Performance Variation with time of Apparel Sewing Workers: A Case Study

Mohammad Iqbal
Professor, Department. of Industrial and Production Engineering, Shahjalal University of Science and Technology, Sylhet-3114, Bangladesh
Mohammad Ali
Professor, Department of Industrial and Production Engineering, Bangladesh University of Textiles, Bangladesh.
Rezwanul Haque
Lecturer, Engineering (Manufacturing), Faculty of Science, Health, Education and Engineering. University of the Sunshine Coast, Australia.
Chowdhury Jony Moin
Ph.D. candidate, Department. of Industrial and Production Engineering, Shahjalal University of Science and Technology, Sylhet-3114, Bangladesh and Assistant Professor, Department of Textile Engineering Ahsanullah University of Science and Technology, Dhaka, Bangladesh.

Doi: 10.19044/esj.2018.v14n15p485 URL:http://dx.doi.org/10.19044/esj.2018.v14n15p485

Abstract

The purposes of this case study is to analyze and identify the variation of sewing workers' performance of the apparel industry with respect to working hours in a day and different working days; and find out possible solutions to overcome these variations. Data was collected following the theory of work study and then statistical hypothesis test such as two-way ANOVA was done to uncover the variations within the work station relative to working hours and working days and the variations were occurred in around 70% work stations whereas 53% stations faced variation in hourly only. Furthermore, the findings were analyzed by Delphi technique with a group of experts to identify the causes and the corresponding solutions. The Delphi experts group used a cause and effect diagram to identify the causes and finally suggested short-term and long-term solutions.

Keywords: Worker performance variation, Time-based, Apparel, Sewing

Introduction

The Textile and Clothing industry was the starter industry for export-orientated industrialization (Gereffi, 2002) and economical developed countries. Now with the advantages of globalization this industry shifted to developing countries. Apparel industries are labor intensive industries (Kim et al., 2006, McNamara, 2008, Mottaleb and Kalirajan, 2014) and a huge number of skilled and unskilled workers contribute for performing various operations. In labor intensive manufacturing, improvements in labor performance and productivity along with process and product quality are important for achieving the target goal (Banker et al., 2002). The meaning of performance of manufacturing industries can be stated in different ways but the most common aspects available in literatures are some indicators relating to productivity, outputs produced, revenue gained and share value of firms (Islam, 2011). Over the past few decades, tools and techniques for modeling and predicting human performance in complex systems have evolved and matured. In labor intensive manufacturing system Human Performance Variation (HPV) may cause variations on the system performance (Siebers, 2006). Different studies have been carried out on workers performance varying with different parameter. Literature shows that worker's performance variations are occurred due to workers' production task cycle times variation, attitude differences, manufacturing system design, food habit, family status, work–life balancing, different age variation, duty as shifting, fatigue, environment (such as temperature) etc. (Fletcher et al., 2008, Johnson et al., 1997, White et al., 2003, Reid and Dawson, 2001, Ahmad Rasdan, 2010). Besides the worker's performance variations; operational limitations such as lower working capacity of workforce, unfavorable working environment and poor R&D intensity and low process capability of manufacturing system are the causes of low productivity which leads industry towards poor performance (Islam and Hossairi, 2008). Labor and environmental standard such as child labor, health and safety features of workplace, working conditions and labor rights are interrelated for worker's performance (Kaur and Metcalfe, 2003). So, to improve the worker performance, identification of the responsible parameter for variation is obvious. This performance may be measured with quantity of output, quality of output, timeliness of output, presence/attendance on the job, efficiency of the work completed and effectiveness of work completed (Mathis and Jackson, 2011). Advanced of production planning, scheduling and simulation based models were also suffered for accuracy due to variations of the worker performance. This paper considers two time based parameters to investigate the performance of the workers- one is working hours, another is working days. The term worker's performance used here means how many parts he/she completed i. e. outputs in a given time (day and hour). This paper took advantage of statistical hypothesis testing heavily based on experimental data, two-way ANOVA (Lind et al., 2005, Walpole et al., 2007) to find out the variations within work station relative to working hours and working days for the most labor intensive sewing process of apparel manufacturing. After ANOVA the findings were analyzed by Delphi method (Loo, 2002, Saha and Roy, 2012), engaging eleven relevant field experts as members of Delphi group. A cause and effect diagram was used to identify the causes and their levels. Finally short-term and long-term solutions were suggested by the expert members of Delphi group.

Literature review

Awareness on the importance of employee performance and searching of ways for improvement of employee's performance to high level now become a concern for practitioners and academicians. Work measurement literature indicates clearly that workers' task performance varies in two ways - different workers doing the same task and same worker repeating a task (Dudley, 1968). For instant, different workers' task performance varies due to gender (Beck et al., 2012) age (Ng and Feldman, 2008) and learning curve effect for same worker repeating a task (Globerson, 1980). Again without presenting the data, a study claimed that analysis of variance (ANOVA) and t-test procedures show little or no significant effect on workers' production task performance for differences between time-related conditions, namely: shift, week, day of the week, hour of day, hour in shift (Fletcher et al., 2008). Literature shows that a number of variables influence on the employee performances at work place in different production and service oriented organizations. These can be simply affects in two ways- positively or negatively. Such as, financial rewards and trainings increase the performance whereas stress, working hours and communication barriers hold back the performance of the employees in banking sector (Iqbal et al., 2015). Study also shows that empowerment, transformational leadership, teamwork, and work environment are capable in improving the overall employee performance of hotel industry (Chei, 2014). A study on oil palm plantation in rural area in Malaysia for job performance among the employees where 72% plantation worker shows that stress, work environment, workload and pay are the determinant of job performance (Munisamy, 2013). Similar results were found in a survey on more than 3200 workers in Britain; showed that factors such as money, recognition and motivation played important role in the job performance of these employees (Bassett-Jones and Lloyd, 2005). A quantitative study reveals that there is positive and direct relationship between employee performance and organizational culture, job satisfaction, training and development and there is a negative relationship between employee performance and stress at the workplace (Hassan M. E. Aboazoum, 2015). A review study divided performance into task and contextual performance and revealed that transformational leadership, organizational justice, work engagement, and public service motivation have direct effects on both performance (Jankingthong and Rurkkhum, 2012). Study on occupational status and work–life flexibility for different types of job level such as upper, middle, and lower showed that the worker performance variation also influenced by different types of flexibility form (Kossek & Lautsch, 2018).

The stitching of components together i.e. sewing process is the most labor intensive task in apparel manufacturing (Cooklin, 2006, Park and Kincade, 2011). There are many factors that affect labor productivity. A study identified the factors and those were-Absenteeism of the employee, Working conditions of the units, Training facilities for the employees, Operator to helper ratio in the shop floor, Poor quality of raw materials and accessories, Frequent changes of styles, Technological changes in the field, Change from high volume to low volume orders, Usage of modern machines, Deviation from standard time in manufacturing and payment system (Shanmugasundaram and Panchanatham, 2011). Sewing process mainly work as assembly line and literature is also rich for improving the performance of apparel sewing section such as Line balancing by balancing work load to work stations (Chen et al., 2014), Financial reward like incentive systems (Bye et al., 2017, Shafiqul, 2013) Environmental of work place improvement (Samaranayake and De Silva, 2013), Ergonomic workstation design (Muhundhan, 2013), line layout (Islam et al., 2014). Integration of Continuous Improvement with existing lean production system helps to increase employees' performance at shop-floor (Wickramasinghe and Wickramasinghe, 2016). Operator utilization rate also varied for both push and pull production system due to lot size, order complexity, the selection of apparel production systems and so on (Mak et al., 2015).

Methodology

The study was conducted in an established apparel manufacturing industry (for sake of confidentiality the name of the companies has not mentioned) of a South Asian developing country. This study was done for a particular product, a basic T-shirt. The learning curve effect in basic T-shirt production line is comparatively less as this is the very common item to be produced in the RMG industry. The working hour in a day has been divided into 8 segments and outputs of each workstation have been taken. It was ensured that the same worker worked at each workstation for five days. Data for 5 days of the production line has been collected with the help of work study department of the industry.

Data Analysis and Results

Statistical analysis

The sewing line involved a set of workstation or workers in which a specific task in a pre-determined sequence is processed. The operations sequence of a basic T-shirt (Knit product) has been shown as in the table-1.

Table 1: Operation sequence of a basic T-shirt

Operation No.	Operation name	Operation No.	Operation name
1	Back and front part machining	10	Piping top stitching
2	Main label attaching	11	Sleeve hemming
3	Size label attaching	12	Sleeve matching
4	Shoulder Joint	13	Sleeve Joint
5	Shoulder top stitching	14	Arm hole top stitching
6	Neck/Rib rolling	15	Sleeve Truck
7	Neck/Rib joint	16	Side seam with care label
8	Neck top stitching	17	Bottom hemming
9	Neck piping		

Mean output of each workstation of different working hours has been calculated and shown in figure 1.

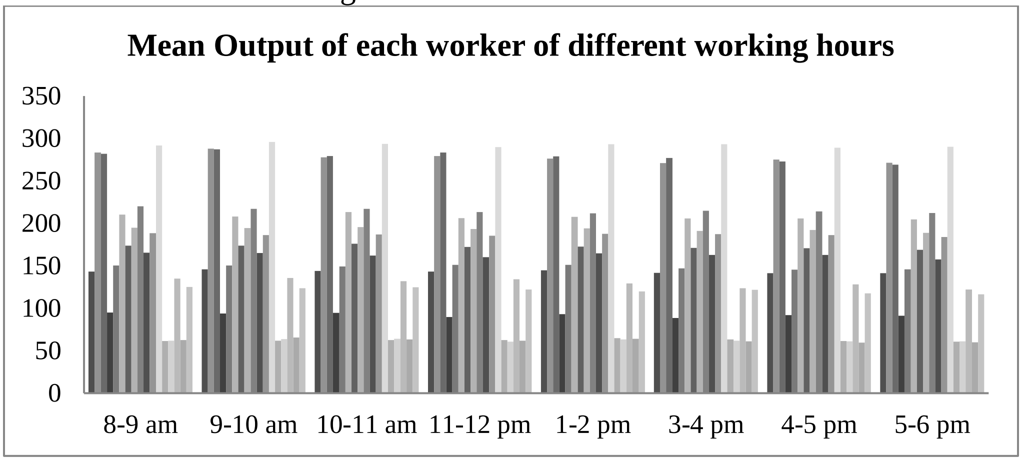

Figure 1: Mean Output of each workers of different working hours in a day

All data for each operation were tested for normality with Kolmogorov-Smirnov test (Mood et al., 1974) using Minitab® 16.1.1 software and found to follow the normal distribution for each operation. As an example the test result for Back and front part machining operation (first operation) is shown in figure 2.

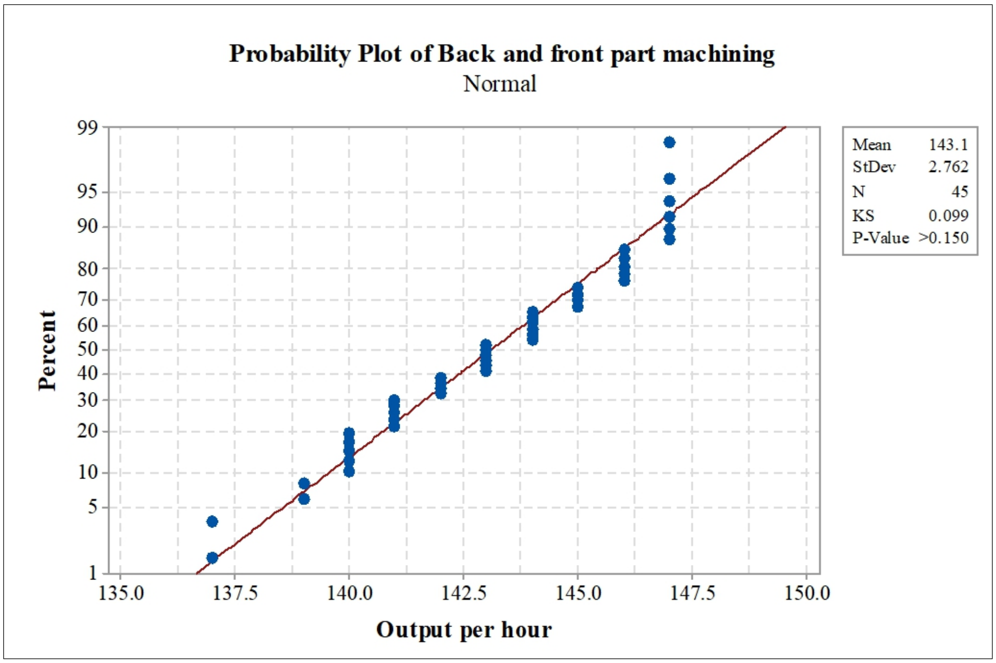

Figure 2: Normality graph for Back and front part machining operation

The two-way ANOVA has been conducted for each operation has been done using Microsoft Office Excel 2007 with the data analysis add-on. In two-way ANOVA, the following null hypothesis and alternative hypothesis were as follow:

1. H_0 = The treatment (Days) means were the same

   H_1 =The treatment means were not the same

2. H_0 = The block (Hours) means were the same

   H_1 =. The block means were not the same

The level of significance was considered 0.05.

For example, ANOVA result of the Main label attaching (second operation) is presented in Table 2.

Table 2: Two-way ANOVA for Main label attaching

Summary	Count	Sum	Average	Variance
Day 1	8	2213	276.625	128.2679
Day 2	8	2218	277.25	128.2143
Day 3	8	2218	277.25	123.3571
Day 4	8	2226	278.25	80.5
Day 5	8	2240	280	75.42857
Hour 1	5	1429	285.8	4.7
Hour 2	5	1397	279.4	145.3
Hour 3	5	1397	279.4	59.8
Hour 4	5	1430	286	17
Hour 5	5	1371	274.2	69.7
Hour 6	5	1371	274.2	159.7
Hour 7	5	1339	267.8	26.7
Hour 8	5	1334	266.8	141.7

ANOVA: Two-Factor for Main label attaching						
Source of Variation	SS	df	MS	Fcal.	P-value	F crit.
Days	136.35	4	34.0875	0.45328	0.769157	2.714076
Hours	1872.975	7	267.5679	3.557999	0.007342	2.35926
Error	2105.65	28	75.20179			
Total	4114.975	39				

The ANOVA result in Table 2 shows that the average number of production for Main label attaching is not varied with the working days as F-critical value is greater than F-calculated value. Whereas, for working hours, the F-calculated is greater than the F-critical value which indicates the average number of production is varied with the production hour. So, for this operation the production per hour i. e. worker's performance variation existed for working hours but not for working days.

Similarly the ANOVA was performed for all other operations and the final results of Two-way ANOVA have been summarized in Table 3 for worker's performance variation due to either working hours or working days or both.

Table 3: Two-way ANOVA analysis result summary

Operation no	Operation name	Variation in performance	
		Working Days	Working Hours
1	Back and front part matching	No Variation	No Variation
2	Main label attaching	No Variation	√
3	Size label attaching	No Variation	No variation
4	Shoulder Joint	No Variation	√
5	Shoulder top stitching	No Variation	√
6	Neck/Rib rolling	No Variation	√
7	Neck/Rib joint	No Variation	√
8	Neck top stitching	No Variation	√
9	Neck piping	No Variation	√
10	Piping top stitching	No variation	No variation
11	Sleeve hemming	√	√
12	Sleeve matching	√	√
13	Sleeve Joint	No Variation	No variation
14	Arm hole top stitching	No Variation	√
15	Sleeve Truck	No Variation	√
16	Side seam with care label	√	√
17	Bottom hemming	No Variation	No variation

From the Table 3, it is seen that in case of operation no. 2, 4, 5, 6, 7, 8, 9, 14 and 15 the performance of workers varies due to the number of hours other than number of days. For the operation number 1, 3, 10, 13 and 17 we observed that both the working hours and number of days has no effect on the workers' performance variation. In case of operation no. 11, 12 and 16 it is clearly seen that both the working hours and working days have effect in the variation of worker performance. The Table 4 shows the percentages of Number of Stations for different variation ways.

Table 4: Percentages of number of stations for different variation ways

Variation way	Number of Stations	%
Hourly only	9	52.9
Day wise only	0	0.0
Both way	3	17.6
No way	5	29.4

Implementation of Delphi technique

The experts of Delphi group were employed to identify the causes and their solution. The credentials of experts are shown in Table 5.

Table 5: Credentials of experts for Delphi Group

Sl. No.	Designation	No. of Members
1	Management personnel (production)	2
2	Supervisor (sewing line)	2
3	Skilled worker (sewing process)	2
4	Engineer (line balancing expert)	2
5	Trainer (sewing process)	2
6	Health expert (Doctor)	1

Cause-and-Effect Diagram by Delphi group

Experts group of Delphi technique prepared a Cause-and-Effect Diagram for worker performance variation in hourly, daily and both way and shown in figure 3.

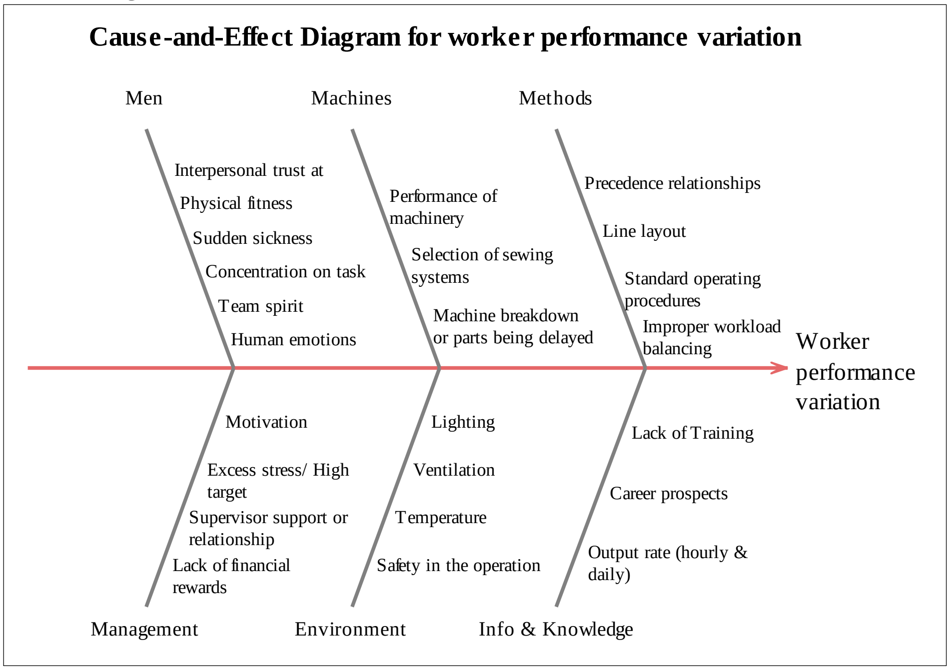

Figure 3: Cause-and-Effect Diagram for worker performance variation

The causes for worker performance variation in hourly, daily and both way were further analyzed by the experts and their opinions were summarized in Table 6. It shows that two causes were responsible for hourly worker performance variation only, whereas twenty one for both way (hourly and daily). The effect of one cause, Selection of sewing systems on worker performance variation in time based output rate was undefined.

Table 6: Levels, causes and time-based variation direction for worker performance

Levels	Causes	Variation direction
Men	Interpersonal trust at work	Both way
	Physical fitness	Both way
	Sudden sickness	Both way
	Concentration on task	Hourly
	Team spirit	Both way
	Human emotions	Both way
Machines	Performance of machinery	Both way
	Selection of sewing systems	Undefined
	Machine breakdown or parts being delayed	Hourly
Methods	Precedence relationships	Both way
	Line layout	Both way
	Standard operating procedures	Both way
	Improper workload balancing	Both way
Management	Lack of financial rewards	Both way
	Supervisor support or relationship	Both way
	Excess stress/ High target	Both way
	Motivation	Both way
Environment	Safety in the operation	Both way
	Temperature	Both way
	Ventilation	Both way
	Lighting	Both way
Information & Knowledge	Target rate of output (hourly & daily)	Both way
	Career prospects	Both way
	Lack of Training	Both way

Proposed solutions by Delphi group

After analysis and discussion the Delphi group suggested the solutions in dividing two ways; one for short-term improvement and another for sustain the improvement. Those are tabulated in Table 7.

Table 7: Strategies for improvement

Variations' direction	Strategies for short-term improvement	Strategies for sustain the improvement
Hourly only	Training Session break Supervision Hourly Visual workplace display Proper workload balancing	Training Supervision Build-up team spirit On time monthly or weekly wages payment Regular Medical checkup
Day wise only	Subjective Medical checkup Strategies (above) for hourly variation only	

Both way	Strategies for hourly only (above) and day wise (above) variation Method improvement	Overtime working hours not more than two No forced overtime working hours Simplify the task using working aids Employers benefits & incentives

Conclusion

The study established that the variation in performance for doing the same task by the same operator was happen in a basic T-shirt sewing line. The variations were occurred in around 70% work stations whereas 53% stations faced variation in hourly only. Delphi group of experts also agreed with 24 causes were responsible for the variations. Among these causes nearly 90% were responsible for hourly and daily performance variations. These variations may create inconsistencies in production planning, factory performance and as well as response to customers. Some operations management strategies like workload balancing, method improvement, team spirit, simplification of task along with training and supervision were the settled opinions by the experts for minimizing these hourly, daily and both way workers' performance variations.

References:

1. Ahmad Rasdan, I. (2010), "Influence of Wet-Bulb Globe Temperature (WBGT) Towards Workers' Performance: An Anova Analysis", in National Conference in Mechanical Engineering Research and Postgraduate Students (1st NCMER 2010), FKM Conference Hall, UMP, Kuantan, Pahang, Malaysia, 26-27 May 2010, Universiti Malaysia Pahang, pp. 435-441.
2. Banker, R. D., Devaraj, S., Schroeder, R. G. and Sinha, K. K. (2002), "Performance impact of the elimination of direct labor variance reporting: a field study", Journal of Accounting Research, 40**,** 1013-1036.
3. Bassett-Jones, N. and Lloyd, G. C. (2005), "Does Herzberg's motivation theory have staying power?", Journal of management development, 24**,** 929-943.
4. Beck, T., Behr, P. and Guettler, A., (2012), "Gender and banking: Are women better loan officers?", Review of Finance, p.rfs028.
5. Bye, E., Bye, E., Erickson, K. and Erickson, K. (2017), "Opportunities and challenges for Minnesota sewn product manufacturers", Research Journal of Textile and Apparel, 21**,** 72-83.

6. Chei, C.H., (2014), “Factors Affect Employees’ Performance In Hotel Industry”, Honors research project, Universiti Tunku Abdul Rahman, March.
7. Chen, J. C., Chen, C.-C., Lin, Y.-J., Lin, C. and Chen, T. (2014), “Assembly Line Balancing Problem of Sewing Lines in Garment Industry”, in Proceedings of the 2014 International Conference on Industrial Engineering and Operations Management, Bali, Indonesia, 2014, 7-9.
8. Cooklin, G. (2006), Introduction to clothing manufacture, Wiley-Blackwell.
9. Dudley, N. A. (1968), Work measurement: Some research studies, Macmillan London.
10. Fletcher, S., Baines, T. S. and Harrison, D. (2008), An investigation of production workers’ performance variations and the potential impact of attitudes. The International Journal of Advanced Manufacturing Technology, 35**,** 1113-1123.
11. Gereffi, G. (2002), The international competitiveness of Asian economies in the apparel commodity chain, Citeseer.
12. Globerson, S. (1980), Introducing the repetition pattern of a task into its learning curve. International Journal of Production Research, 18**,** 143-152.
13. Hassan M. E. Aboazoum, U. N., Mochammad Al Musadieq (2015), “Analysis Factors Affecting Employees Job Performance in Libya”, IOSR Journal of Business and Management (IOSR-JBM), 17**,** 42-49.
14. Iqbal, A., Ijaz, M., Latif, F. and Mushtaq, H. (2015), “Factors affecting the employee’s performance: A case study of banking sector in Pakistan”, European Journal of Business and Social Sciences, 4**,** 309-318.
15. Islam, M., Mohiuddin, H., Mehidi, S. H. and Sakib, N. (2014), “An optimal layout design in an apparel industry by appropriate line balancing: A case study”, Global Journal of Research In Engineering, 14, 5.
16. Islam, M. S. (2011), “Is R&D A Measure of Manufacturing Performance? Answer from Labor Intensive Industries”, in Proceedings of the 2011 International Conference on Industrial Engineering and Operations Management, 2011 Kuala Lumpur, Malaysia.
17. Islam, M. S. and Hossairi, A. (2008), “Technology Management: A Conceptual Frame Work for Bangladesh Economy”, Siddhant-A Journal of Decision Making, 8**,** 1-9.

18. Jankingthong, K. and Rurkkhum, S. (2012), "Factors affecting job performance: A review of literature", Silpakorn University Journal of Social Sciences, Humanities, and Arts, 12**,** 115-128.
19. Johnson, A. T., Dooly, C. R., Caretti, D. M., Green, M., Scott, W. H., Coyne, K. M., Sahota, M. S. and Benjamin, B. (1997). "Individual work performance during a 10-hour period of respirator wear", American Industrial Hygiene Association Journal, 58**,** 345-353.
20. Kaur, A. and Metcalfe, I. (2003) "South Asia—globalisation and Bangladesh: labour and environmental issues", South Asia: Journal of South Asian Studies, 26**,** 253-254.
21. Kim, J.-O., Traore, M. and Warfield, C. (2006), "The textile and apparel industry in developing countries", Textile progress, 38**,** 1-64.
22. Kossek, E. E., & Lautsch, B. A. (2018). Work–Life Flexibility for Whom? Occupational Status and Work–Life Inequality in Upper, Middle, and Lower Level Jobs. Academy of Management Annals, 12(1), 5-36.
23. Lind, D. A., Waite, C. A., Marchal, W. G. and Wathen, S. A. (2005), Basic statistics for business & economics, McGraw-Hill Ryerson.
24. Loo, R. (2002), "The Delphi method: a powerful tool for strategic management", Policing: An International Journal of Police Strategies & Management, 25**,** 762-769.
25. Mak, L., Wong, W. and Leung, S. (2015), "Analysis of Impacts of Production Order Complexity and Lot Size on Apparel Production Systems Using Simulation Technique", Research Journal of Textile and Apparel, 19**,** 70-84.
26. Mathis, R. L. and Jackson, J. H. (2011), Human resource management: Essential perspectives, Cengage Learning.
27. Mcnamara, K. (2008), "The Global Textile and Garments Industry: the role of information and communication technologies (ICTs) in exploiting the value chain", InfoDev. www. infodev. org/en/Document, 582.
28. Mottaleb, K.A. and Kalirajan, K.P., (2014), "Determinants of Labor-intensive Exports by the Developing Countries: A Cross Country Analysis", The Singapore Economic Review, 59,05, p.1450043.
29. Muhundhan, M. (2013), "Improved Work Station Design for Improved Productivity", International Journal of Scientific Engineering and Technology, 2**,** 225-227.
30. Munisamy, S. (2013), "Identifying factors that influence job performance amongst employees in oil palm plantation" Project Paper of Bachelor degree in Psychology, Open University Malaysia 2013.

31. Ng, T. W. and Feldman, D. C. (2008), "The relationship of age to ten dimensions of job performance", American Psychological Association, 93, 2, 392– 423.
32. Park, H. and Kincade, D. H. (2011), A historical review of environmental factors and business strategies for US apparel manufacturing industry 1973-2005. Research Journal of Textile and Apparel, 15**,** 102-114.
33. Reid, K. and Dawson, D. (2001), "Comparing performance on a simulated 12 hour shift rotation in young and older subjects", Occupational and Environmental Medicine, 58**,** 58-62.
34. Saha, G. and Roy, D. (2012), "Designing office shirt: an integrated approach", Journal of Fashion Marketing and Management: An International Journal, 16**,** 327-341.
35. Samaranayake, S. and De Silva, S. (2013), "Effect of green workplace environment on employee performance", International Conference on Sustainable Built Environment (ICSBE-2010) Kandy, 13-14 December 2010.
36. Shafiqul, M. I. (2013), "Labor incentive and performance of the industrial firm: A case study of Bangladeshi RMG industry", IOSR Journal of Business and Management (IOSR-JBM), 7**,** 52-63.
37. Shanmugasundaram, S. and Panchanatham, N. (2011), "Embracing Manpower for Productivity in Apparel Industry", International Journal of Innovation, Management and Technology, 2**,** 232.
38. Siebers, P.O. (2006), "Worker performance modeling in manufacturing systems simulation: proposal for an agent-based approach", Handbook of Research on Nature Inspired Computing for Economics and Management, Idea Group Publishing.
39. Walpole, R. E., Myers, S. L., Ye, K. & Myers, R. H. (2007), Probability and statistics for engineers and scientists.
40. White, M., Hill, S., Mcgovern, P., Mills, C. & Smeaton, D. (2003), "High-performance'Management Practices, Working Hours and Work–Life Balance", British Journal of Industrial Relations, 41**,** 175-195.
41. Wickramasinghe, D. & Wickramasinghe, V. (2016), "Effects of continuous improvement on shop-floor employees' job performance in lean production: the role of lean duration", Research Journal of Textile and Apparel, 20.