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OPTIMIZATION OF CYCLE TIME IN HYUNDAI MOTORS INDIA LTD

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Abstract

This paper sheds light on the application of quality control tools to reduce Cycle time (including Weld time and Squeeze time). Successive use of these tools identifies and addresses the weakness and leads to improved processes. These tools address the problems in logical and sequential manners which are easy to observe and interpret result. The main *gist of this paper is to achieve the target cycle time of body build line. Cycle time includes process time, during which a unit is acted upon to bring it closer to an output. Every production line always has a target cycle time. With the collected data it was found that cycle time was higher than the target cycle time, so it needed to be optimized. There are lots of factors which are to be eliminated in order to achieve the target cycle time. The root cause of the factors affecting the target cycle time was observed using quality improvement tools known as the Ishikawa diagram or the 'Fish Bone Diagram'.*

Keywords

Cycle time, Weld time, Squeeze time

1. Introduction

Hyundai Motor India Ltd (HMIL) is a wholly owned subsidiary of Hyundai Motor Company (HMC).HMIL is the largest passenger car exporter and the second largest car manufacturer in India. It currently markets, nine car models across segments – in the A2 segments it has the Eon, i10, Grand i10, i20, Elite i20 and i20 Active, in the A3 segments it has Fluidic Verna, in the A4 segments it has Elantra, in the A5 segments it has Sonata and in SUV segment it has Santa Fe, Creta. HMIL's fully integrated state-of-the-art manufacturing plant near Chennai boasts of advanced production, quality and testing capabilities. It currently exports to more than 120 countries across Africa, Middle East, Latin America and the Asia Pacific regions. In its commitment to provide customers with cutting-edge global technology, HMIL set up a modern multi-million-dollar R&D facility in Hyderabad. The R&D Centre endeavors to be a Centre of excellence in automobile engineering. By exporting the 1,000,000th car in February, 2010, HMIL becomes the 'Fastest' Indian Passenger car manufacturer to achieve this stupendous milestone. Since inception of Hyundai Motor in India, it has become the leading exporter of passenger cars with a market share of 48% of the total exports of passenger cars from India, making it a significant contributor to the Indian Automobile Industry. Recently HMIL has been producing a car in every 72 seconds of the time interval.

Squeeze Time is the time interval between the initial application of the electrode force on the work and the first application of current. Squeeze time is necessary to delay the weld current until the electrode force has attained the desired level. It requires 20 cycles for one spot welding. Weld time is the time during which welding current is applied to the metal sheets. Hold time is the time, after the welding, when the electrodes are still applied to the sheet to chill the weld.

Cycle time is the total time from the beginning to the end of your process, as defined by you and your customer. Cycle time includes process time, during which a unit is acted upon to bring it closer to an output, and delay time, during which a unit of work is spent waiting to take the next action.

Every manufacturing company will have target cycle time within which the manufacturing line has to be maintained. The target cycle time to be maintained here is 65 seconds.

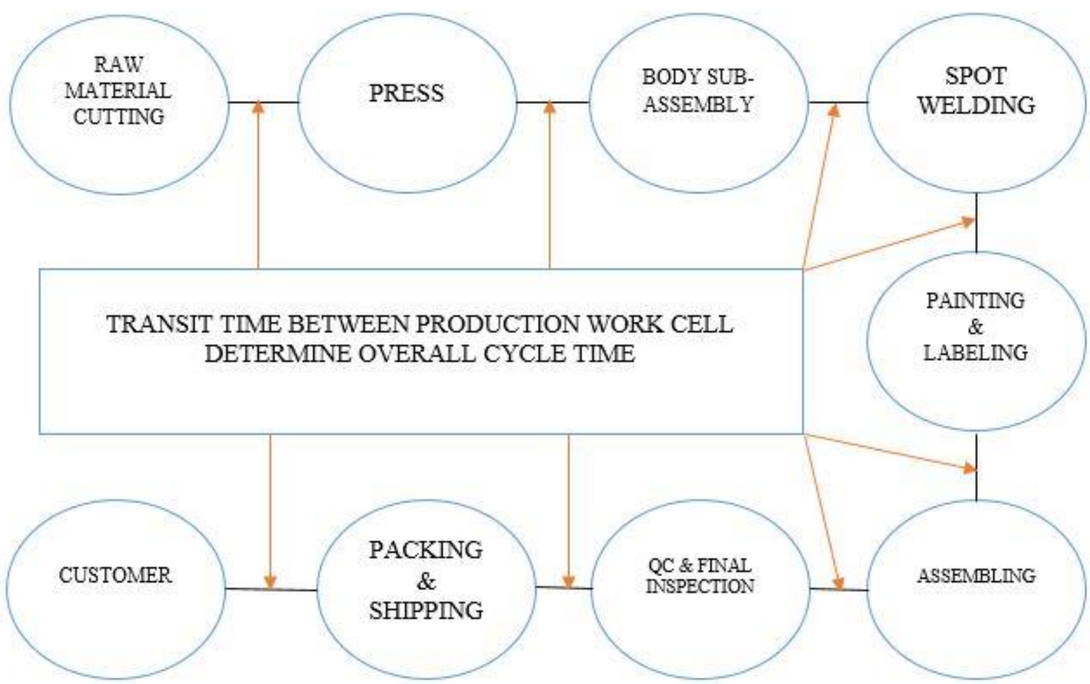

Figure 1: *Manufacturing Process Plant Layout*

2. Literature Review

In order to meet global competition, companies are in need of improving their product development and process, this can be done by applying Lean Philosophy; which focuses on reducing waste & increasing its value at the same time (TQM). Lean eliminates waste by optimizing processes to improve efficiency & minimizing production time rather than focusing on the traditional approach of rework & scrap reduction (Cooper, Keith & Macro, 2007) [4]. According to Russel & Taylor, 1999waste is anything (equipment, effort, resource, parts, space & time) which is present in surplus [12]. The lean perspective of waste of time includes; wait time, idle time & resources, over processing, over production, downtime, unnecessary motion (Huskins, 2007; C.K & M, 2007) [11]. According to Varun Dixit & Y.P Aggarwal, Lean Philosophy is implemented in a manufacturing system by using several Lean Tools and principles in a concurrent manner [13]. The benefits of following Lean perspective over conventional approach are- good quality products at relatively low production cost (Fleischer & Liker, 1997) [7]. (Neeraj, Ratnadeep and Sam, 2014) in their research represented that every automobile industry is adapting new processes and techniques of assembly that will optimize the assembly process and reduces assembly time [9]. The research of (Praveen, Deepak and Manoj, 2015) describes that VSM (Value Stream Mapping) is used to know the flow of information from the customer to the company for a product and also there is a reduction in the production lead time with the help of VSM [10]. (Ajit, P.C. Mishra, B.C. Routra and Amitabha, 2012) in their research describes that reduction of lead time can be controlled as the lead time is reduced the loss caused due to stock out can also be reduced [1]. (Mushtaq, Praveen, Sajid and Dr. Vivek, 2014) in their research represented that in manufacturing or automobile industry the process of cycle time can be reduced by increasing process at one work unit [8]. Manufacturing layout parameters affect manufacturing system functioning like total process cycle time. Reduction in production cycle time contributes to lower cost of an item (Hiten & Sanjay, 2014) [3]. There is always a progressive attempt to make stronger and lighter body automobiles by incorporating metallurgical properties of metals with latest technologies like forming technologies, welding technologies, etc. (Matsushita, Taniguchi & OI Kenji, 2013)

[6]. Welding process disturbance influences the stability of the welding arc. Welding parameters and metallurgical reaction in the arc and welding pool and affect the weld metal. Welding arc absorbs most of the products generated by welding arc. Welding parameters depend on the potential of ionization which further depends on chemical composition of welding arc stream (K Lukas & Z Rymarski, 2006) [5]. The electrode force during welding can be controlled with the use of servomechanism. Variation in electrode force during welding affected the resistance joule heating and welds nugget growth. The weld failure mode also varied with different force profiles (Aravinthan & Abdul, 2014) [2].

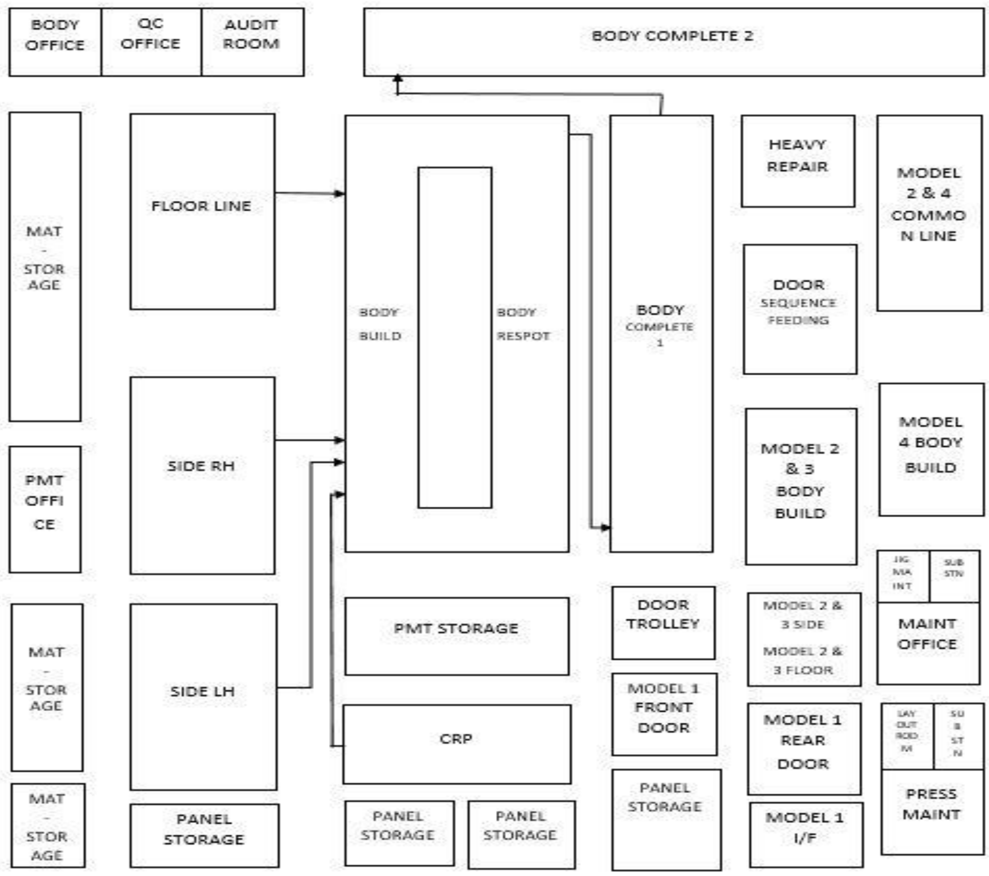

Figure 2: *Layout of Body Shop*

3. Research Methodology

Time studies for a Target cycle time was determined by quantitative analysis. At various points on the shop floor the data was collected from users/operators, engineers, project managers and through observation and record analysis.

Now the observed data is further analyzed and various factors are stated in Fishbone diagram, then the possible causes of these factors are determined and the causes which have greatest effect is optimized for achieving overall target cycle time.

The following are the objectives for further analysis of the data:

- To optimize the process cycle time
- To minimize the cycle time/to achieve target cycle time

3.1 Problem Identification

It is observed that the target cycle time of the body build & respot line (62seconds) is not maintained for all the combination of BIWs (Body In White) and is found to be 10 seconds higher, which affects the overall production time and rate.

3.2 Causes of Problem

Some of the important parameters to be considered for cycle time study are:

- Unwanted process elimination
- Simultaneous process elimination
- Equipment motion optimization
- Weld quality factors

3.3 Root Cause Identification

The factors influencing the cycle time delay are recognized using the quality improvement tool called as "Fish bone diagram". This diagram is also called as cause and effect diagram. In this diagram, the root cause of the problem can be identified. The data taken which are required for the study and the cause and effect diagram is drawn.

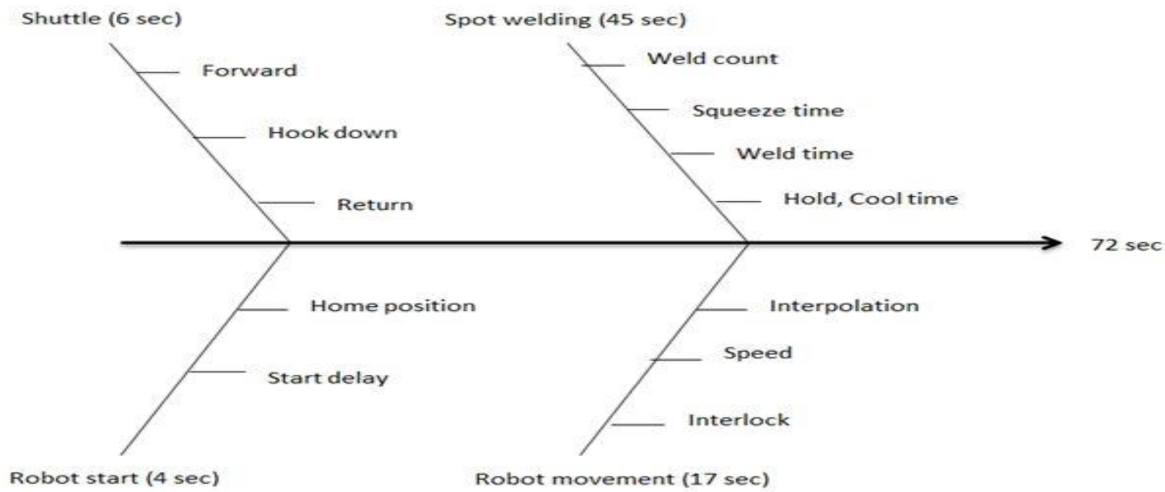

Figure 3: *Fish Bone Diagram before Optimization*

Data required for the optimization of all these factors are taken in different cycles. In one single line usually BIWs (Body in White) of two model cars are made. So data are taken for all the models in different combinations. Initially the cycle time of the line is taken for all the four models in different combinations and it was found to be higher than that of target cycle time. The factors that affect the cycle time management are to be recognized and iteration process should be carried out for optimization.

The encircled parameters are the small issues which can be rectified to achieve the target cycle time. This chart is used under the 80-20 principle. According to that principle, 80% of major issues are solved when the 20% of minor issues are rectified. The merge problems are identified from the Ishikawa diagram and is mentioned below.

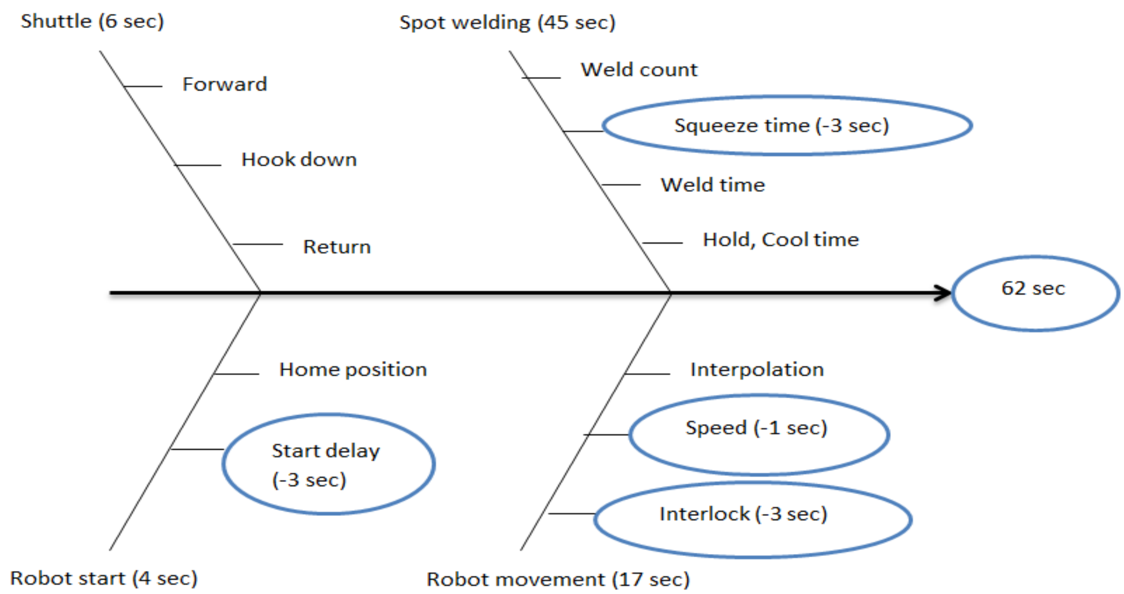

Figure 4: *Fish Bone Diagram after Optimization*

3. Solutions

4.1 Unwanted Process Elimination

- **Observation:** It was observed that the robot moves from its home position only after the complete movement of the shuttle. The robot remains in its home position until the shuttle stops its motion.
- **Rectification:** There is an idle time of 3 seconds in this process. The robot starts moving from its home position only when the shuttle completes its motion from one station to another station. This can be rectified by programming the robot in such a way that it moves from its home position to a non-interference position or ready position as the shuttle starts moving. By implementing this the idle time 3 seconds comes under the motion of the shuttle. Thus the cycle time is reduced up to 3 seconds by implementing this method.

From the below shown diagram it is clearly evident that the robot possesses the idle time of 3 seconds and it is rectified by re-programming the robot to move simultaneously with the shuttle. Thus 3 seconds are reduced in cycle time. Cycle time changes from 72 seconds to 69 seconds.

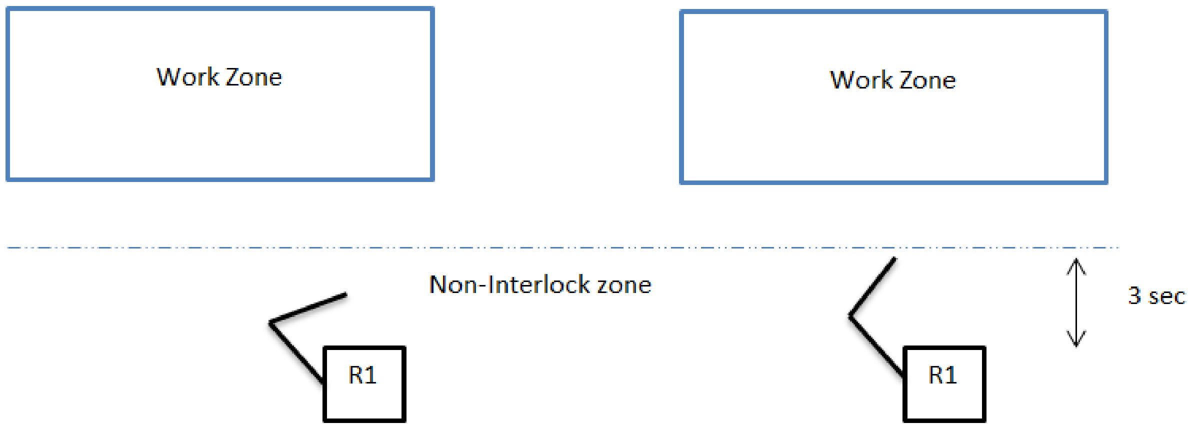

Figure 5: *Unwanted Process Elimination*

4.2 Simultaneous Process Enhancement

- **Observation:** It was observed that when a robot has to work in the working area of another robot, it stands still till the other robot completes the work. So, there is an increase in cycle time which needs to optimize.
- **Rectification:** It was observed that there is an idle time of 3 seconds when two robots have interlocking zone. Due to this the simultaneous working of robots is not possible. This is rectified by changing the path of both the robots in such a way that both moves in a similar direction without having any interlocking zone.

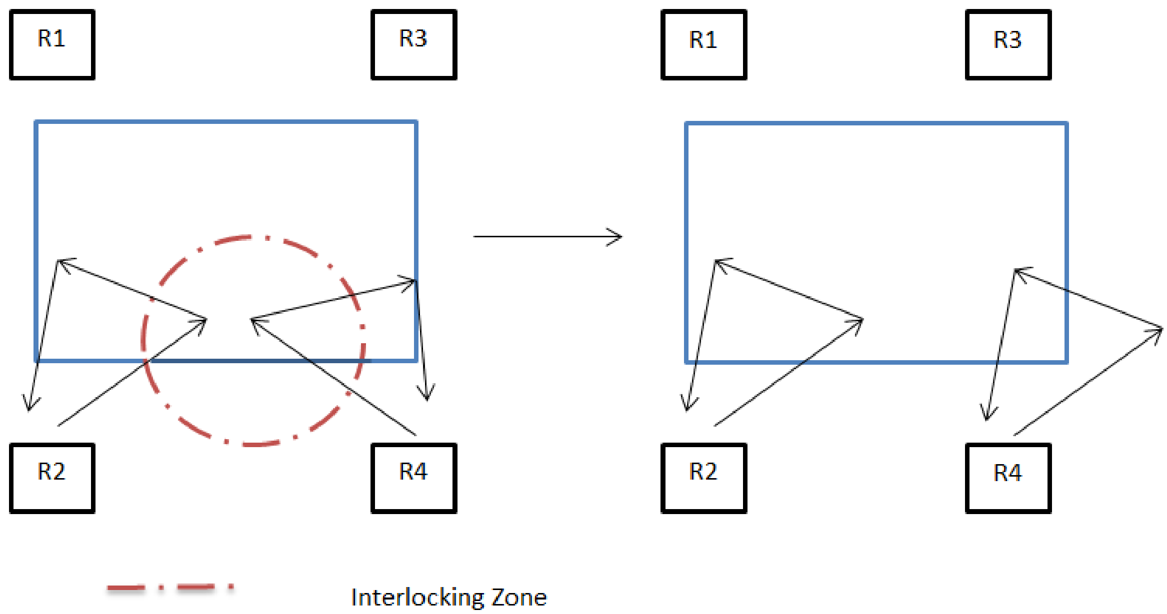

Figure 6: *Simultaneous Process Enhancement*

By implementing this, there is a reduction in cycle time up to 3 secondsand the cycle time changes from 69 seconds to 66 seconds.

4.3 Equipment Motion Optimization

- **Observation:** Designates movement speed of the tool end. Units are mm/Sec, cm/min, Sec and %. A Sec designates speed at movement time, and a % is rated at maximum speed. The maximum speed of a robot depends with respect to its end effector speed and the robots specialization. The maximum speed of the robot will be automatically calculated in the controller according to the position or acceleration or deceleration parameters.
- **Rectification**: Usually the maximum speed of the robot is not implemented on it for safety reasons. Only 75% of the speed are implemented. The speed in turn depends on the type of work to be done. Hyundai robots are meant for certain specifications. For the step forward/backward activities, special keys are used to adjust the speed by the unit of 50mm/s within the range from 50mm/s to 250mm/s. The maximum speed for the robot tool and link

will be restricted below the set speed. By maintaining the safe speed level of robots, cycle time up to 2 seconds is reduced.

The path of the robots is traced and the path which is involved in welding are given only 75% of the speed of the robot and the idle motion are given 100%speed of the robot. The idle motion is the safest zone where the speed of the robot can be increased thus decreased the cycle time.

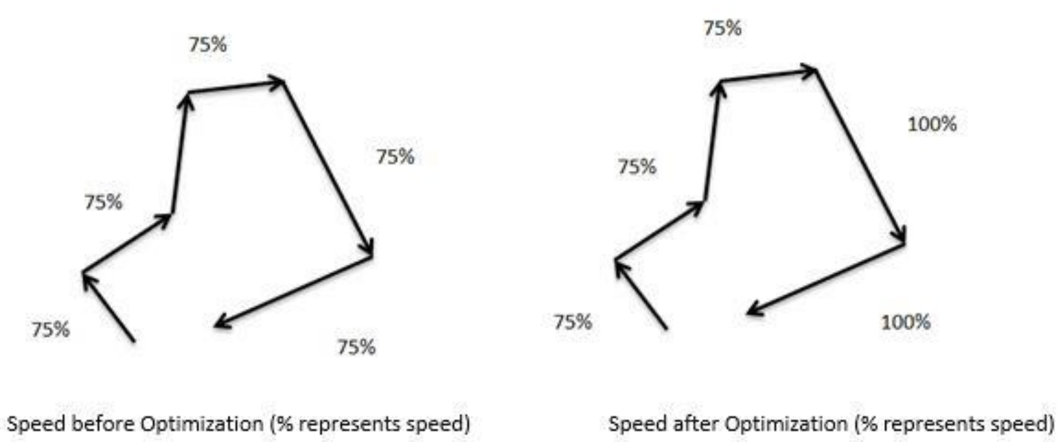

Figure 7: *Equipment Motion Optimization*

By increasing the speed of the robots during its idle motion, 1 second in cycle time is reduced and the cycle time is reduced from 66 seconds to 65 seconds.

4.4 Weld Quality Factors

- **Observation:** Usually the squeeze time is more for any spot welding process AC supply of 50 Hz is used in the sense 50 cycles per second is consumed. If the spot welding process of one spot requires 1 second, then squeeze time requires more number of cycles when compared to other three steps.
- **Rectification:** It was found that the squeeze time requires more cycles than the other steps. It requires around 20 cycles for one spot. Squeeze time is the only modifiable

parameter. For one spot it takes 0.4 seconds. If the robot welds 20 spots, then the squeeze time alone requires 8 seconds.

By reducing the squeeze time to half its value, nearly 3 seconds of cycle time are reduced and the cycle time is reduced from 65 seconds to 62 seconds.

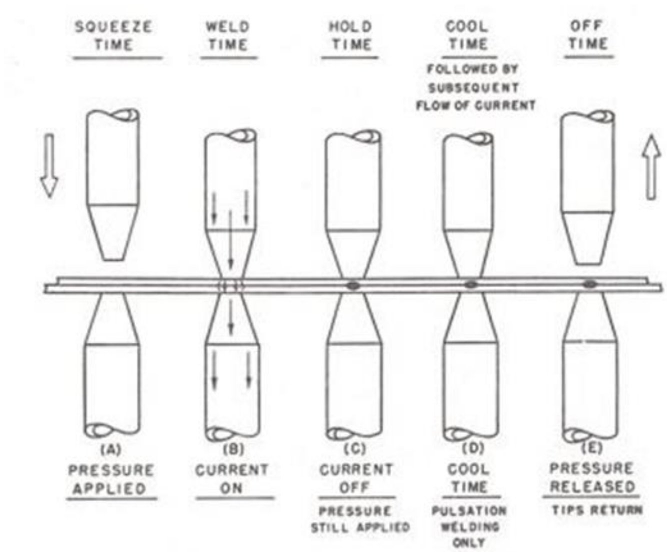

Figure 8: *Weld Quality Factors*

5. Conclusion

A case study is done with BB and BR line & the problems which are responsible for cycle time delay are recognized. The parameters are optimized using the tools of quality & are implemented thus bringing about the reduction in cycle time up to **10 seconds**.

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