process, the most important asset of the industry is its workers, since the industry is labour-intensive. Any negligence on the part of worker might lead to the rejection of a shoe.

The types of defects that are responsible for the rejection of a particular shoe are as follows:

1 upper colour variation
2 grain mismatch
3 skin fit discolour
4 double punch
5 dirty upper
6 open stitch
7 crooked lasting
8 toe lasting wrinkle
9 seat lasting wrinkle

10 back height variation

11 over cementing

12 over roughing

13 discolour sole

14 defective sole.

About 60%–70% defects are due to the negligence on the part of workers.

5.2 Specific problem statement

Currently, the critical to process parameter considered for sigma calculations is ‘productivity’. Productivity can be referred to as how much output can be produced with a given set of inputs. In this case, the main inputs are the human resources available, material provided and most important of all the, time limit specified for every quantity of output. Thus, any deviation from the target value will be termed as ‘critical error’. Here, target value refers to the ‘quantity specified within the stipulated time period’. Thus, the problem is to identify the reasons for low production rate and apply corrective measures.

Thus, the problem can be restated as ‘to reduce the defects and improve the productivity of the process’ thereby increasing the sigma level by a reasonably large value. The current Six Sigma rating is measured at 3.77.

5.3 Scope

Productivity enhancement will focus on optimum utilisation of resources and labour cost savings as well as reduction in per unit cost of product. The savings can be reutilised at the lowest organisational level for strengthening employee skills, incentivising the performers and equip with better production systems to increase production rate.

5.4 Voice of the customer

- quality
- availability
- durability
- variety.

5.5 Need for the project

- maximum utilisation of machines and manpower
- skill mapping
- right person at right job
- control wastage
- employees motivation for effective output.

5.6 Proposed benefits

- Notional savings: Increased employee morale, reduced rework and cost and productivity improvement.
- Strategic benefits: Benchmarking for further improvements.

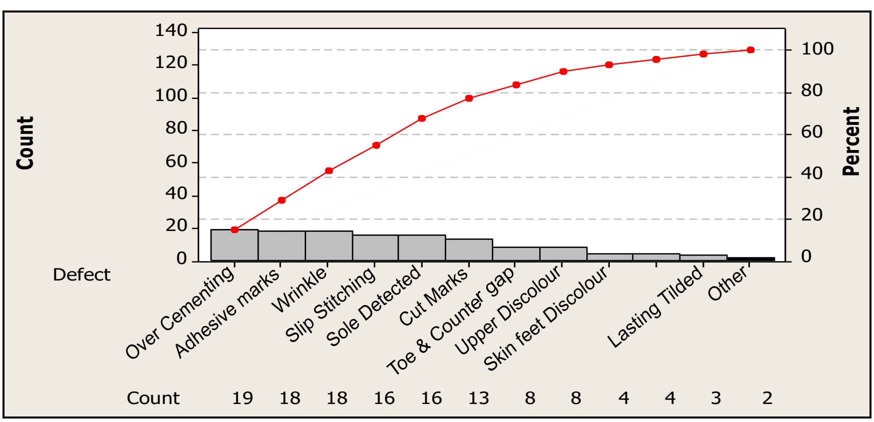
5.7 Impact on key business issues

- increased morale of employees
- maximum utilisation of resources
- increased productivity of employees
- reduced rework.

6 Performance: the measure phase (Pareto analysis)

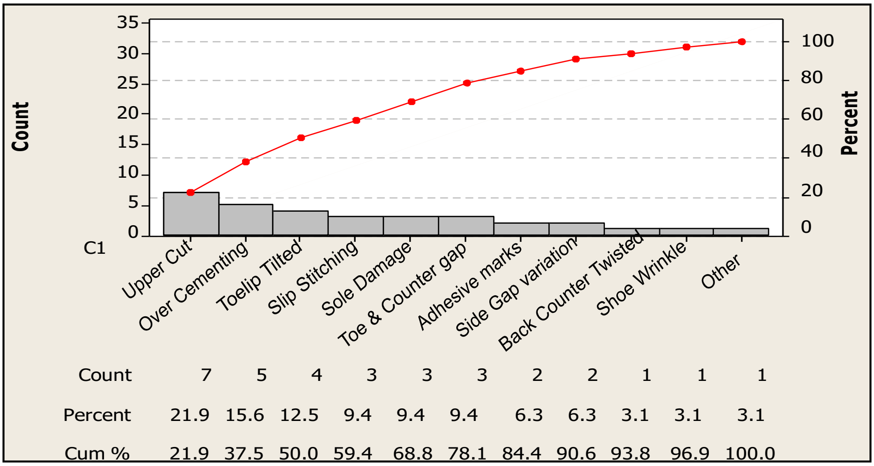
Pareto analysis is a statistical technique used in the measure and analyse phases of Six Sigma process for selection of a limited number of tasks that produce significant overall effect. The Pareto chart is one of the seven basic tools of quality control (Hart and Hart, 1989). As a result of Pareto analysis, the responsible factors for causing defects were identified. Pareto chart 1 shows the defects in the overall process. Over-cementing, adhesive marks, slip-stitching and wrinkle defects are covering 55% of the total defects.

Figure 2 Pareto chart-1 of defects in shoe-making process (see online version for colours)



Pareto chart 2 shows the major defects in stitching process, e.g., upper cut, over-cementing and toe-lip tilted, which cover around 50% of the overall defects. Using the feedback and comments obtained from representatives of the company and attendees, it was found that most of these defects are due to negligence on the part of workers.

Figure 3 Pareto chart-2 of defects in stitching process (see online version for colours)

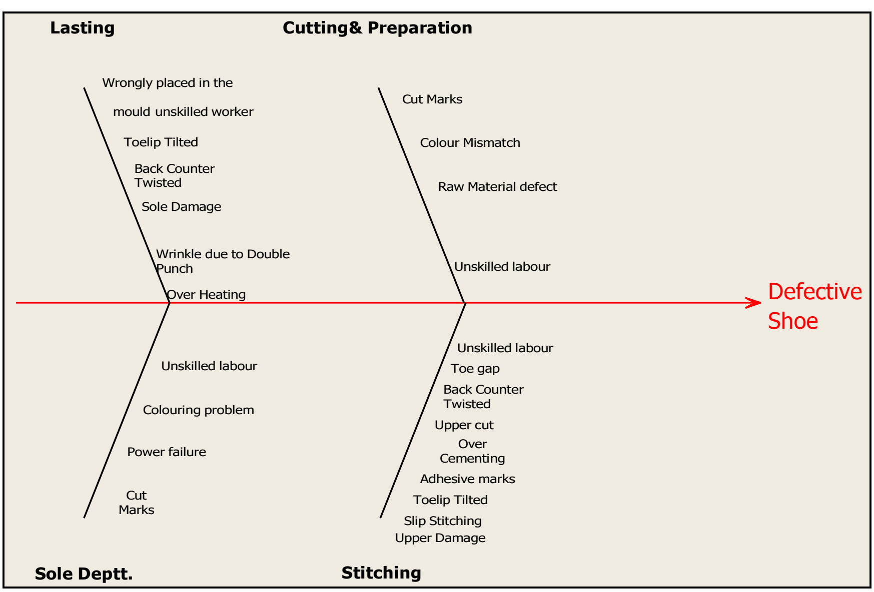


7 The analyse phase

7.1 Cause and effect diagram of defective shoe

A fishbone diagram was formed to see the defects in different processes which are resulting in a defective shoe. In the stitching process, most of the defects like over-cementing, cut marks, toe lip tilted, slip stitching, etc. is due to worker being semi-skilled or not concentrating at work. Thus, there is a need to rectify these errors by proper on-job-training of employees.

Figure 4 Cause and effect diagram of defects in different process (see online version for colours)



7.2 Productivity study in Line 1 and Line 5 of stitching process

Productivity study was done in stitching process to see the effectiveness of employees in Line 1 during the forenoon and afternoon shifts using nested ANOVA technique:

Hoa Mean effectiveness of employees is same.

Hob Forenoon and afternoon effects are same.

Table 1 Nested ANOVA for productivity

Analysis of variance for C3					
Source	*DF*	*SS*	*MS*	*F*	*P*
C1	14	1,161.6667	82.9762	1.952	0.046
C2	45	1,912.5000	42.5000	0.685	0.907
Error	60	3,725.0000	62.0833		
Total	119	6,799.1667			

Variance components			
Source var.	*Comp.*	*% of total*	*StDev*
C1	5.060	7.54	2.249
C2	–9.792*	0.00	0.000
Error	62.083	92.46	7.879
Total	67.143		8.194

Expected mean squares		
1	C1	1.00(3) + 2.00(2) + 8.00(1)
2	C2	1.00(3) + 2.00(2)
3	Error	1.00(3)

Note: *Value is negative and is estimated by zero.

Conclusions: It is clear from Table 1 that there is no difference in forenoon and afternoon effects but the employees vary in their efficiencies.

For the purpose of differentiating between the best and fair employee, Duncan test was performed. Results of which are as follows.

7.3 Duncan’s test

On the basis of Duncan’s test, groups of employees were formed showing similar capacity for Line 1:

- Group1 = 61.875, 62.5, 63.125, 63.75, 65, 65, 65
- Group 2 = 66.875, 67.5, 68.125, 68.125, 68.125, 69.375
- Group 3 = 71.875, 72.5

Similar study was conducted for Line 5, where again the groups of employees were formed and to see if the groups were formed properly, the employees with lowest and the highest standard deviations were considered and equality of variance test was performed on it.

Table 2 One-way ANOVA table for employee productivity in line-5

Source	*DF*	*SS*	*MS*	*F*	*P*
Factor	11	1,296.2	117.8	5.16	0.000
Error	36	821.8	22.8		
Total	47	2,118.0			
S = 4.778		R-sq = 61.20%		R-sq(adj.) = 49.35%	

Level	*N*	*Mean*	*StDev*	*Individual 95% CIs for mean based on pooled StDev*
				---------+---------+---------+---------+
1	4	37.500	5.000	(------*-----)
2	4	41.750	5.679	(------*------)
3	4	43.750	4.787	(------*-----)
4	4	41.250	2.500	(------*------)
5	4	48.750	2.500	(------*------)
6	4	50.000	0.000	(-----*------)
7	4	50.000	0.000	(-----*------)
8	4	45.000	5.774	(-----*------)
9	4	42.500	9.574	(-----*------)
10	4	45.000	5.774	(-----*------)
11	4	35.000	0.000	(-----*------)
12	4	33.750	4.787	(-----*------)
				---------+---------+---------+---------+

Using Duncan's test, groups are formed as follows:

- Group 1 = 33.75, 35, 37.5, i.e., employee nos. 1, 11, 12 are showing similar capacity.
- Group 2 = 41.25, 41.75, 42.5, 43.75, 45, 45, i.e., employee nos. 2, 3, 4, 8, 9 and 10 are showing similar capacity.
- Group 3 = 48.75, 50, 50, i.e., employee nos. 5, 6, 7 are showing similar capacity.

Table 3 Performance rating of employees

Target value	*Maximum achieved*	*Minimum achieved*	*Rating of employees*		
			Best	*Good*	*Fair*
Line 1 70 pairs/hour	72.5 pairs/hr.	61.875 pairs/hr.	Group 3	Group 2	Group 1
Line 5 (low production) 70 pairs/hour	50 pairs /hr.	33.75 pairs/hr.	Group 3	Group 2	Group 1

7.3.1 Summary of results in Lines 1 and 5 of stitching process

From Table 3, it is clear that there is a considerable gap in the target achieved in Lines 1 and 5. After having discussions with the middle management, it was found that the difference was due to differences in skill set of employees. Employees working in Line 1 were found to be more skilful than in Line 5. This emphasises on proper training and monitoring of all employees to meet the specific targets.

8 The improvement phase

In improvement phase, the general factorial design and Taguchi experiments were performed and the key influence factors of the optimal combination for cooling time, temperature, viscosity were obtained to analyse their effect on adhesive strength of the material used in the shoe-making process.

8.1 Taguchi's orthogonal array experiment to identify the significant factors

In the variance analysis in Table 5 using ANOVA, SS stands for sum of squares (factors) between groups and the sum of squares in the group (error). MS stands for sum of squares divided by the number of degrees of freedom of the mean square, F stands for test statistics, P stands for significance level, and the P value is smaller, the influence is more significant. When the general P value is less than 0.05, it just means the factor has a significant effect.

Table 4 Taguchi's L9 orthogonal array experimental design

No.	*Cooling time (s)*	*Temperature (Celsius)*	*Viscosity (kg/m.s.)*	*Adhesive strength (N/mm)*
1	300	120	50	4.07
2	300	121	52	4.56
3	300	122	54	5.6
4	350	120	52	4.77
5	350	121	54	5.6
6	350	122	50	5.77
7	400	120	54	5.71
8	400	121	50	6.07
9	400	122	52	6.28

Table 5 Analysis of variance

Source	*DF*	*Adj. SS*	*Adj. MS*	*F-value*	*P-value*
Cooling time (s)	2	2.44482	1.22241	53.90	0.018
Temperature (Celsius)	2	1.60542	0.80271	35.40	0.027
Viscosity (kg/m.s.)	2	0.30889	0.15444	6.81	0.128
Error	2	0.04536	0.02268		
Total	8	4.40449			

The ranks in a response table identify which factors have the largest effect. The factor with the largest delta value is given rank 1, the factor with the second largest delta is given rank 2, and so on. Thus, for the signal to noise ratios, factor 1 is ranked 1, followed by factors 2 and 3.

Table 6 Response table for signal to noise ratios

Level	*Cooling time (s)*	*Temperature (Celsius)*	*Viscosity (kg/m.s.)*
1	13.44	13.63	14.36
2	14.59	14.60	14.24
3	15.59	15.38	15.02
Delta	2.14	1.75	0.78
Rank	1	2	3

Note: Larger is better.

8.2 General factorial regression: mean adhesiveness versus cooling time (s), temperature (Celsius) and viscosity (kg/m.s.)

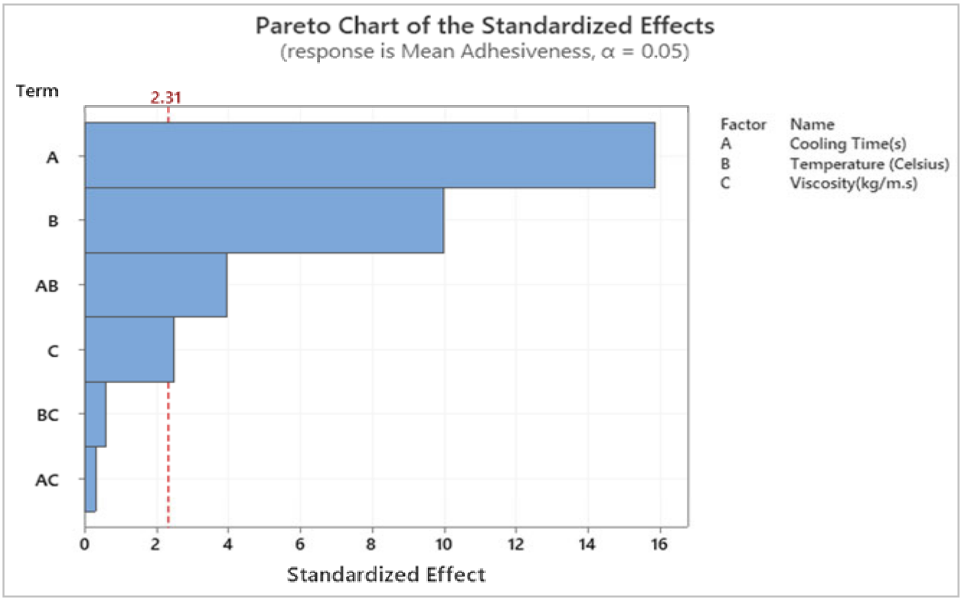
In the ANOVA table under Section 7.2, it is clear that interaction effect of cooling time and viscosity, temperature and viscosity is not significant, which is also evident from the signal to noise ratio rankings. Thus, cooling time and temperature have significant effect on adhesiveness. According to the factorial plot for mean adhesiveness, the optimal parameter combination is corresponding to factors A3, B3, C2, i.e., for 400 s cooling time, 122°C temperature and viscosity of 52 kg/m.s. and the same is shown by S/N ratio results.

Table 7 ANOVA table

Analysis of variance					
Source	*DF*	*Adj. SS*	*Adj. MS*	*F-value*	*P-value*
Model	18	12.3939	0.68855	30.07	0.000
Linear	6	11.4258	1.90430	83.15	0.000
Cooling time (s)	2	7.9884	3.99421	174.41	0.000
Temperature (Celsius)	2	3.2061	1.60306	70.00	0.000
Viscosity (kg/m.s.)	2	0.2313	0.11564	5.05	0.038
2-way interactions	12	0.9681	0.08068	3.52	0.041
Cooling time (s) * Temperature (Celsius)	4	0.8520	0.21300	9.30	0.004
Cooling time (s) * Viscosity (kg/m.s.)	4	0.0426	0.01064	0.46	0.761
Temperature (Celsius) * Viscosity (kg/m.s.)	4	0.0736	0.01839	0.80	0.556
Error	8	0.1832	0.02290		
Total	26	12.5771			

Model summary			
S	*R-sq.*	*R-sq(adj.)*	*R-sq(pred.)*
0.151332	98.54%	95.27%	83.41%

Figure 5 Pareto chart of the standardised effects (see online version for colours)



8.3 Recommended solution or action plan

1 To develop competencies at the individual level:
- Competencies are about indicators of performance at the work place. They describe a specific type of behaviour that is shaped by the individual's knowledge, skills, personality, values and motives.
- Competencies can provide a sound basis for describing, predicting and measuring performance and also for driving development and personal change.

2 There should be an appraisal system through which due recognition should be given to sincere and hard-working employees.

3 Training sessions to be held for all employees. For proper monitoring of workers, the other lower mgmt. level employees like supervisors, etc. should also be rated by the middle management.

4 Training of employees at all levels essential to improve the production.

5 Incentive schemes can be introduced to reward the efficient employees.

6 In practice, there is on-job-training for unskilled employees. This takes more than expected time to learn the process, e.g., there is a process called 'fitting of components', which requires special training in the respective area. If not possible to follow the method of formal training in the specialised areas, the skilled and efficient employees can be used to train these unskilled employees.

7 Weekly monitoring and analysis of output is necessitated.

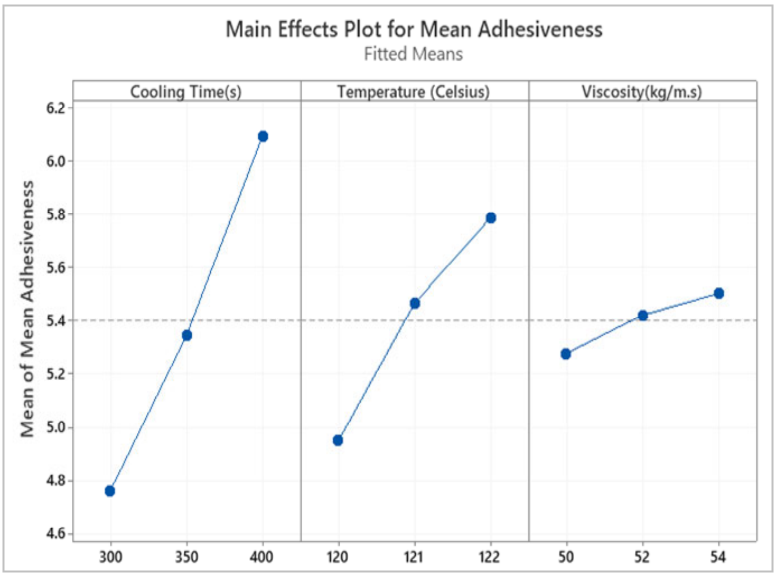
8 Employees should be trained in all kinds of operations. This is important when excess demand occurs for a particular shoe article.

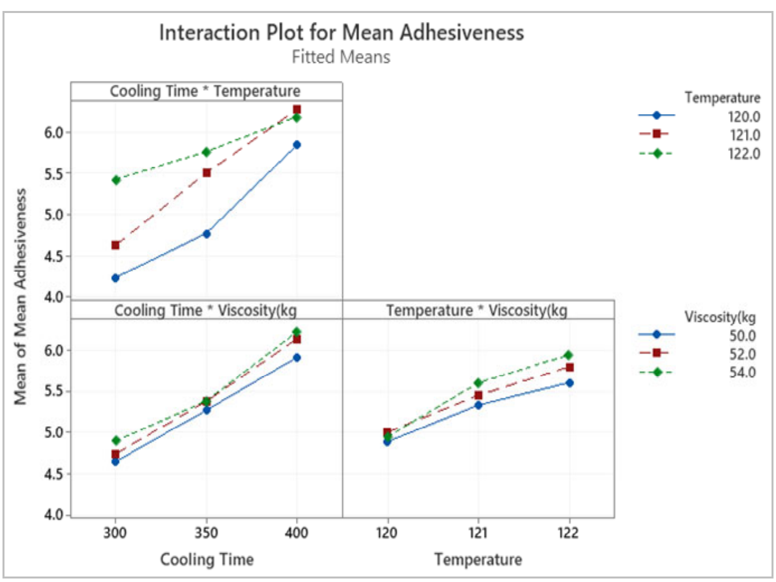
9 Human resources and production deptt. to conduct problem solving sessions.

10 Effective motivational methods to be used for employee satisfaction and increasing productivity.

11 The parameters cooling time and temperature must be maintained at optimum levels.

Figure 6 Factorial plots for mean adhesiveness (see online version for colours)





8.4 Competency framework for ABC India Ltd.

8.4.1 Manage self (individual contributor)

- achievement orientation
- align with company culture
- concern for quality
- initiative
- learning ability
- teamwork
- adopting professional standards
- communication
- execution
- integrity
- reliability.

Table 8 Impact of Six Sigma deployment on key business issues

Processes	• Improvement of existing processes to eliminate the cause of defects
	• Design new processes for the perfect successful launch
	• Lower costs and higher efficiency lead to more profits
	• Reduced costs and increased profits
Employees	• Empowered to change faulty processes and fix problems
	• Higher satisfaction and motivation
	• Increased efficiency and productivity
Customers	• Improve total customer focus
	• Better satisfied customers to get more business and loyal customers

The efforts have been made in the stitching and overall process to reduce the defects and improve the sigma level by a reasonably large value with the help of Six Sigma DMAIC process. However, further improvements in the process are subject to following the suggested recommendations and adhering to improve and control measures, e.g., training and rating of employees, daily/weekly analysis of output data, etc.

9 Control phase

There is a need to place high emphasis on the importance of devoting the same high level of energy and commitment throughout this phase. Leaving any loopholes in the process can result in the process reverting to the former performance levels and loss of some or all of the gains. Monitoring and controlling of the strategies recommended along with rigorous follow-up and corrective action with comprehensive yet simple documentation can increase the likelihood that the gains are sustained. The ultimate goal is to control the future state process to ensure that any deviations from target are corrected before they result in any defects.

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