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An implementation of lean scheduling in a job shop environment

Haider, A.[a,*], **Mirza, J.**[a]

[a]University of Engineering and Technology, Department of Industrial Engineering, Taxila, Pakistan

A B S T R A C T

Globalization has demanded innovative manufacturing and continuous improvement in order to stay competitive. This need has compelled the manufacturing world to devise strategies for producing cost-efficient parts without compromising quality. The Toyota Production System was at the beginning of such initiatives. It was successful in addressing cost through elimination of non-value-added time and quality by monitoring and controlling the productions of defective parts. Lean thinking originated from the Toyota Production System and inherited its concepts and methodology. In contrast to the Toyota Production System, the implementation of lean has been proposed in almost every domain of life. In the manufacturing domain it is a common misconception that lean is suitable for mass production only. This research has been built upon the belief that lean is for everything and has challenged this stereotype by implementing it within a job shop environment. A manufacturing industry was selected that was rebuilding battlefield tanks. The existing system was suffering delays and missing delivery targets due to uncertain and costly production. The proposed and existing systems were modeled and simulated using Arena 10.0 software. This work was successful in reducing the manufacturing-led time, work in process inventory and average cycle times with a reduction in cost and space utilization. Cost benefit analysis was performed showing that the proposed system would be beneficial after 1500 parts. We are further expanding our proposed approach towards the tool manufacturing shop in order to study the impact of lean and its suitability for scheduling in job shops.

A R T I C L E I N F O

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**Corresponding author:*
aftab775@yahoo.com
(Haider, A.)

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1. Introduction

Manufacturing industry has gone through evolutionary changes in last few decades. Standardization and interchangeability has helped developing countries to earn their share of manufacturing due to lower labor costs. Competitiveness and economic challenges have diverted manufacturing activity from West to East. Industries with obsolete manufacturing systems are losing business due to excessive production costs and uncertain production delivery times. These factors have strengthened manufacturing industries in Eastern world [1]. Japan introduced innovative manufacturing system that was later known as Toyota Production system (TPS) [2]. This system believed in identification and elimination of seven critical wastes in production, supply chain and management processes [1]. Quality was the essence of TPS philosophy that helped it to revolutionize the manufacturing industry [1, 3]. Lean thinking is an off spring of TPS [3, 4]. Market challenges to manufacture at lower cost with less time and more throughput, paved way for lean manufacturing [4]. Lean manufacturing believes in systematic elimination of waste, relies on continuous flow concepts and customer pull. This management system overwhelmingly succeeds in satisfying customers on delivery, quality and price through elimination of non-value-added activities and wastes [3]. This manufacturing philosophy believes in elimination of wastes for entire supply chain and aims to provide good quality products through low processing and cycle times, and more responsiveness to customer needs [5]. With the success of TPS in Japan and a tremendous boost in Japan's manufacturing activity in 1970's, US manufacturers were forced to review their existing ford system and analyze the success story of TPS [3, 4]. Eventually, lean manufacturing motivated by TPS appeared in American factories [3]. It became important to get lean to stay competitive and succeed in challenging market place [4]. Value stream mapping, one piece flow, 5S system, quick changeover, Kanban, cellular strategy and total productive maintenance are tools of lean manufacturing to improve quality, cost and delivery [6].

Waste, in lean paradigm, is a non-value-added activity that puts extra burden on the customer and customer is definitely reluctant to spend on it [3, 4]. Overproduction is the worst in seven basic wastes in production activity. Lean thinking strongly opposed the concept of "make to stock" and stressed the need for "make to order". Overproduction results from over engineering, misuse of automation, poor scheduling, and just in case logic. Balancing the assembly line and adjusting the productivity may help to overcome this waste. Another important waste in manufacturing is long waiting times. This may occur due to saturation of work load on some workstations. Adjusting the process times and making the system flexible to cope with breakdowns may be helpful to eliminate this waste. Overproduction and long waiting times result in large work in process inventory. One piece flow strategy is an effective way to deal with this inefficiency of production system [7]. Long processing times and waiting times contribute to large work in process. Transportation is considered non-value-added activity and must be minimized to improve the cycle times of part production. This waste is resultant of poor facility design and layout and large batch sizes. This waste also contributes to larger work in process inventory. Undue motion of the work force, equipment and machines is another waste that causes larger lead times. This is also due to poor facility layout and improper location of machines and equipment. Avoiding the unnecessary movements may be helpful to reduce work in process and improve the lead times and reduce cycle times. Production of defective products is well known waste and efforts to curtail this waste are covered under the umbrella of quality management. Identification and fixing the defects is not the real purpose of quality management. Efforts should be to identify the causes of poor quality and adopt methods to eliminate re-occurrence of defects. Utilization of resources must be optimal and properly planned. Underutilized resources increase the cost of product and make the work in process (WIP) inventory larger [3, 7]. Ideally a production process must be free from these seven wastes. These wastes hamper the business performance and make the production activity expensive and costly. Lean manufacturing ensures elimination of wastes in the overall manufacturing process and helps to reduce the cost of production. Lean is concerned with improvement in entire process flow instead of one or more individual processes [1, 8].

Lean manufacturing is known for its success stories in reducing cost and improving the market share through better quality for mass production industries [4]. Our research is concerned with exploring the feasibility of lean in a job shop environment.

Maroofi and Deghan [9] has presented a conceptual framework for possible implementation of lean in job shop environment. Proposed model uses LET project that comprises business procedure management, supplier management, and value system management. They devised two phrased solution for supplier management using fuzzy logic and ant colony optimization. They suggested separate value stream map for each product due to high variety of products. Value stream map can be used for better scheduling of parts and can be helpful to eliminate wastes and non-value-added activities. Our proposed approach has addressed the same problem through modeling and simulation. Instead of proposing separate value stream map for each product, we have made necessary changes in the layout and reduced the waiting and queue times through sequencing of the parts. We provided one piece flow for process improvement and suggested re-arrangement of workstations.

Eng and Ching [10] claimed that lean is not suitable for all situations and presented quick response manufacturing as an alternative for job shop environment. They believed that quick response manufacturing is suitable for low volumes and high variety and can be successfully used to reduce critical path times. Our research was to challenge this stereotype and was successful in proving that lean can be used for high variety environment as well.

Assaf [11] used programme evaluation and review technique (PERT) to address the job shop scheduling problem. Processes were throughly studied and then author suggested new sequencing of processing using PERT. Author used parallel sequencing for independent processes and was successful to reduce the lead times. Our research also re-arrnages the workstations after thorough study of existing system. We used expert judgment to re-arrange our 10 workstations problem. Usability of PERT for large number of workstations cannot be denied but implementation will require formation of groups for different part families. This methodology is similar to already existing group technology and cellular manufacturing. We have used part and processes matrix instead of PERT to separate the part families.

Modrák and Semančo [12] presented the cell design methodology to transform job shop production process to lean. They defined decision making rules and principles to achieve One Piece flow for job shop. Similarly, we have devised the One Piece flow for our case study and implementation has resulted in achieving the WIP equal to workstations.

Irani [13] believes that there is no specific lean tool that is ideal for job shop. It is always better to blend these tools and methodologies to prepare a customized recipe, suitable for a specific job shop environment. Author has not provided any specific solution for the job shop and only discussed prospects and consequences of different methods and tools.

Djassemi [14] introduced three stepped lean implementation process. It constituted training, Kaizan continuous improvement and implementation. Author implemented this approach on pilot projects and identified the improvements made during continuous improvement phase. This approach was successful to reduce the overtimes by 37 % and improve on-time delivery by 11 %. This approach is altogether different from our approach. This approach relies on continuous improvement methodology and our research is concerned with elimination of wastes.

Section 1 outlines emergence of lean from Toyota Production System and brief review of lean in job shop environment. In section 2, we have briefly identified the common problems faced by job shops. Section 3 is about the performance criteria and measures used to compare lean with existing system. In section 4 and 5, we have introduced and explained the experimental set up and results. Section 6 is the last but not the least that concludes our research work and explains future directions.

2. Lean in job shop

Manufacturing is a business activity aimed at producing goods and providing services to satisfy humanly needs. Through value added physical and mental labor, raw material is transformed into useful product that satisfies the demands of customers. Such value addition activities are known as manufacturing process and overall combination of these processes makes a manufacturing system. Manufacturing systems can be either product oriented or process oriented. Process oriented processes provide continuous production and are known as continuous production systems whereas product oriented manufacturing processes are known as discrete part manufacturing. Discrete part manufacturing systems are further categorized as low, medium and high based on the quantity produced by an industry. There can be range of products being manufactured by an individual industry. This range of products can be either similar or different to each other. Range of products is known as variety and high variety limits the quantity of production. High variety results in low volumes of productions and low variety may guarantee high production [7, 15].

Job shop is a low volume high variety manufacturing environment. In order to produce range of products, a job shop requires highly skilled and versatile workforce and flexible manufacturing capability. Automation and specialization in some specific task are not supported in job shop environment. Job shops are characterized by fixed position layout, where product remains at single location during the entire production process. Workforce and equipment move to the fixed product for value addition activities. Ships, submarines, locomotives, aircrafts and battlefield tanks manufacturing are some typical examples of job shop environment having fixed position layout [7, 16].

Lean manufacturing can deal with missing order dates, high production costs, decline in market share and limited capacity. Is lean philosophy equally successful in job shop environment? We have selected a defense organization having job shop environment and manufacturing and rebuilding battlefield tanks. We found that Precision Defense Organization (PDO) is facing problems in:

- Manufacturing and rebuilding of sub-components of battlefield tanks well in time to ensure committed delivery of final product.
- Optimal utilization of resources with inability to identify bottleneck workstations.
- Determination of exact production capacity before making commitments with customers.

Middle management remains under tremendous pressure to meet unrealistic targets. Despite extra shifts and undue expenditure on overtime, targets are missed and linger on. Our focus was to determine the benefits of the utilization of lean thinking in PDO, because it is common misunderstanding that lean manufacturing is suitable for mass production systems only and will not be successful in job shop environment [17]. This work study was an endeavor to address these problems and ensure smooth production in job shop environment.

3. Performance measures and evaluation criteria

In order to determine the usefulness of our proposed solution for the improvements in existing system, we have identified some performance measures. These performance measures are:

1. Work in process (WIP) inventory
2. Manufacturing lead time
3. Average cycle time
4. Throughput/Productivity
5. Cost reduction
6. Work place area
7. Delivery commitments (mean tardiness)

3.1 Work in process (WIP) inventory

In process components in a system for some period of time are known as work in process (WIP) inventory. WIP is considered highly significant factor in production system as large size of WIP increases production costs. Optimally, the size of WIP should be equivalent to the number of workstations in the manufacturing system.

3.2 Manufacturing lead time

Time from release of an order to manufacturing of finished product is called manufacturing lead time and is inclusive of processing time, wait time, inspection and transportation time. Manufacturing lead time includes value addition and non-value addition times. Manufacturing lead times can be reduced after excluding all or some parts of non-value addition activities.

3.3 Average cycle time

In manufacturing lead times, the time spent on value addition activities is called cycle time. It is processing time to transform raw material into finished product and excludes wait, transportation and queue times.

3.4 Throughput/Productivity

Rate of production is termed as productivity or throughput for manufacturing activity. Work in process (WIP), manufacturing lead times and average cycle times are primary performance measures. Productivity is dependent upon these primary measures and can be termed as secondary performance measure. Manufacturing lead time (MLT) is inversely proportional to productivity. Higher MLT results in lower productivity and vice versa.

3.5 Cost reduction

An increase in productivity results in cost friendly manufacturing activity. We have selected this performance measure to compare the existing manufacturing system with the proposed. Cost reduction is the ultimate requirement of any business activity and its importance cannot be denied.

3.6 Workspace reduction

Another important aspect of lean manufacturing is to optimally utilize the space for manufacturing and production. We will review and compare the workspace utilization for existing and proposed system. Reduction in workspace can be guaranteed through elimination of seven wastes of production activity as described by Just In Time (JIT) and lean thinking.

3.7 Delivery commitments

Industries determine production capacity to commit delivery targets with customers. These commitments may be based on expert judgment of operations manager or modeling the existing system. We have found that PDO is committing the targets and deliveries based on their expertise and previous experiences. We preferred to model the existing system to determine the exact production capacity of PDO. We have identified lateness and tardiness as performance measures to gauge delivery fulfillment performance measure of PDO.

Lateness of a job is the difference between the due time and actual delivery time. Preferably, lateness should be positive or zero. In case of late deliveries and inability to meet targeted commitments, lateness may become negative. Ideally, occurrence of negative lateness should be avoided.

Tardiness of a job is the maximum value of lateness and is always negative. An occurrence of delivery commitment before the targeted deadline is called earliness and is not part of our performance measures.

4. Experimental study

A battlefield tank comprises three main mechanical assembling units, i.e., gun barrel, hull and turret. In our study at PDO, we have selected hull assembly for our experiment and analysis. Since PDO is busy in rebuild and manufacturing of battlefield tanks, we have selected hull rebuild and repair shop involved in repair of suspension and power pack parts and components as per original engineering manual (OEM), in hull assembly section of PDO. Overall process flow for rebuild of suspension parts is given in Fig. 1.

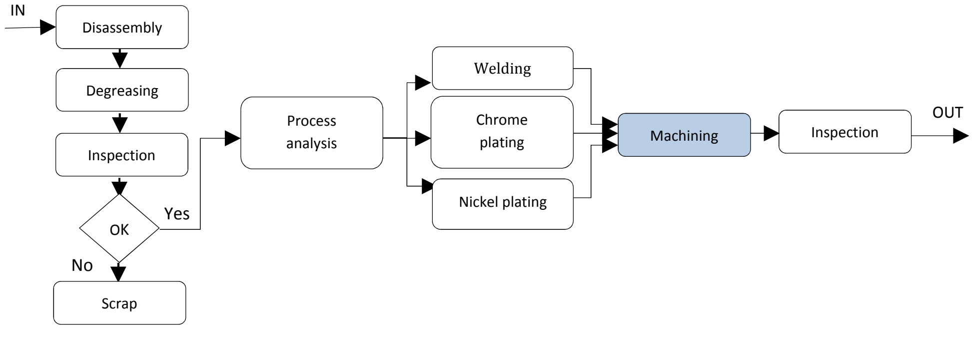

Fig. 1 Process flow of PDO job shop

Our research is concerned with the machining phase of suspension parts. These parts include balance arm, crank arm, sprocket hub, driven gear, driven shaft, final drive, idle wheel disc, left right supports, shock absorber blade and worm gear. An individual tank assembly requires 2 parts of each except balance arms and shock absorber blades. There is requirement of 10 balance arms and 4 shock absorber blades for typical Chinese and Russian origin battlefield tanks. Each part has different routing and processing requirements. These are highly and frequently wearing out parts in suspension and power pack assemblies of hull section in battlefield tanks. These parts delay the final assembly of hull section and contribute to overall delay in battlefield tank assembly. Shop floor involved in repairing of these parts is equipped with center lathes, gear lathes, radial drilling machine, broaching machine, vertical lathe, vertical and universal mills, broach, bench drilling machine, universal grinding machine and inspection cum bench fitting. These are those machines that are selected after making cells and groups of similar parts. Each part has different sequence of operations, e.g. sequence of operations for sprocket hub is, vertical lathe (turning), broaching, milling, internal grinding and for balance arm, sequence is turning, milling, cylindrical grinding, heat treatment, surface treatment and inspection.

Our proposed approach (Fig. 2) comprises three main phases. First phase is concerned with study of processes and layouts and identification of part families and formation of cells. Second phase is continuous improvement phase. In this phase, we re-arranged the workstations using the sequencing chart of parts in group such that there was no backward movement of the part during the processing. A part enters from one side of the cell, moves ahead and departs from the other side after value addition. We identified delays through analysis of waiting times, queue times, arrival times and processing times. Third phase implements lean thinking and uses quick changeover, total preventive maintenance, elimination of wastes and Kaizan methodologies. Using Kaizan continuous improvement methodology, we re-adjusted arrival times and reduced waiting times through increase in resources and provision of quick change over. We reduced processing time through improvement in time to failure and reduction of breakdown times. This helped us to establish One Piece flow in job shop.

We have used manufacturing simulation software Arena 10.0 [18] to model existing and proposed scenario of the PDO case study. Existing system has spaghetti layout with woven routing of parts for value addition processes. We have generated part families for these parts and re-arranged the placement of workstations to provide a U-shaped cellular manufacturing.

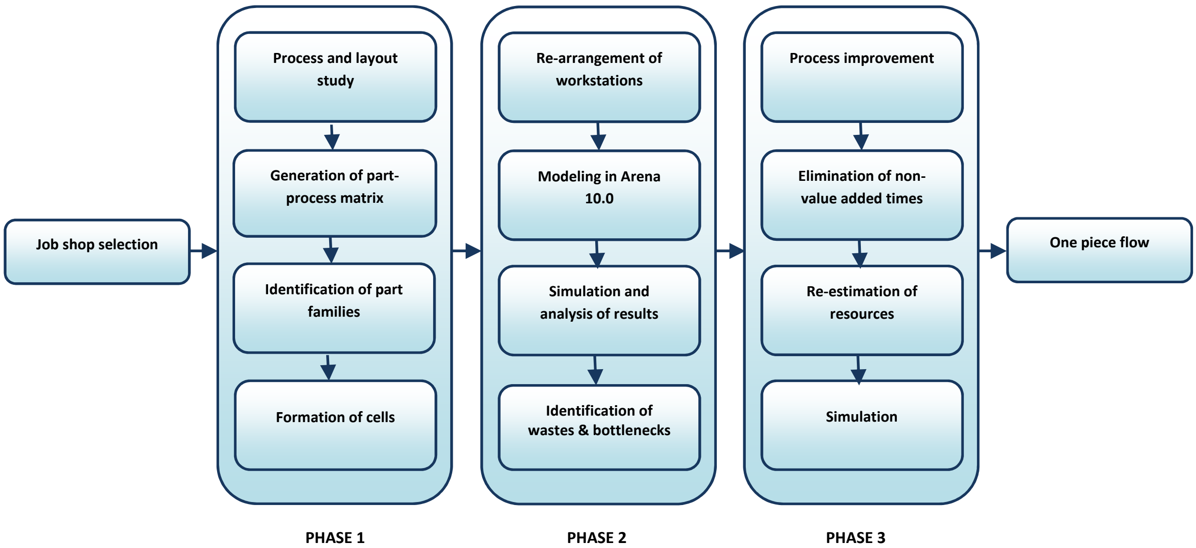

Fig. 2 Proposed methodology

5. Experimental results

We modeled and simulated our proposed and existing manufacturing systems using Arena 10.0 and we have compared these through predefined performance measures discussed in Section 3.

5.1 Work in process (WIP) inventory

Higher WIP are neither preferred nor welcomed. Lower WIP results in lower manufacturing lead times. In existing system, WIP was 22.85, but lean scheduling helped us to reduce it to 10. One Piece flow states that number of parts in process should not be more than the number of workstations. There are 10 workstations in PDO suspension rebuild job shop. We have observed that lean scheduling has provided 'One piece flow' and has comparatively reduced the WIP, making it equal to the number of workstations in the proposed system (Fig. 3).

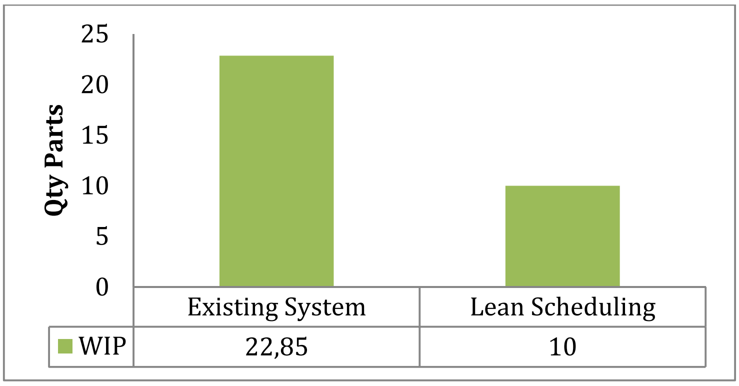

Fig. 3 WIP inventory for lean and existing system

5.2 Average cycle time

Value addition time or processing time of MLT is known as cycle time. It is time spent to convert a raw material into finished part. If we analyze the results, we can found a drastic decrease in cycle times for proposed scenario, where lean scheduling has been implemented. However, final drive and idler wheel are having almost same processing times in existing and proposed systems (Fig. 4). These parts visit few work stations as compared to others and do not undergo milling, drilling and broaching process.

Available time for production of these parts is 12000 to 12120 for 5 days, 8 hours shift. In existing system, final drive and idler wheel discs are the only parts that can be rebuilt within the stipulated time. In proposed lean scheduling, balance arm is consuming longer time than the available time. Other parts can be rebuilt within the scoped time for these parts (Table 1).

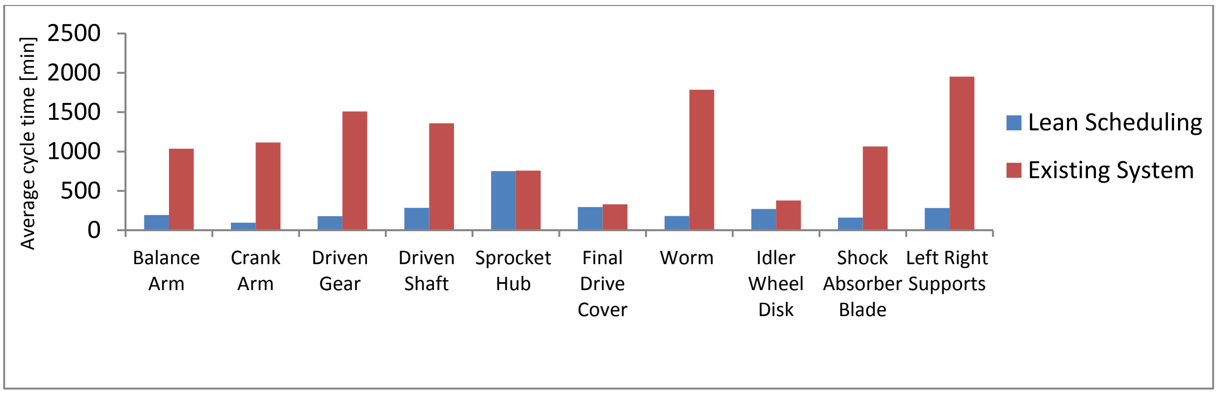

Fig. 4 Average cycle times for lean and existing system

Table 1 Average cycle times for lean and existing system

S. No.	Part	Qty	Existing system	Lean scheduling
1	Balance Arm	100	1034.8	193.24
2	Crank Arm	20	1115	97.75
3	Driven Gear	20	1507.7	178.65
4	Driven Shaft	20	1358.3	284.89
5	Sprocket Hub	20	757.7	751.11
6	Final Drive Cover	20	328.57	294.47
7	Worm	20	1785.4	181.81
8	Idler Wheel Disc	20	377.91	271.11
9	Shock Absorber	40	1065	160.76
10	Left, right Support	20	1950.9	282.3

5.3 Manufacturing lead time

Manufacturing lead times include time spent on value added and non-value-added activities. We have analyzed the existing situation with the intent to discover the effect of non-value addition on MLT. Unfortunately, the time spent on wastes is too large in comparison to the actual processing times. This scenario clearly indicates that there exists room for improvement in the existing systems and non-value addition times must be decreased to increase the productivity of the system (Fig. 5). In order to decrease these non-processing times, we implemented Kaizan, quick changeover and One Piece flow for our proposed system.

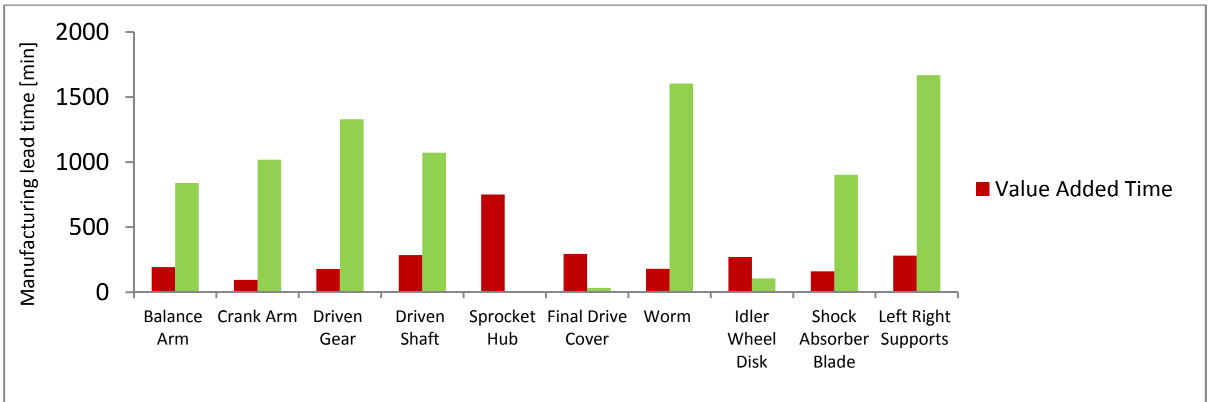

Fig. 5 MLT for lean and existing system

5.4 Lateness in delivery commitments

After analysis of the results in Fig. 6, we found that proposed system is also having lateness in production of one part, i.e. balance arms with lateness of about 4 days.

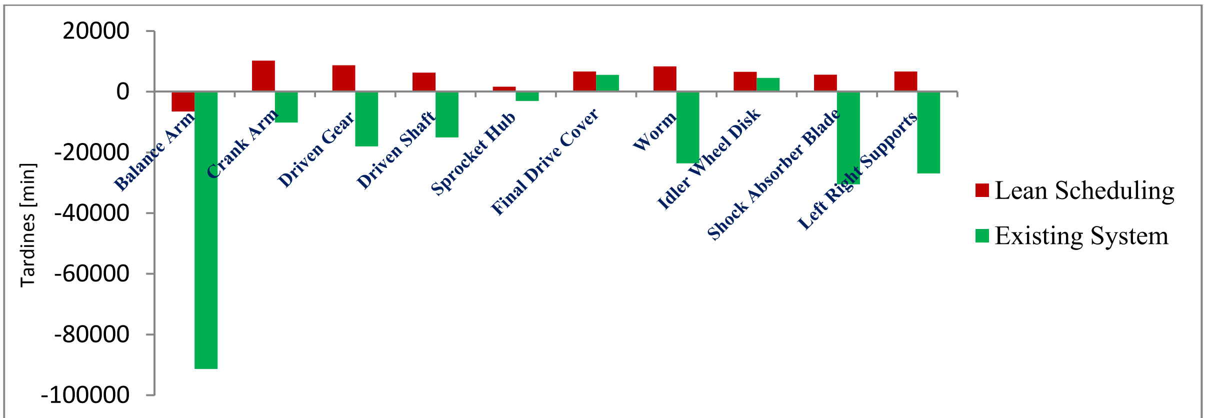

Fig. 6 Tardiness for lean and existing system

We reviewed the reasons for delay in processing of balance arms and found that these parts are being delayed due to extensive load on turning work stations and can be improved by reducing queue times at these workstations. However, existing system was facing severe tardiness and was unable to meet the production targets. Lateness in the existing system can be related with resource utilization given in section 5.7. Available time for rebuild of these suspension parts approximates from 12000 to 12120 based on 5 days, 8 hours shift. Results also reflect the need to review the planned targets for the job shop (Table 2).

Either the target of balance arms should be re-evaluated or efforts should be made to improve the process time on centre lathes for these parts. This can be done through use of tungsten carbide tooling to avoid unnecessary delays and reviewing the NC program for these parts.

Table 2 Tardiness for lean and existing system

S. No.	Part	Existing system	Lean scheduling
1	Balance arm	-91360	-7204
2	Crank arm	-10180	0
3	Driven gear	-18034	0
4	Driven shaft	-15046	0
5	Sprocket hub	-3034	0
6	Final drive cover	0	0
7	Worm	-23588	0
8	Idler wheel disc	0	0
9	Shock absorber	-30480	0
10	Left, right support	-26898	0

5.5 Throughput

We have plotted achieved throughput against monthly target for existing system and proposed lean scheduling (Fig. 7). We have again noticed that sprocket hubs and balance arms are not meeting the targeted deadlines for the proposed system. We have found that excessive queue times at turning work station are the reason for this delay and can be further improved if processing time and setup time can be reduced for these parts. These parts have higher setup times and this can be reduced through use of some specialized fixtures to accommodate speedy changeover of parts during machining. Existing system is capable to produce final drive cover and sprocket hubs in desired targeted quantity. It severely lacks in production of balance arms and left right supports (Table 3).

This job shop mostly seeks the support of sister job shops to help meet the targeted quantity. Our proposed system lacks in sprocket hubs mainly due to non-availability of broaching machine and balance arms due to heavy load on centre lathes.

Table 3 Throughput for lean and existing system

S. No.	Part	Targets	Existing system	Lean scheduling
1	Balance arm	100	12	62
2	Crank arm	20	11	20
3	Driven gear	20	8	20
4	Driven shaft	20	9	20
5	Sprocket hub	20	16	17
6	Final drive cover	20	20	20
7	Worm	20	7	20
8	Idler wheel disc	20	20	20
9	Shock absorber	40	11	40
10	Left, right support	20	6	20

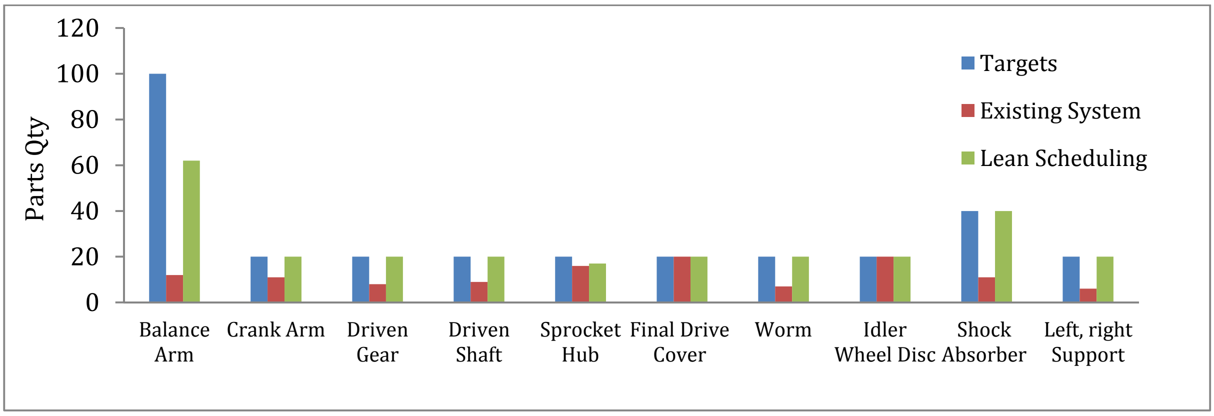

Fig. 7 Productivity for lean and existing system

5.6 Workplace utilization

Lean scheduling has been helpful to reduce the space requirement for parts waiting for processing at next stations (Fig. 8). Secondly, it has fairly reduced the work stations with provision of sophisticated work stations that are capable to perform multiple jobs. CNC milling centers can be used to replace lathes, milling, and drilling stations.

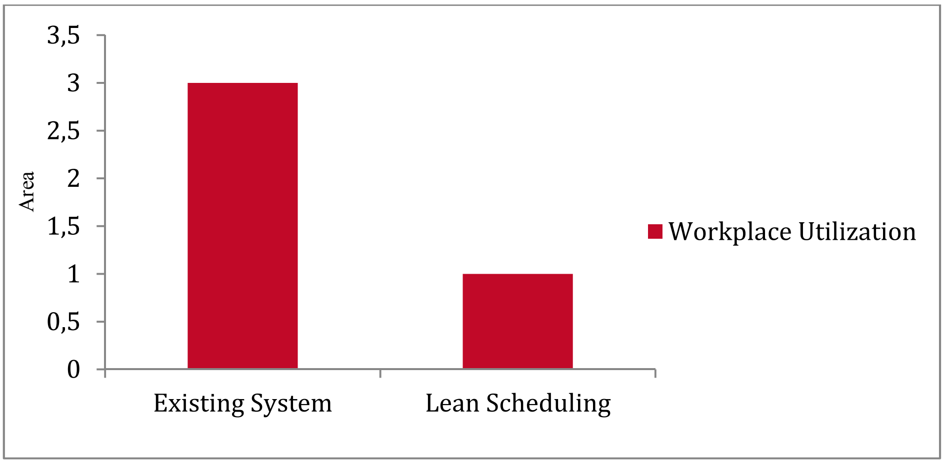

Fig. 8 Space utilization for lean and existing system

5.7 Resource utilization

Resource utilization is the ratio of available time and resource utilized time. Our research found it that most of the workstations are under-utilized. Some workstations, i.e., centre lathe and gear lathe, are causing unnecessary delays and contribute to larger waiting times for the parts in the queue. We identified improvements for these workstations. We suggested fixtures for these workstations to reduce setup times. These workstations were suffering lack of tooling for machining purpose. Secondly, there was longer time to replace the faulty parts due to lack of necessary inventory of capacitors, servo motors, belts, and gears. These improvements helped us to improve the mean time to failure and break down times. A comparative study of existing and proposed system is given in Fig. 9. We improved utilization through balancing of processing times and addressing the saurated and starving workstations.

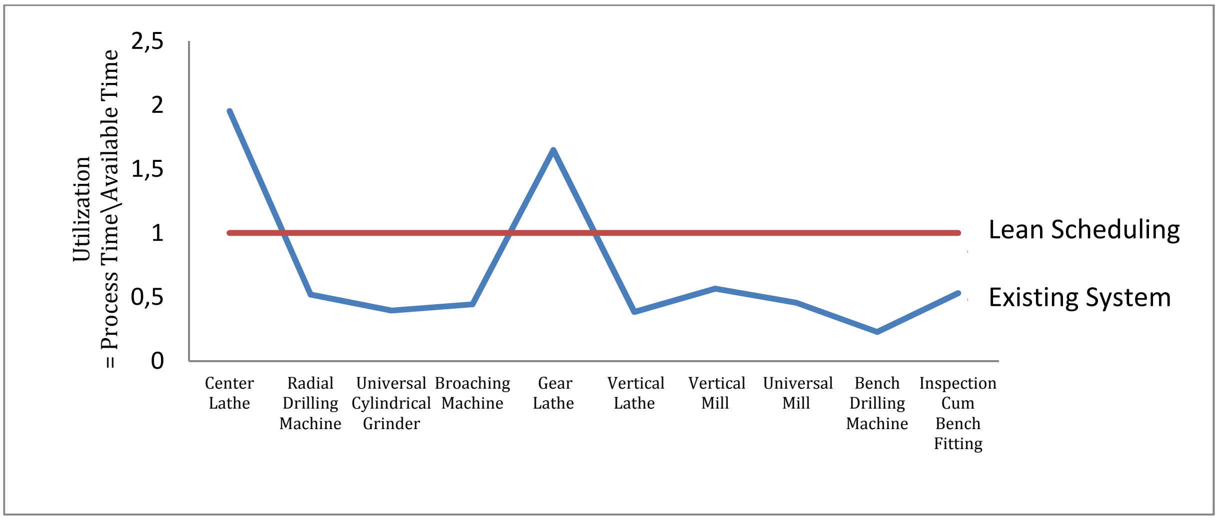

Fig. 9 Resource utilization

5.8 Cost analysis

Manufacturing cost for a product in production setup consists of fixed and variable costs. Variable costs change with the change in level of production activity. However, fixed costs remain constant and are not influenced by production activity. Manufacturing cost is mathematically represented as: *Total Cost = Fixed Cost + Variable Cost (Quantity of Parts)* [7, 16].

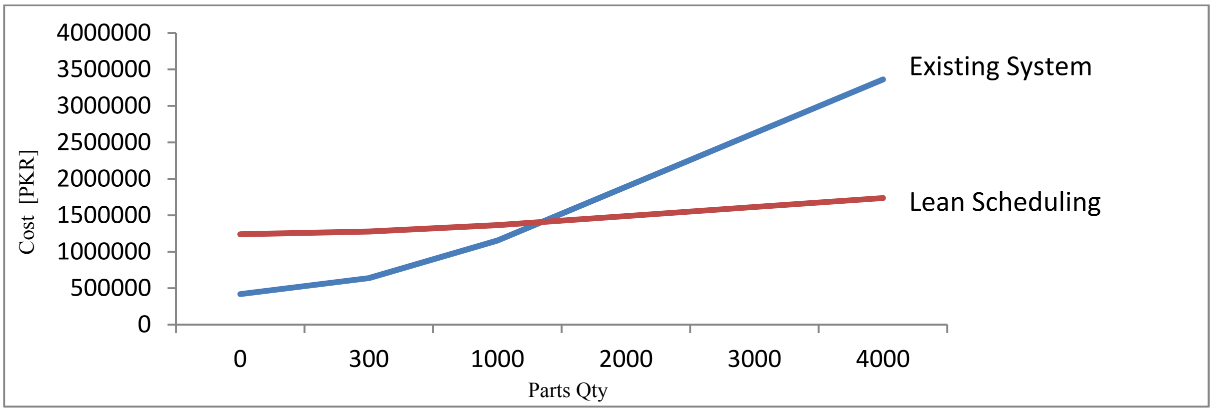

Fig. 10 Cost analysis for lean and existing system

Fixed and variable costs for existing system are 0.42 and 0.00074 Million PKR (1 US $ = 46 PKR.). Similarly, for proposed system these costs are 1.24 and 0.00015 Million PKR. We have performed the cost benefit analysis for both systems and found that proposed system will be beneficial after the production of 1500 parts (Fig. 10). PDO is producing 300 parts in one month (Fig. 11). It can be inferred from this cost analysis that lean system will be beneficial after passage of first five months.

These results showed that lean scheduling can be helpful in improvement of delivery times for job shop environment (Table 4). In problem statement, we have identified three major objectives for our study. These include on-time delivery, improved resource utilization and determination of exact production capacity of job shop. We were able to determine the exact targets for job shop. It was not possible to produce balance arms and sprocket hubs according to planned commitments within available resources. This work helped to propose suggestions for enhancement in resources to meet the targeted deliveries of balance arms and sprocket hubs.

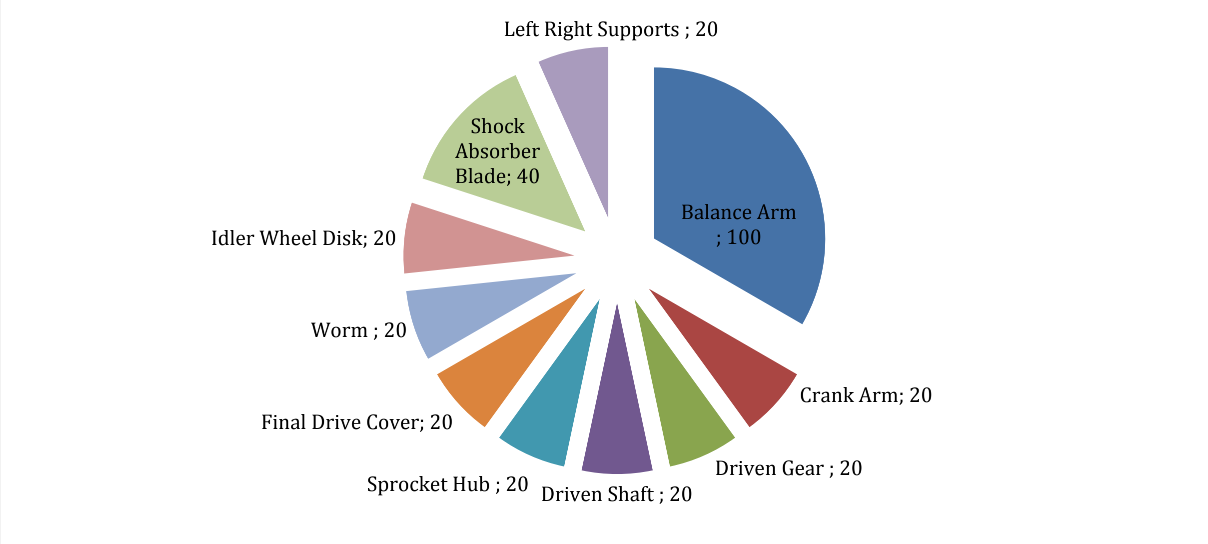

Fig. 11 Production targets of job shop

Table 4 Comparison of proposed and existing system

S. No.	Parameter	Unit	Existing system	Lean scheduling
1	WIP	no.	22.85	10
2	MLT_{avg}	Time (min)	2400.12	715.5
3	Space utilization	area	3	1
4	Cycle $time_{avg}$	Time (min)	1128.13	269.42
5	Throughput	no.	46.45	94.7
6	$Lateness_{avg}$	Time (min)	-20851	+4864.98
7	$Utilization_{avg}$	ratio	0.53	1.0

6. Conclusion and future work

Lean philosophy is preferred in manufacturing organizations due to its ability to produce the products at competitive prices. Lean scheduling is conceptually similar to lean manufacturing and revolves around elimination of wastes, continuous improvement, total preventive maintenance and quick changeover. Our implementation of lean in job shop reflected that lean scheduling is possible in job shop as well and can bring positive impact on manufacturing activity. It may be helpful to reduce the long lead times with reduction in non-processing times and implementation of 'One Piece flow'. Scalability of our proposed approach for larger setups needs validation. We have implemented our approach on one process, i.e. machining in job shop. There exists a lot of room to further expand it and implement it on the complete process flow of suspension parts. We have made few assumptions about the arrival times of the parts. Sometimes, predecessor activities may undergo delays and cannot be completed as desired. Such delays will effect our proposed approach. Another drawback of our proposed approach is requirement to alter the layout and make it feasible for cellular manufacturing. Alteration is a costly activity and organizations may not opt for it. We believed that inventory of parts to repair workstations will remain replenished all times. Last but not the least aspect of our proposed system is about the fixtures to reduce setup times on workstations. Feasibility to manufacture these fixtures needs to be validated for our proposed approach. Despite these consequences, we have been successful to provide a framework to make lean job shops. Our proposed approach has been successful to challenge the stereotype that lean is for mass production and is not feasible for smaller setups.

Our proposed approach can also be used for capacity planning of job shops and provide accurate targets for production activity. We are working on this concept to determine the production capacity of newly commissioned tool shop. Secondly, we are working on a proposal to provide ideal production layout for assembly of rebuilt parts for T-80 UD battle tanks.

Acknowledgement

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