International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

# Coalesce of Automation and SMED to Enhance SUR–A Case Study

**Dr. R. Saravanan[1], K. Mothilal[2]**

[1]Principal & Professor, Department of Mechanical Engineering, Elenki Institute of Engineering and Technology, Hyderabad, Telungana State, India

[2]Assistant Professor, Department of Mechanical Engineering, Elenki College of Engineering and Technology, Hyderabad, Telungana State, India

**Abstract:** ***Globalization increases the customization of products. The firms produce a wide variety of jobs with smaller lot size to meet the requirements. The frequency of changeovers increases due to variety of lots involved. The Set-Up time Reduction (SUR) is a crucial factor to boost up the production rate and profit. Single Minute Exchange of Dies (SMED) is a powerful methodology and commonly encountered for SUR. Many works were reported to enhance SUR by combining SMED with other methods. This work deals with coalesce of automation and SMED to enhance SUR in a press shop. Ishikawa diagram plotted for deploying the possibilities for implementing SMED. Pareto analysis employed to identify the most influenced factors. Time study employed for measuring the setup activities. Engineering and technology employed for automation along with SMED methodology. Reduction of SUR achieved 52.4%, which enhance the net cost of effectiveness INR 4,78,820 per month.***

**Keywords:** Set-Up time, SUR, SMED, Automation, Time study, Pareto Diagram, Ishikawa Diagram

## 1. Introduction

Nowadays manufacturers are facing cut throat competition due to globalization. They need to produce the products in High variety with Low Volume (Hi-V Lo-V) with High Quality at Lowest Cost (Hi-Q Lo-C). This trend in manufacturing significantly increases the changeovers. The changeovers must be executed accurately with minimum time which enables them to respond to demand flexibly [1]. [2] Implemented six sigma approach in tool design, and tool parameter optimization and casted off the expansion plan. [3] Attempted cycle time reduction through the mechanization of production environment critical activities. [4] Redesigned the material handling equipment for improving productivity. But [5], [6] concluded that the reduction of setup time gives a huge speed on the process and it is most effective with Single Minute Exchange of Dies (SMED). The SMED is a method which has group of techniques. These techniques make it possible to execute the setup in single digit minutes, i.e., less than ten minutes [7]. [8] Highlighted that SMED/ One-Touch exchange of Die (OTED) contribution in Lean is inevitable to discard the waste and its role in lean also very significant. [9] Discussed about the method of analyzing and reduction of time needed in between the good part producing with illustration.

After experimenting SMED at an automobile industry, it was concluded that the classical tools like statistical analysis; chart analysis, etc. can be combined with SMED for obtaining very positive results [10]. Some of the interesting cases are discussed below. [11] Experimented with computerized methods in pick and place chip shooter machines. The computerized tools and information systems were employed in the feeder system to reduce the incremental set up time per feeder to 11 seconds from 67 seconds. [12] Achieved 33% reduction of the change over time of the welding cell through SMED. [13] Implemented SMED in an automobile industry and achieved a 20 % reduction of time in the bottle neck area and an additional 200 units/month production also achieved. [11] implemented SMED methodology in an automobile industry and achieved setup time reduction from 40 minutes to 12 minutes and improved production from 92200 pieces to 98080 pieces. [15] concluded after his experiments with punch press changeovers time reduction that SMED is an effective technique to not only reduce time in changeovers but also reduces the amount of direct labor required. [16] experimentally verified and reported that the SMED and its 57 powerful techniques to improve the ability of manufacturing organizations. [17] investigated the lean features in automated PCB manufacturing Unit and developed the Future Value Stream Map (FVSM) by using SMED, to effectively identify wasteful activities and production in Small and Medium Industries. [18] reported that SMED contributed in manufacturing improvement and also equipment development. [19] highlighted that SMED is a valuable approach to modern manufacturing and its improvements can be classified into three categories like mechanical, procedural and organizational improvements. Their experimentation was in the packaging industry. The distinction between the adjustments and settings were discussed in [20]. The prerequisites for SMED were furnished by [21] for Textile industry. [22] discussed about the identification of internal and external setups for enhancing the productivity by reducing adjustment times and setup change.

Furthermore the Decision making on SMED depending upon many factors. The [23] integrated SMED and Multiple Criteria Decision Making Technique (MCDM) to obtain greater system flexibility and improve its productivity. They involved the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), the Preference Selection Index (PSI) and the Analytical Hierarchal Process (AHP). This paper is unique and deals with combining automation and SMED methodology to achieve very positive results.

This article deals with reducing change over time of dies in press shop. Change over time can be defined as the time taken between last and next good part producing, including inspection and approval. The SMED methodology combined with automation technology for resolving the issue.

## 2. Materials and Methods

### A. Problem Overview

In the conventional method requires manual attention and involvement for the entire setup duration. Damage of the dies and the bed was experienced during changeover. The changeover times per product line observed and illustrated in Figure 1.

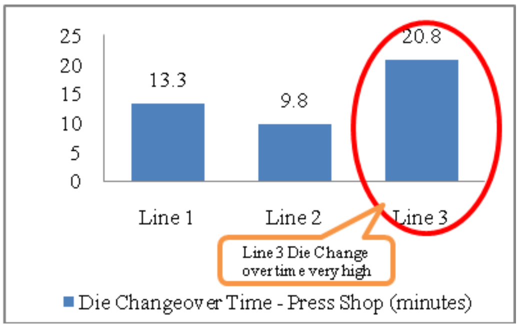


**Figure 1:** Line wise Changeover time (Before)

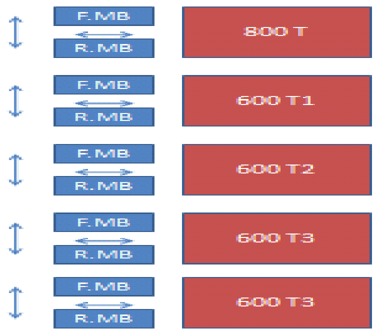


**Figure 2:** Layout of Line 3

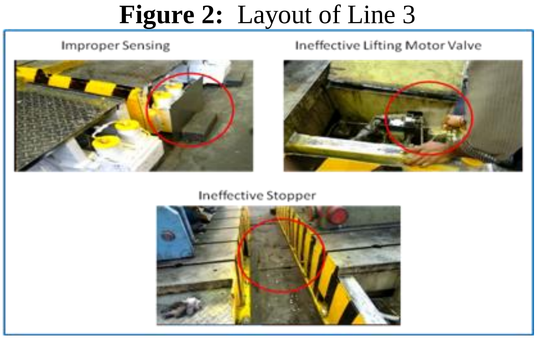


**Figure 3:** Improper sensing, ineffective method of lifting the motor valve, ineffective stopper

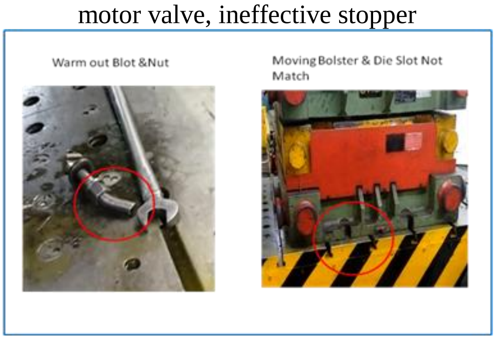


**Figure 4**: Worn out bolt and nuts (Left) die slot are not matched (right)

The line 3 consumes more time for changeover causes delay in production. Some of the common abnormalities were found in the line 3 (Figure 2). They are improper sensing, ineffective method of lifting the motor valve, ineffective stopper. (Figure 3), worn out bolt and nuts Moving Bolster and die slot are not matched (Figure 4)

### B. Novel Approach

Many approaches proposed earlier to solve the issue of SUR drastically. Here it was analyzed and adopted SMED with automation as an appropriate permanent solution for above discussed problem. According to the SMED concepts the target is to reduce the setup time to single digit minutes. The possibilities were deployed in Ishikawa Diagram (Figure 5). The setup and time consuming (in minutes) details are illustrated by help of a Pareto Chart in Table 1 and Figure 6 respectively. Based on these analyses and physical fact finding the problems were located in Moving bolster, Slide & Die cushion adjustment, Bolt & Nut clamp and de-clamping and Bolt & Nut worn out. Based on the brain storming method some of the corrective measures were proposed like Sensing type to be modified, Lifting Motor Valve to be changed, Track Stopper to be corrected, Damage wheel to be changed, Quick Parallel Clamp to be arranged, Unawareness for tool Shut Height, Die cushion Height & Die cushion Pressure and Time study to be done. Further the proposals were technically analyzed and made permanent corrective measures like Retro reflective Sensor was added , Motor valve was changed, Track Stopper was corrected, the wheel was modified and changed, Clamp was modified. The details of permanent corrective measures were illustrated well with photographs. The improper sensing (auto reflector - Before) was modified (Refer Figure 7) With retro reflective sensor (photo sensor - After). Conventional wheel has two guides with 5mm thicker rib at both ends. The modified wheels have additional guides (four guides) and 10 mm thicker ribs on both ends (refer Figure 8) For additional tracking accuracy. The track is also modified for additional guidance on wheels (Refer Figure 9). Conventional clamp is type, which was damaged more times during changeover, so universal clamp assembly is provided for easier change over with fewer damages (Figure 10). Manual Bolster Moving operation is automated with PLC (Programmed Logic Circuit) and its moving speed is controlled by Retro reflective Sensor. The PLC program is personalized for avoiding Moving Bolster Partial Lifting (refer Figure 11). After successful implementation of these modification time studies was carried out.

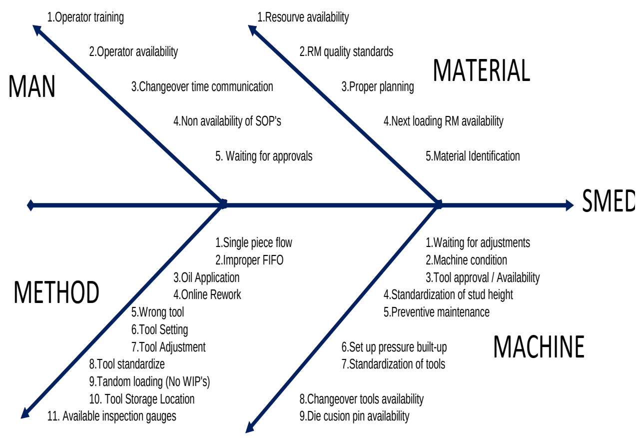


**Figure 5:** Fish Bone Diagram (Ishikawa Diagram)

**Table 1:** Tool Change Over Activity- Press Shop Line 3

| Tool Change Over Activities- Press Shop Line 3 (Jan-15) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| S.no | Elements/Activity | Internel | External | Time (Sec) | | | Action to taken | Responsibity | Remarks |
| | | | | Present | To be Eliminated | Proposed | | | |
| 1 | LOI completion | Y | | 12 | 5 | 7 | | operator | |
| 2 | Switch changing to inch mode | Y | | 2 | 0 | 2 | | operator | |
| 3 | Ram down to BDC | Y | | 2 | 0 | 2 | | operator | |
| 4 | Spanner searching &Taken | | Y | 10 | 0 | 10 | | CL1(Eliminate) | |
| 5 | Mesh guard opening | | Y | | 0 | 0 | | CL2 | |
| 6 | Nut loosened ( 8 nos) | Y | | 97 | 37 | 60 | 4 Top Nut&Bolt Only Loosened & Warm out Bolt &Nut to be replaced ,2spanner need for each side | Operator/CL 1 | R &S |
| 7 | Putting back the spanner & bolts in the place | | Y | | 0 | 0 | | Operator/CL 1 | |
| 8 | Ram up to TDC | Y | | 7 | 0 | 7 | | Operator | |
| 9 | MB 2 possition change | | Y | 0 | 0 | 0 | | Operator | |
| 10 | MB 1 declamping & lifting | Y | | 92 | 0 | 92 | | Operator | |
| 11 | MB1 moving out (X axis ) | Y | | 48 | 0 | 48 | | Operator | |
| 12 | MB1 down | y | | 189 | 169 | 20 | MB Sensor to be corrected | Operator | S |
| 13 | MB1 moving out (Y axis ) | y | | 20 | 0 | 20 | | Operator | |
| 14 | Switch changing MB1 to MB2 | Y | | 4 | 0 | 4 | | Operator | |
| 15 | MB 2 moving in (Y axis) | y | | 50 | 30 | 20 | MB Sensor to be corrected | Operator | S |
| 16 | MB 2 lifting | y | | 59 | 39 | 20 | MB Sensor to be corrected | Operator | |
| 17 | MB Track cleaning | | Y | 0 | 0 | 0 | This activity to be combined in MB Moving | CL1 | C |
| 18 | MB 2 moving IN (X axis) | Y | | 46 | 0 | 46 | | Operator | |
| 19 | MB clamping | Y | | 27 | 0 | 27 | | Operator | |
| 20 | Rod taken for aligning the die | | Y | 0 | 0 | 0 | | | |
| 21 | Aligning the die by rod | | Y | 0 | 0 | 0 | | | |
| 22 | Ram down to BDC | Y | | 3 | | 3 | | Operator | |
| 23 | Shut height adjusting | Y | Y | 128 | 88 | 40 | This activity to be combined in MB Moving &Proper Shut Hight to be display in Tool | Operator | C &S |
| 24 | Visual checking - Gap between tool top to ram | Y | | 0 | 0 | 0 | | Operator | |
| 25 | Die cushion on | Y | | 2 | 0 | 2 | | Operator | |
| 26 | Die cushion adjusting | | Y | 156 | 116 | 40 | This activity to be combined in MB Moving &Proper Die Cushion to be display in Tool | Operator | C&S |
| 27 | Top 4 Bolt tightning | Y | | 101 | 61 | 40 | Warm out Bolt &Nut to be replaced | Operator/CL 1 | S&R |
| 28 | Ram up to TDC | Y | | 4 | 0 | 4 | | Operator | |
| 29 | Moving to searching of waste | | Y | 0 | 0 | 0 | | CL 2 | |
| 30 | Die cleaning | Y | | 10 | 0 | 10 | | CL 2 | |
| 31 | bottoming adjusting | Y | | 65 | 45 | 20 | Proper Shut Hight to be display in Tool | Operator | S&R |
| 32 | Ram up & down to checking stroke | Y | | 30 | 0 | 30 | | Operator | |
| 33 | Bottom 4 Bolt tightning | | | 49 | 19 | 30 | Warm out Bolt &Nut to be replaced | CL1&2 | S&R |
| 34 | mesh guard closing | | Y | 0 | 0 | 0 | | CL2 | |
| 35 | MB 1 possition change | | Y | 0 | 0 | 0 | | Operator | |
| 36 | RM loading in table | | Y | 19 | 19 | 0 | Pre planned | FLT driver | E |
| 37 | RM packing removing | | Y | 0 | 0 | 0 | | CL 2 | |
| 38 | Putting the blank on the die &part production | Y | | 7 | 0 | 7 | | CL1 | |
| 39 | Component given to QC for checking | Y | | 3 | 0 | 3 | | Operator | |
| 40 | FOI completion | | Y | 4 | 0 | 4 | | Q/A | |
| | | Total time in (sec) | | 1246 | 628 | 618 | | | |
| | | Total time in (min) | | 20.8 | 10.5 | 10.3 | | | |

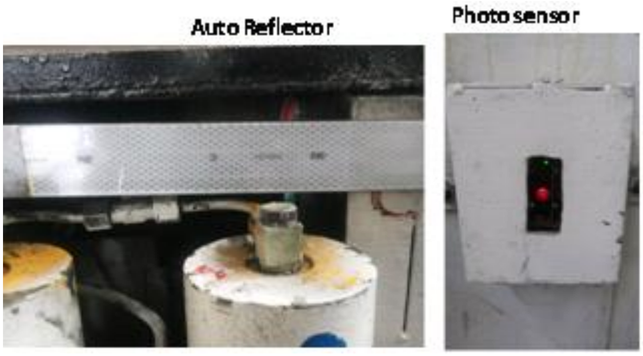


**Figure 7:** Before and After Kaizen illustration at Sensor issue area

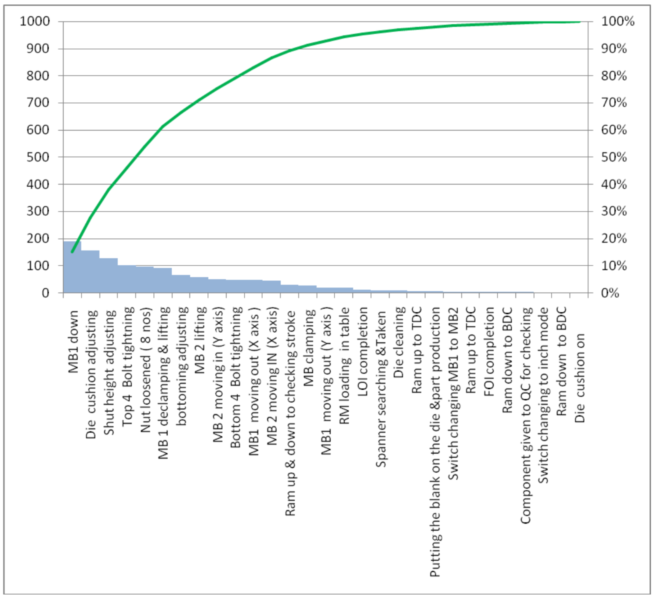


**Figure 6:** Pareto Chart


**Figure 8:** Wheel Modifications


**Figure 9:** Track Modification

**Figure 10:** Universal clamp


**Figure 11:** Manual (Before) and Automated (After) Moving Blaster

## 3. Results and Discussion

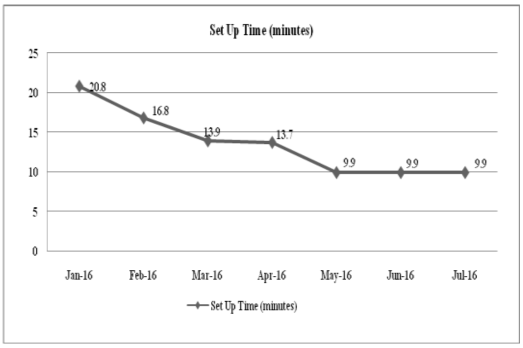


**Figure 12** Set-Up time Reduction (SUR) – Before –After and Sustainment status

Table 2 Micro Level Cost Effectiveness (Profit)

| | Shift | | | Day | | |
|---|---|---|---|---|---|---|
| | Before | After | Saving | Before | After | Saving |
| 800T | 13360 | 14100 | 740 | 37435 | 39335 | 1900 |
| 600T1 | 13150 | 14050 | 900 | 37270 | 39155 | 1885 |
| 600T2 | 13135 | 13485 | 350 | 37190 | 38800 | 1610 |
| 600T3 | 13075 | 13425 | 350 | 37145 | 38710 | 1565 |
| 400T | 13060 | 13410 | 350 | 37095 | 38450 | 1355 |
| TOTAL | 65780 | 68470 | 2690 | 186135 | 194450 | 8315 |

Table 2 Macro Level Cost Effectiveness (Profit)

| | Week | | | Month | | |
|---|---|---|---|---|---|---|
| | Before | After | Saving | Before | After | Saving |
| 800T | 226860 | 236120 | 9260 | 1048180 | 1101380 | 53200 |
| 600T1 | 223320 | 234415 | 11095 | 1043560 | 1096340 | 52780 |
| 600T2 | 221460 | 233990 | 12530 | 1004130 | 1125200 | 121070 |
| 600T3 | 218760 | 233830 | 15070 | 1002915 | 1139845 | 136930 |
| 400T | 216330 | 233350 | 17020 | 1038660 | 1153500 | 114840 |
| TOTAL | 1106730 | 1171705 | 64975 | 5137445 | 5616265 | 478820 |

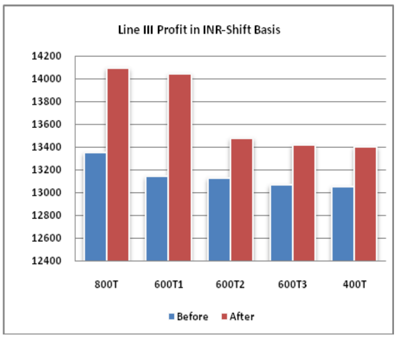


**Figure 13** Machine wise Cost Effectiveness per Shift

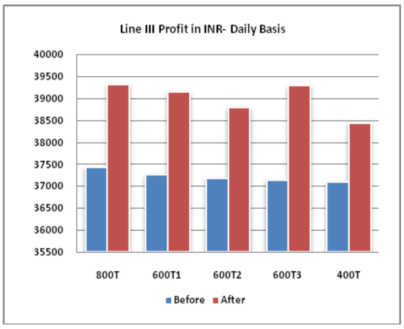


**Figure 14** Machine wise Cost Effectiveness per day

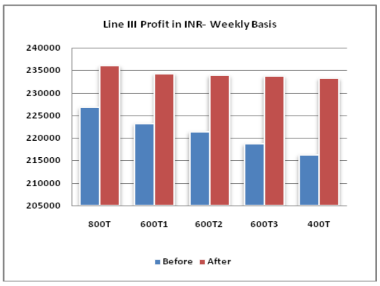


**Figure 15** Machine wise Cost Effectiveness per Week

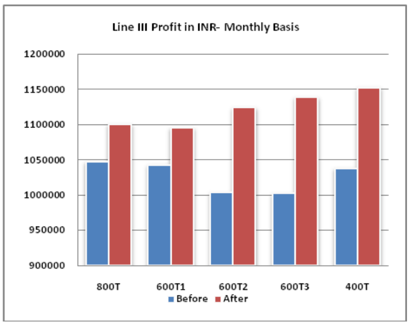


**Figure 16:** Machine wise Cost Effectiveness per month

Initially the setup time is 20.8 per change over and stepping down gradually during the execution of SMED after that it is sustained for 9.9 minutes (refer Figure 12). Hence the setup time reduction achieved 52.4% from the benchmark. This effect in production very significantly. The benefits were computed in terms of INR and tabulated in Table 2 and Table 3 for micro and macro levels respectively, and those results are depicted graphically illustrated in Figure 13 to Figure 16.

## 4. Conclusion

The SUR reduction to single digit is achieved by executing the SMED methodology with Automation and illustrated the same with a case study. The executed method increased flexibility of production, facilitates quick response in planning within available capacity, facilitates Smaller Batch Sizes, facilitates sequential production and reduced cycle time of production and hence increased cost of earning from 51,37,455 INR to 56,16,265 INR per month. Employee morale and motivation increased. Manpower used for additional works due to automated setups.

## References

[1] R.I. McIntosh, S.J. Culley, A.R. Mileham, and G.W. Owen, “A critical evaluation of Shingo’s ‘SMED’ (Single Minute Exchange of Dies) methodology, International Journal of Production Research, 38 (11), pp. 2377-2395, 2000.

[2] T Gopalakrishnan and R Saravanan, “Cast Off expansion plan by rapid improvement through Optimization tool design, Tool Parameters and using Six Sigma’s ECRS Technique”, IOP Conf. Series: Materials Science and Engineering, 183, doi:10.1088/1757-899X/183/1/012016, 2017.

[3] C Gnanavel, R Saravanan, M Chandrasekaran and R Pugazhenthi, “Case Study of Cycle Time Reduction by Mechanization in Manufacturing Environment”, IOP Conf. Series: Materials Science and Engineering 183, doi:10.1088/1757-899X/183/1/012023, 2017.

[4] C Gnanavel, R Saravanan, M Chandrasekaran and J J Jayakanth, “Improvement of Productivity in TIG Welding Plant by Equipment Design in Orbit”, IOP Conf. Series: Materials Science and Engineering 183, doi:10.1088/1757-899X/183/1/012020, 2017.

[5] Antonio Carrizo Moreira, Gil Campos Silva Pais, “Single Minute Exchange of Die:-A Case Study Implementation” Journal of Technology Management and Innoviation, 6(1), pp29-46, March, 2011.

[6] António Carrizo Moreira and Pedro Manuel Torres Garcez, 'Implementation of the Single Minute Exchange of Die (SMED) Methodology in Small to Medium-sized Enterprises: A Portuguese Case Study", International Journal of Management, 30(1), pp.66-87, March 2013.
[7] S. Shingo, A revolution in manufacturing. The SMED System, productivity Press, Cambridge, MA; pp. 12-14, 1985.
[8] R.Sundar, A.N.Balaji, R.M.SatheeshKumar, "A Review on Lean Manufacturing Implementation Techniques", Procedia Engineering, 97, pp.1875 – 1885, 2014.
[9] Berna Ulutas, "An application of SMED Methodology", World Academy of Science, Engineering and Technology, International Journal of Mechanical, Aerospace, Industrial, Mechatronic and Manufacturing Engineering, 5(7), pp.1194- 1197, 2011.
[10] Ana Sofia Alves, Alexandra Tenera, "Improving SMED in the Automobile Industry: A case study", Proceedings of production and operation management society 20th annual conference, Orlando, Florida U.S. May, 2009.
[11] Sheri Coble Trovinger, Roger E. Bohn, "Setup Time Reduction for Electronics Assembly: Combining Simple (SMED) and IT-Based Methods", Production and Operations Management, 14(2), pp.205–217, June 2005.
[12] Pablo Guzmán Ferradás, Konstantinos Salonitis, "Improving changeover time: a tailored SMED approach for welding cells", Procedia CIRP, 7, pp.598 – 603, 2013.
[13] Rahul.R.Joshi, G.R.Naik, "Application of SMED Methodology-A Case Study in Small Scale Industry", International Journal of Scientific and Research Publications, 2(8), pp.243-246, August, 2012.
[14] B.Suresh Kumar and S. Syath Abuthakeer, "Implementation of Lean Tools and Techniques in an Automotive Industry", Journal of Applied Sciences, 12 (10), pp.1032-1037, 2012.
[15] T.B. Michels, "Application of Shingo's Single Minute Exchange of Dies (SMED) methodology to reduce Punch Press Changeover Times at Krueger International", Thesis, University of Wisconsin-Stout, 2007.
[16] M. Sivasankar, N.Dhanadapani, S. Manoj kumar, N.Karthick, K.Raja, J.Yuvaraj, "Experimental Verification of 'Single Minute Exchange of Dies (SMED)", Recent research in Science and Technology, 3(3), pp. 92-97, 2011.
[17] Amir Azizi, Thulasi a/p Manoharan, "Designing a Future Value Stream Mapping to Reduce Lead Time using SMED-A Case Study, 2nd International Materials", Procedia Manufacturing, 2, pp.153–158, 2015.
[18] M.Cakmakci, "Process Improvement: Performance Analysis of the setup time reduction – SMED in the automobile Industry", International Journal of Advanced Manufacturing Technology, 41, pp.168-179, 2009.
[19] B.Kayis, S. Kara, "Set-Up Reduction in Injection Moulding Process: A case study in Package Industry", Proceedings of 4th International Conference and Exhibition on Design and Production of Machines and Dies/molds, Cesme Turkey, 2007.
[20] S .Patel, P.Shaw, And B.G. Dale, "Set-up Time Reduction and Mistake Proofing Methods: A study of application in a small company", Business Process Management Journal, 7(1), pp.65-75, 2001.
[21] C.Moxham, R. Greatbanks, "Prerequisites for the implementation of the SMED methodology: A study in the textile processing environment", International Journal of Quality & Reliability Management,18(4), pp. 404-414, 2001.
[22] R.M. Warkhedkar, M.S.Desai, "Productivity Enhancement by reducing adjustment time and setup change" International Journal of Mechanical Engineering & Industrial Engineering, 1(1), pp. 37-42, 2011.
[23] Mohammed Ali Almomani, Mohammed Aladeemy, Abdelhakim Abdelhadi, Ahmad Mumani, "A proposed approach for setup time reduction through integrating conventional SMED method with multiple criteria decision-making techniques", computer and industrial engineering, 66, pp.461-469, 2013.

## Author Profile

**Dr.R.Saravanan** is Principal and Professor of Mechanical Engg. at Ellenki Ins. of Engg. and Tech. (ELLIET).He acquires all his degrees at nationally ranked institutions in India.He possesses mammoth experience in Teaching, Research and Industries. His area of research includes Composite Materials, Material processing, Manufacturing, Design, Automobile and Manufacturing Management.

**Er.K.Mothilal** is an Assistant Professor in the Department of Mechanical Engineering at Ellenki College of Engineering and Technology, Hyderabad, India. His current research area is Industrial Engineering.