Improving Automotive Efficiency through Lean Management Tools: A Case Study

Raed EL-Khalil, Hussein Zeaiter

Abstract**—**Managing and improving efficiency in the current highly competitive global automotive industry demands that those companies adopt leaner and more flexible systems. During the past 20 years the domestic automotive industry in North America has been focusing on establishing new management strategies in order to meet market demands. The lean management process also known as Toyota Manufacturing Process (TPS) or lean manufacturing encompasses tools and techniques that were established in order to provide the best quality product with the fastest lead time at the lowest cost. The following paper presents a study that focused on improving labor efficiency at one of the Big Three (Ford, GM, Chrysler LLC) domestic automotive facility in North America. The objective of the study was to utilize several lean management tools in order to optimize the efficiency and utilization levels at the "Pre-Marriage" chassis area in a truck manufacturing and assembly facility. Utilizing three different lean tools (i.e. Standardization of work, 7 Wastes, and 5S) this research was able to improve efficiency by 51%, utilization by 246%, and reduce operations by 14%. The return on investment calculated based on the improvements made was 284%.

Keywords**—**Lean Manufacturing, Standardized Work, Operation Efficiency and Utilization, Operations Management.

I. Introduction

In the current highly competitive manufacturing market automotive companies in North America are forced to be more innovative and efficient in the way they conduct business. According to a forecast report conducted in 2012 by AlixPartner Automotive Outlook and reviewed by the U.S. committee on oversight and government reform, the U.S. automotive sales is predicted to drop by 5 million vehicles today than 5 years ago. The report indicated that one of the top reasons foreign companies outperform the Big Three manufacturers is its ability to implement innovative processes that optimize efficiency, improve quality, and reduce lead time. In 2011 the Big Three was able to improve its market share by 4.3% [1]; the sustainment of this increase will depend on the following:

1) The foreign companies' ability to reclaim their market share,
2) The Big Three ability to produce new innovative product and continue to invest in new process that support improving efficiency and reduce investment cost.

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Toyota motors, that is currently one of the leading automotive companies in the world in production and quality was on the verge of closing its doors after it filed for bankruptcy 60 years ago. Its first step toward improving was a massive investment in new technologies that can improve efficiency, improve quality and reduce cost. According to [2] one of the main drivers behind Toyota success is the implementation of Lean management process which Toyota developed and mastered in order to improve its efficiency and reduce its cost. Currently, in addition to going through bankruptcy (GM and Chrysler) in 2009 the Big Three automotive companies in North America are facing several issues including [3]:

1) Shrinking automotive market by 25% from 2005 to 2012,
2) Shifting customer demand,
3) Ongoing economic crisis and its impact of customer purchase power,
4) High Unemployment rate (8.2% as of August 2012),

In order to overcome the above issues the Big Three must make a commitment to invest in new technologies [4], [5]. One of the most important processes that the Big Three must focus on is the full implementation of Lean management process inside their industry [6] and beyond its borders [7] According to [8] it took the Big Three ten to fifteen years to learn, adopt, and implement the lean management techniques or Toyota Production System (TPS). The Big Three was able to achieve some process efficiency improvement but not to the same extent as Toyota motors due to several internal issues such as lack of commitment to the process by the Big Three upper management and the labor union contract and restrictions [9]. The main shortcoming of lean implementation at the Big Three was driven by the fact that managers viewed lean as a supplementary tool rather than a continuous improvement tool which is achieved by implementing lean tools in a sequential comprehensive manner [10]. For example, standardized work analysis (a lean tool) must be done prior to line balancing (another lean tool); and workplace organization (i.e. 5S, 7 wastes, visual management) is a prerequisite for a successful standardized work implementation.

It is critical to note that some of the techniques utilized in the lean management was originally developed by one of the Big Three companies namely Ford Motor Company. For example at the core of lean management is standardization of work technique. The standardized work at the automotive industry was initially utilized by Henry Ford in 1913 at his Highland Park, Michigan assembly plant [2]. Ford's assembly plant was the first manufacturing facility to utilize dynamic build process or flow process in which each technicians was given a specific sequence of work within a defined space on the conveyor line or assembly line. This work sequence was standardized in other words the engineers for that conveyor line defined a consistent "specified" sequence of tasks to be performed by the technicians on each vehicle that pass down the assembly line [11]-[13]. For this reason, authors such as Mehri [14] believe that standardization increases boredom and stress. The strict and repetitive motions will most likely negatively affect workers satisfaction and skills and lead to a deterioration in the operators' quality of work [15]. According to [16], [17] these are unfair acquisitions; he refers to Taylor and Gilberths to prove that if standardized work was properly done, organizations will achieve higher throughput and better quality products in an even safer environment. The author also remarks that in the end of the 20^{th} century, scholars shifted their research from work measurement analysis and focused on lean implementation.

However, standardization is the key factor for a kaizen lean environment [18], [19] and as Taiichi Ohno states "without a standard, there can be no improvement" [19]. Münstermann et al. [20] proved that process standardization has significant positive impact on process performance. Wuellenweber et al. [21] state that process standardization also increases the ability to control and manage operations. There is a consistent agreement concerning the benefits of standardized work in eliminating unnecessary motion, reducing variability, waste, and cost, and enhancing quality. Realizing its importance, Vinodh [22] and Mehri [14] took standardization concept to a higher level and discussed how it can be applied to non-cyclic jobs. Standardization provides the foundation for lean implementation; the success in improving organizational efficiency is mainly guided by the ability to establish standardized work where process inefficiencies can be identified and eliminated.

The following paper presents a study conducted at one of the automotive assembly plant for one of the Big Three companies in North America. This study applied several lean management techniques: Standardized work, 7 Waste's and the 5'S at chassis department zone in order to overall zone performance. The objective of this study is to determine the maximum efficiency and utilization that can be achieved utilizing the lean management tools. In addition this paper presents a document that could be used as a template for standardized work analysis (SWA).

II. Background: Assembly And Lean

A. Automotive Assembly

The manufacturing process for the automotive industry passes through three main stages, as illustrated in Fig. 1. The stage at which the actual vehicles construction takes place is typically referred to as the assembly stage or the manufacturing and assembly process. Within the manufacturing process the flow of operations is designed in a sequential pattern. This process is known as continuous flow or referred to as line flow.

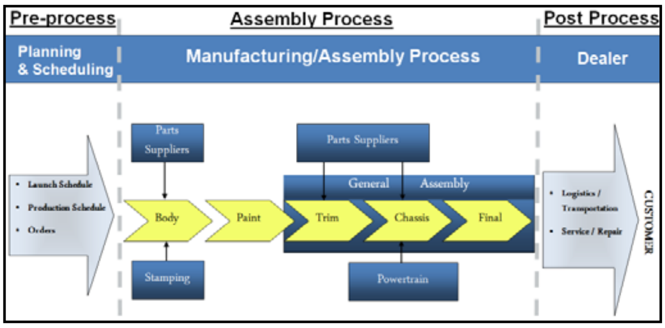


Fig. 1 Manufacturing process flow

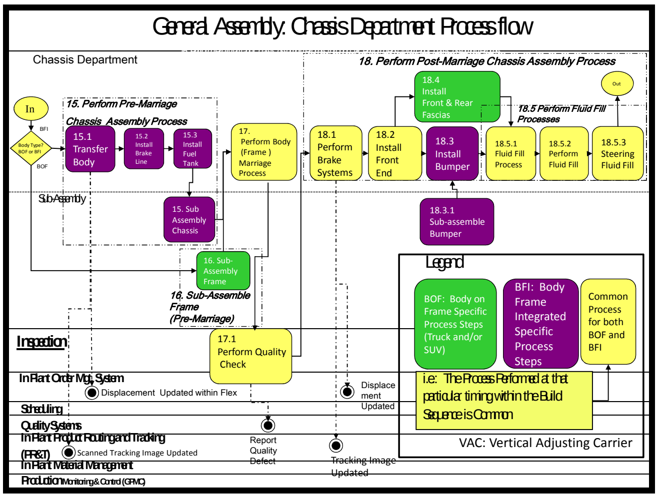


Fig. 2 Chassis department process flow

The automotive facility where the manufacturing process takes place is comprised of three main departments and each department is divided into several sections or zones. The sequences and /or departments are as follows:

1) Stage one is the body shop department (Body in White) which is divided into 7 to 9 zones. Stamping parts come to the facility from the stamping plant and they are welded together in order to form the shell of the vehicles. This department is highly automated; most of the work is done by welding robots,
2) Stage two is the paint shop and it is divided into 6 to 7 zones. After the body shop constructs the shell, it is shipped to the paint shop where the shell is washed, coated, and painted. This department is less automated than the body shop department,
3) Assembly stage is divided into three departments which are the following: Chassis, Trim, and final assembly. Each department contains 5 to 7 zones. At the trim department installation of the interior parts (i.e. wires, HVAC, carpet, and others) takes place. The chassis department is divided into several zones and subassembly zones, illustrated in Fig. 2. The chassis department stages are designed for installing all under body parts (i.e. full line, brake line, Axle, engine, prop shaft, fuel tank). The last stage in the manufacturing process is the final assembly where the marriage of the trim to chassis subcomponents takes place

in addition to the installation of other parts (e.g. wheels, doors, moldings).

B. Standardization of Work

The standardized work process is designed for the purpose of providing the technician with the current best method to safely and efficiently perform his or her work, at a target quality level set by the organization.

The standardization of work is the one of the first tools in the continuous improvement process. It is considered to be one of the most powerful tools utilized in lean management [12], [23]. The standardization of work process is divided into two parts or stages. In stage one, standardization of work focuses on documenting the current state of a job and or work station in order to establish a current best practice analysis. In part or stage two standardization of work focus on utilizing lean manufacturing tools (e.g. 5S, 7 wastes, Just in Time) in addition to engineering knowledge and experience in order to establish a new and more efficient state for completing the operation or task assigned [24], [25].

Key points for establishing standardized work are the following [17]:

1) "Synchronize" machine, manpower, material, and time to produce what is needed at the shortest time by ensuring a logical and disciplined organization
2) Work sequence standardization is done in order to achieve safety and high quality and throughput
3) Objectives are achieved by ensuring employee involvement in operation improvement. Employees are technicians directly concerned with the lean tools implementation in their work station.
4) Standardized work analysis is used when there is a well-defined repeatable process.

There are three main pieces of information that are essential for establishing a standardize work analysis/document. These three elements need to be clearly established and or defined in order for a proper continuous improvement process to take place. Those three elements are the following:

1) Customer Demand rate (Takt Time). Takt time is how often (in seconds) a unit must be produced to meet customer demand. Takt time formula is the following:

$$Takt\ Time\ (seconds) = \frac{Net\ Operating\ Time}{Customer\ requirments} \quad (1)$$

2) Operator work sequence. Defined as the sequence of steps followed by the operator in order to accomplish task required. The objective of this step is to list and detail each task with time required to conduct that task. Time associated with each task have to be identified in one of the two categories: value added (VA) or non-value added (NVA) work and or task based on the definition of each, as illustrated in Fig. 3. This information will be critical for calculating efficiency and utilization of each operator. The calculation for efficiency and utilization is determined by the following two equations:

$$Operation\ Efficiency = \frac{Operation\ Cycle\ Time}{Line\ Cycle\ Time} \quad (2)$$

$$Operation\ Utilization = \frac{Value\ Added\ Work}{Line\ Cycle\ Time} \quad (3)$$

Line Cycle Time is the amount of time that the vehicle/unit is physically in the workstation.

Operation cycle time = Value added (VA) + Opportunity for improvement (OFI)
OFI = Non-Value added (NVA) work (the objective is to reduce and or eliminate non-value added work)

3) Standard in process stock (Inventory). This includes inventory in buffer station and inventory between stations (i.e. all inventory that is required to the keep system up and running).

Value Added (VA) ○	Include all activities that transform product into its final form		
	People	**Machine**	**Material**
None-Value Added (NVA) □ ⊳ △	- Waiting for Machine - Waiting for product - Fixing equipment - Sorting defects - Repairing rejects - Inspecting product - Searching for tools	- Unscheduled Maintenance - Extended change over - Set-up time - Excessive production - Excessive Capacity	- Handling - Moving - Transporting - Sorting - Stacking - Inspecting

Fig. 3 Value added and None Value added task

At the automotive, industry the process of standardize work will typically consider several stations at a time or a specific zones that include several operation and or technicians. Initially, and before making any improvements, the process focuses on establishing the current state of work (baseline) analysis for each station [25]. Based on the results from the initial stage, a team of employees (i.e. management and technicians) will start making recommendations of improvements. Each recommendation will be considered, in some cases it will be tested, if proven, it will be adopted in the new and improved work station. Generally the requirements for the new process consider the following:

1) Workloads of employees/technicians are balanced to maximize minutes per hour and value added work content,
2) Ergonomics stress for each operation is minimized,
3) Employee work function are organized in a safe manner with awkward movement minimized,
4) All employees perform operation elements in standard sequence each time,
5) Standard work chart elements will be documented and each task and data is detailed. See recommended standardized work analysis (SWA) document Fig. 4. Time indicated in the SWA is in seconds,
6) The size of employee work envelop is minimized to reduce walking distances,
7) Location Materials, tolls and equipment is as close as possible to use point (operator use point).

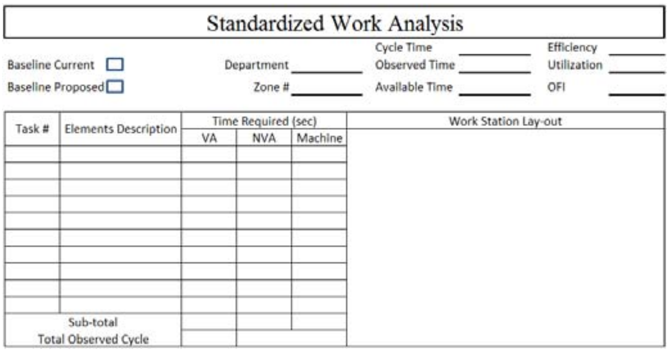


Fig. 3 Standardized work analysis (SWA) document established by this study

C. The 7 Waste

Waste identification & elimination is the foundation for continuous improvement. The objective for implementing the 7 wastes is to identify and eliminate waste at all levels in the manufacturing and assembly process. In manufacturing the types of waste that can be identified at each work station vary, depending on the layout and the operation conducted at each station. Generally, the type of wastes that can be identified at each station will fall under one of the 7 wastes presented in Table I.

TABLE I
THE 7 WASTE TYPES AND DESCRIPTION

No	Waste Type	Description
1	Over Production	Producing More or faster than the customer demands
2	Inventory	Supplies in excess of customer demand
3	Transpiration	Material movement not in direct support of the customer
4	Processing	Effort which adds no value to the customer
5	Waiting	Time that is a result of two dependent variables not being synchronized
6	Product Defect	Adjustments of a product to fulfill customer requirements
7	Motion	Excess walking, bending, or reaching

D. The 5's

The purpose of implementing the 5's is to support the technicians and reduce waste by providing a safe, neat, clean, efficient arrangement of the workplace where tools, equipment and material have a specific location and or position. Types of 5's and definition of each is illustrated in Table II. Based on the feedback given by facility management at the facilities visited, the resolute for the 5's are the following:

1) Safety comes first. Safety rules are implemented and followed by all employees,
2) All facilities has to operate in a hospital clean environment,
3) Visual management is standardized across areas, centers and plants,
4) Everything Is in its place and there's a place for everything,
5) Tools are readily accessible to those responsible for performing Housekeeping.

TABLE II
THE 5'S TYPES AND DESCRIPTION

No	5's Type	Description
1	Sifting	Involves separating the essential material from the nonessential
2	Sweeping	Involves removing nonessential items from the work area
3	Sorting	Involves organizing the essential material in the workplace
4	Sanitizing	Involves a regimented scheduled cleaning of the entire work area
5	Sustaining	Involves performing the 5's on an ongoing and systematic basis

III. CURRENT AND PROPOSED STATES

The process of implementing lean management will include two stages. Stage one involve establishing a base line for current condition. This base line involves determining opportunity for improvement through establishing standardized work analysis (SWA) sheet for all operations within the studied area in order to determine the level of improvements that can be made. Stage two involves making improvement based on the information determined in stage one. This improvement will include all stations within the focused area and or zone and it utilize lean tools or techniques such as Waste elimination and 5's implementation in order to improve operating efficiency and utilization. A team of facility employees was involved in reviewing and concurring with every finding and recommendation given throughout this research. This team included: technicians, engineers, and supervisors that are most familiar with the studied area.

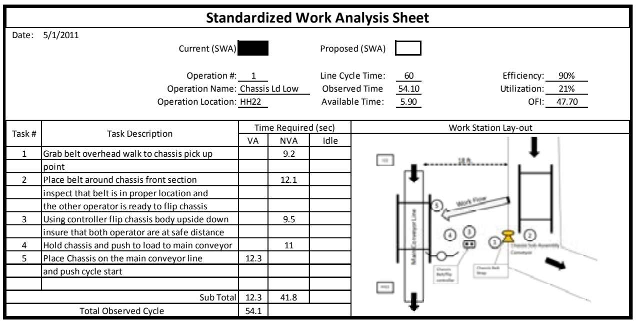
A. Chassis Pre-Marriage: Current State

The study focused on implementing the lean management process tools at the "Pre-Marriage" area, (zones: 15.1, 15.2, and 15.3) illustrated in Fig. 2. The assembly plant studied produce three different types of trucks. The studied area at the chassis department includes: 90 technicians, 18 team leaders, and 3 inspectors. The work conducted by those employees includes installing and or assembling 83% of the under-body parts. The following list indicates actual plant current operating facts:

1) The current Pre-marriage area efficiency (before implementing recommendations given by this study) given by the facility managers is 58% and the utilization is 24%. This information was based on records from year 2007,
2) The line cycle time 60 seconds (sec) or 1 minute (min),
3) Operating time per shift (minus breaks and lunch) = 480 min – 45min = 435min or 7.25 hours per shift,
4) Required production per hour based on 7.25 working hours per shift is = 48 vehicles per hour at a takt time of 1.25 minutes per vehicles.

B. Base Line: Current Condition

A current baseline standardized work analysis (SWA) was established for all 90 technicians within the studied area. The SWA's were determined through actual operator's observation and measurements taken that include time of each task and the work station space. The information determined was illustrated in the SWA's established. An SWA sample for operation #1 is presented in Fig. 5.



Standardized Work Analysis Sheet

Date: 5/1/2011

Current (SWA) ■ Proposed (SWA) □

Operation #: 1 | Line Cycle Time: 60 | Efficiency: 90%
Operation Name: Chassis Ld Low | Observed Time 54.10 | Utilization: 21%
Operation Location: HH22 | Available Time: 5.90 | OFI: 47.70

Task #	Task Description	Time Required (sec) VA	NVA	Idle
1	Grab belt overhead walk to chassis pick up		9.2	
	point			
2	Place belt around chassis front section		12.1	
	inspect that belt is in proper location and			
	the other operator is ready to flip chassis			
3	Using controller flip chassis body upside down		9.5	
	insure that both operator are at safe distance			
4	Hold chassis and push to load to main conveyor		11	
5	Place Chassis on the main conveyor line	12.3		
	and push cycle start			
	Sub Total	12.3	41.8	
	Total Observed Cycle	54.1		

Fig. 5 SWA sample: Operation#1 SWA

Based on the information obtained from the current SWA's created; a Value added (VA) and None-Value Added (NVA) chart was established. Fig. 6 illustrates a sample of the VA and NVA chart created.

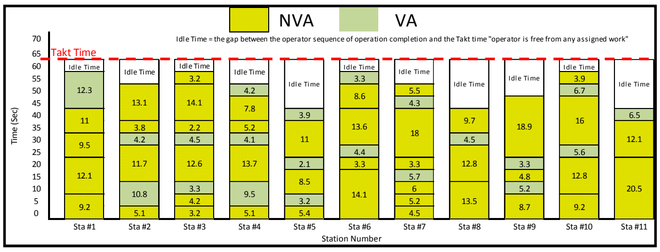


Fig. 6 Sample of current base line for chassis department

The current actual chassis "Pre-Marriage" area SWA's establish shows the following:

1) Average overall Efficiency is 57% and utilization is 13% (compared to the facility current records 58% Efficiency and 24% utilization),
2) Average available time is 26 minutes with an opportunity for improvement (OFI) is 52 minutes.
3) Average observed time is 34 minutes,
4) 6 station overall are operating 20% of the time over Takt Time.

C. The Methodology and Analysis

The methodology followed for improving the operating efficiency and utilization at each station is illustrated in Fig. 7. The main focus was to optimize each station in order to achieve the highest efficiency and utilization possible. Implementing the standardized work, 7 Wastes elimination and the 5S process required in most cases a changes in technicians:

1) Process sequence. Recommending and implementing a new 'more" efficient way to accomplish task,
2) Station Layout. Material, tools, parts, and fixtures were moved to new location or placed in different containers to increase efficiency and utilization,
3) Tools and fixture. New tools were provided that can support faster response and reduce injury,
4) Communication. The way the technician alert inspector or resolve a problem in order to prevent defects from leaving the department without being fixed properly.

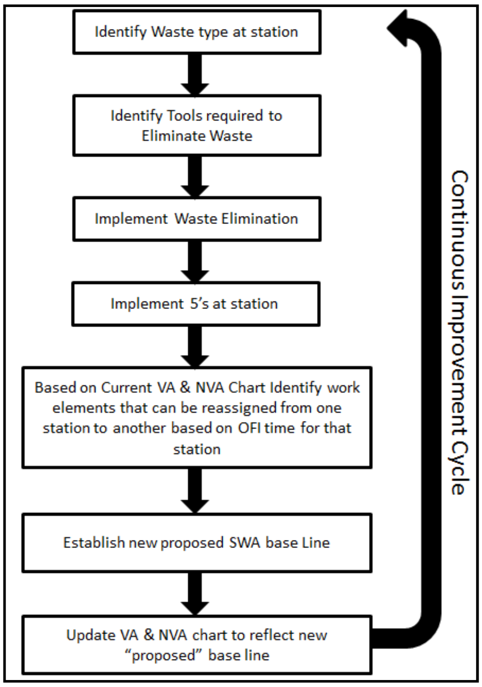
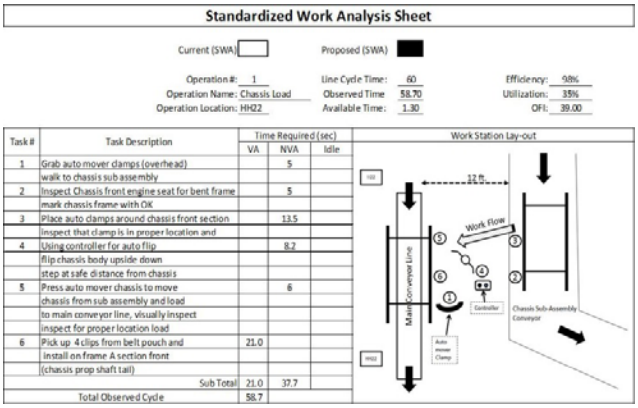


Fig. 7 Methodology for establishing proposed SWA and VA/NVA Chart



Standardized Work Analysis Sheet

Current (SWA) □ Proposed (SWA) ■

Operation #: 1 | Line Cycle Time: 60 | Efficiency: 98%
Operation Name: Chassis Load | Observed Time 58.70 | Utilization: 35%
Operation Location: HH22 | Available Time: 1.30 | OFI: 39.00

Task #	Task Description	Time Required (sec) VA	NVA	Idle
1	Grab auto mover clamps (overhead)		5	
	walk to chassis sub assembly			
2	Inspect Chassis front engine seat for bent frame		5	
	mark chassis frame with OK			
3	Place auto clamps around chassis front section		13.5	
	inspect that clamp is in proper location and			
4	Using controller for auto flip		8.2	
	flip chassis body upside down			
	step at safe distance from chassis			
5	Press auto mover chassis to move		6	
	chassis from sub assembly and load			
	to main conveyor line, visually inspect			
	inspect for proper location load			
6	Pick up 4 clips from belt pouch and	21.0		
	install on frame A section front			
	(chassis prop shaft tail)			
	Sub Total	21.0	37.7	
	Total Observed Cycle	58.7		

Fig. 8 Proposed SWA for Operation #1

D.SWA Analysis

Each station studied required different changes. For example operation one was changed from the current base line presented in Fig. 5 to the new proposed base line presented in Fig. 8. In order to improve the operation efficiency and utilization the team recommended the following:

1) Provide a safer faster Chassis flipping auto-mover machine. New auto-mover machine is designed by the facility managers based on the recommendations given,
2) Provide operator with side holster that can carry enough clips. In the old SWA the operator used to walk to the clip box every cycle and in the current SWA operator only go

to the box once every 4 hours since the holster carry enough clips,

3) Install clamps on the auto-mover for easier load and unload. Designed by the facility engineers to handle all different chassis produces.

In other stations such as station # 14 the operator installs U-bolts and Saddles on chassis for axle and drive shaft. In the original SWA the operator used to spend 42.5% of his or her time walking to get parts. A recommendation was given (and tested) to provide the operator with parts on a wheeled rack that can be located within 3 feet from installation point therefore eliminating waste (processing and motion wastes) and creating a location that is up to the 5S standards, as illustrated in Fig. 9. This one step improvement was able to improve operation efficiency by 35% and increased OFI by 25% therefore giving the operator more time in order to take on additional work in order to improve the area overall efficiency. The team identified flexible tools and equipment's that the operators could use to reduce time for assembly and improve the process. As an example, the team identified 42 stations that can utilize a pulse tool to replace a regular air nut runner which will provide better tolerance control, faster response time and improve ergonomics for the technicians. In addition, 75 operators were provided with waist holsters and or pouches to hold small parts such as: bolts, clips, and screws. Providing this holster or pouch reduces the need to obtained small parts from boxes during every cycle and frequency for refill was reducing to 1 time every two hours.

Implementing recommendations provided by this study and testing its feasibility for all the stations in the pre-marriage area had to consider several factors. The following are the top four issues that the team considered before making recommendations and changes:

1) Cost limitations were considered for recommendations made, due to financial limitations most changes (i.e.. tools, fixture, racks, tables…etc.) had to be manufactured in house,
2) Some recommendations made did not work. Labor union contractual agreement for example does not allow operators to conduct inspection work due to different classification,
3) Some non-value added work can't be eliminated due to restrictions in floor space and tools utilized,
4) Since the plant operates on three shifts and but the team only include employees from first shifts. Recommendations made by the team were reviewed by the effected employees for all shifts and several changes were made in order to adjust to their needs.

All new changes were tested and adjustments were made accordingly. A new proposed VA and NVA was created to reflect all changes made, a sample is illustrated in Fig. 10.

Fig. 9 Rack utilized for waste elimination

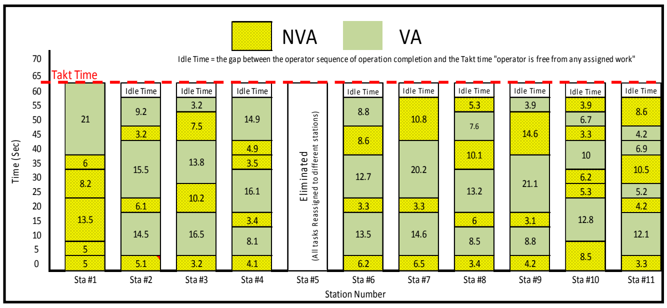


Fig. 10 Proposed new VA and NVA Chart (First 11 operations in chassis Department)

IV. Results

The new SWA's established for the pre-marriage chassis area were implemented and monitored for 6 weeks, several minor issues were witnessed most of those issues were related to improper new tool usage by technicians. The following are the benefits achieved in the pre-marriage area as a result of establishing a new proposed SWA's and tested SWA's:

1) The old "current" base line of 90 operations was reduced to 77 operations "new proposed" base line, for an overall labor efficiency improvement of 14%.
2) The SWA's overall efficiency increased from 57% to 86%, for an improvement of 51%.
3) The SWA's overall utilization increased from 13% to 45%, for an improvement of 246%.

From a cost perspective the Return on Investment (ROI) based on the work conducted was calculated with the support of the controller office at the facility. A list of cost saving (CS) and cost changes items were determined, illustrated in Table III. The forecasted benefit in quality, safety and throughput was determined based on 3 month data obtained from the pre-marriage area "after" implementing the proposed state. The ROI% improvement achieved came up to 284% Improvement.

The ROI equation (4) for evaluating the proposed design:

$$\boldsymbol{ROI}\,\% = \frac{\boldsymbol{CS-C}}{\boldsymbol{C}} \tag{4}$$

where, CS is the cost savings due to design changes for the entire vehicle program life. C is the cost of the design changes during the vehicle program life. A program life of 5 years is assumed.

TABLE III
COST SAVING AND COST IMPLEMENTATION (DATA IS SUPPORTED BY FACILITY FINANCE DEPT.)

Item	Type	Description	Cost ($ Million)
1	C	Equipment Required: *Pulse Tools, Auto Movers, wireless Tools, Holsters, Racks, Fixtures, Balancers, others tools*	0.8
2	C	Skill trade and Engineering *Assigned: 2 full time engineers (6 Month), 3 full time skill trade employees (5 Month), Other team members part time (3 Month)*	0.65
3	C	Team Expanses *Benchmarking visit to other facilities, other expenses*	0.3
		Total C type cost	1.90
1	CS	Labor Efficiency Improvement	5.9
2	CS	Other Forecasted Improvement *Injury rate Improvement (10%) Quality Improvement (5%) Uptime Improvement (5%)*	1.4
		Total CS type saving	7.3

V. CONCLUSION

The following research clearly indicates that there are significant opportunities for efficiency improvement with in the domestic automotive industry in North America. The importance of the lean management tools in driving this improvement was clearly demonstrated through this research. It was very clear that lean process implementation should be mutually developed with the involvement of all the levels of the organization and it should be reviewed and updated on continuous bases. The first and most critical step in the implementation of lean is standardization of work. The standardization process establishes precise procedures for each technician in a production process. The driving force behind making improvement is based on how clearly we can understand and detail the sequence of tasks conducted by the operator, the rate of production needed, and the inventory required for each station. The fundamental principle of standardized work is that it focuses on providing the customer with a product that will meets expectations in a cost effective way.

Through the processes of working with the facility team and pre-marriage chassis area technicians in order to implement the lean management tools several issues were noted:

1) 60 % of the employees on the team at the manufacturing facility were not familiar with the lean management tools and never took any training in the area of lean management,
2) 20% of the technicians in the affected area (previous to this study) took training classes on lean but they were never involved or asked to make recommendations on how to improve their operation. The facility controller indicated that due the lack of funding was the main reason for lack of training,
3) 50% of recommendations on improvement were made by the technicians. All employees in chassis pre-marriage area were given a training class on lean for one day before being asked to make recommendations; thus emphasizing the point made by [26] and [27] which stressed on states that kaizen events are better implemented incrementally from down up which will generate a creative set of line operators,
4) After implementing the proposed work assignment in the pre-marriage area employees were asked about their satisfaction levels with the new processes: 80% of technicians indicated strong satisfaction, 15% indicated neutral opinion and 5% unsatisfied. The satisfied employees noted that the main reason for satisfaction is driven by their involvement in designing their own work station,
5) A question was asked to managers that are familiar with lean management about their confidence in improvements that of lean process can achieve (before implementation of this study)? 80% indicated that improvements can be made if and only if the upper management provided resources and support required.

The case study in this paper shows that the lean management process can be utilized in order to improve manufacturing facility labor efficiency and utilization. The proposed standardized work analysis was able to: reduce the level of technicians by 14%, improve efficiency by 51%, and improve utilization by 246% for the chassis department pre-marriage area with an ROI of 284%.

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REFERENCES

[1] The Wall Street Journal, "Auto Sales", Retrieved from http://online.wsj.com/mdc/public/page/2_3022-autosales.html#autosalesD. 2012.
[2] J. P. Womack, J. Daniel, and D. Roos, *The machine that changed the world*, New York: Rawson Associates, 1990.
[3] AlixPartner, "Lingering Low Employment Nationally, Demographic Shifts, Potential Contagion from Europe Present Big Challenges to the Auto Industry", Retrieved from http://www.alixpartners.com, 2012.
[4] R. EL-Khalil, K. Taraman, and S. Taraman, "Body shop flexibility: Impact of framing system on overall performance", *Asian International Journal of Science and Technology*, Vol. 3 No. 2, pp. 110-128, 2010.
[5] R. EL-Khalil, "Simulation Analysis for managing and improving productivity: a case study of an automotive company", *Journal of Manufacturing Technology Management*, Vol. 26 No. 1, pp. 112-135, 2015.
[6] J. Liker, *The Toyota way: 14 management principles from the world's greatest manufacturer*, New York: McGraw Hill, 2004.
[7] Matsui. Y, "An empirical analysis of just-in-time production in Japanese manufacturing companies", *International Journal of Production Economics*, Vol. 108 No. 1, pp. 153–164, 2007.
[8] McKinsey and Company, Lean Implementation at the US automotive companies, Retrieved from http://www.mckinsey.com/insights, 2014.
[9] C. Chen, A.L. Bergenwall, and R.E. White, "TPS's process design in American automotive plants and its effects on the triple bottom line and sustainability", *International Journal of Production Economics*, Vol. 140 No. 2, pp. 374-384, 2012.

[10] S. Bhasin, and P. Burcher, “Lean viewed as a philosophy”, *Journal of Manufacturing and technology management*, Vol. 17 No.1, pp. 56-72, 2006.
[11] J. Cabadas, J. *River Rouge: Ford's Industrial Colossus*, Motor Books International, St Paul, MN, 2004.
[12] R. EL-Khalil, and M. Farah, “Lean Management adoption level in Middle Eastern Manufacturing Facilities”, *The Business Review, Cambridge*, Vol. 2, No 2, pp 158-167, 2013.
[13] R. EL-Khalil, “Managing and Improving Robot Spot Welding Efficiency: A benchmarking Study”, *Benchmarking: An International Journal*, Vol. 21, No. 3, pp 344-363, 2014.
[14] D. Mehri, “The darker side of lean: an insider’s perspective on the realities of the Toyota production system”, *Academy of Management Perspectives*, Vol. 20 No. 2, pp. 21–42, 2006.
[15] K. Newsome, “The women can be moved to fill in the gaps: new production concepts, gender and suppliers”, *Gender, Work, & Organization*, Vol. 10 No. 3, pp. 320–341, 2003.
[16] M. Hughes, “A true rap for work measurement”. *Industrial Engineer*, Vol. 44 No. 10, pp. 213-226, 2012.
[17] R. El-Khalil, “Auto zone: Pour on the efficiency by applying work study analysis to car production”, *Industrial Engineer Journal*, Vol. 43 No. 11, pp. 30-34, 2011.
[18] H. Wittenber, “Kaizen the many ways of getting better”, *Assembly Autonomation*, Vol. 14 No. 4, pp. 12-17, 1994.
[19] T. Whitmore, “Standardized work: Document your process and make problems visible”, *Manufacturing Engineering*, Vol. 140 No. 5, pp. 171-179, 2008.
[20] B. Münstermann, A. Eckhardt, and T. Weitzel, “The performance impact of business process standardization: An empirical evaluation of the recruitment process”, *Business Process Management Journal*, Vol. 16 No.1, pp 29- 56, 2010.
[21] K. Wuellenweber, D. Beimborn, T. Weitzel, and W. Koenig, “The impact of process standardization on business process outsourcing success”, *Information Systems Frontiers*, Vol. 10 No. 2, pp. 211-24, 2008.
[22] S. Vinodh, “Standardized work for noncyclical processes”, *International Journal of Production Research*, Vol. 49 No. 21, pp. 6589-6590, 2011.
[23] J.K. Liker, “Becoming lean: Inside stories of U.S. manufacturers”, Oregon: Productivity Press, 1998.
[24] M. Kocakulah, J. Brown, and T. Joshua, “Lean Manufacturing principles and their Application”, *Cost Management Magazine*. Vol. 22 No. 3, pp. 112-138, 2008.
[25] L. Wilson, “How to implement lean manufacturing”, New York, NY: McGraw-Hill, 2010.
[26] J.A. Farris, E.M. van Aken, T.L. Doolen, and J. Worley, “Critical success factors for human resource outcomes in Kaizen events: an empirical study”, *International Journal of Production Econ.omics*, Vol. 117 No. 2, pp. 42-65, 2009.
[27] W.M. Feld, *How to implement lean manufacturing tools, techniques, and how to use them*, Boca Raton: St Lucie Press, 2010.

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