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Reduction in Manufacturing Cycle Time cum Cost propels Productivity and Business growth in Aerospace Industries.

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Abstract- The manufacturing cycle time as well as cycle cost reduction of detailed and critical components which induces the opportunities of productivity and leads for business growth in aerospace industries. It can emerge as economy growth for nations. Major portion of budget of any country goes for purchasing, research, development and modernization of aircraft, helicopter, rockets, missiles etc. It is therefore required to focus to reduce manufacturing time cum cost of detailed and critical components for aerospace flying machines. This field creates an environment for revenue generation in our economies as well. The cost effective manufacturing of aerospace flying machines lead for cascading development in aviation industries. At low cost manufacturing generates more production of aerospace machines by immense engagement and effective utilization of men, machines, materials for revenue generation and stopping steep drainage of cash flow from economy of nation. This research will revolutionize to aerospace industrialists and manufacturers by focusing on, time reduction, cost reduction, quality improvement for high business growth in manufacturing. The growth in business can be done by enhancing productivity with respect to lowering manufacturing time and lowering manufacturing cost of aircraft, helicopters, satellite, rockets, space shuttle etc. The effectiveness of time reduction and cost reduction of detailed and critical components are the prime concerned parameters for productivity enhancement as well as business growth in aerospace manufacturing industries.

Index Terms- Manufacturing cycle time, Cycle cost reduction, Critical components, productivity, sustainability, aerospace industries.

I. Introduction

Aerospace industries are the industries of aircraft, helicopter, satellite, rockets, missiles, space shuttle etc. These industries manufacture the detail parts and critical components of aerospace machines which are assembled to fabricate the flying machines. Manufacturing in less time propel the cost reduction and enhance the productivity and business growth in aerospace segment. Manufacturing cycle cost is based on time elapsed at the rate of cost per unit time to manufacture, to move, to be in queue and to be inspected through manufacturing processes and value added in raw material.Manufacturing cycle time reduction is a very much challenging task for aviation and aerospace manufacturing organization. It has a confluence of many intricacies, factors, complex interaction of time elapsed in operations. If labour time be reduced, the delivery time also will be intently reduced, by reducing of different machining operations time. Reduction in operation time will lead reduction in delivery of helicopters, aircraft, satellite, rocket to our customers. This research will give a direction and guidance to manufacturers and industrialist as to how reduce the manufacturing time and cost under operations of machine, inspection, movement, queuing during manufacturing for detail and critical components of aircraft, helicopter and other aerospace flying machines. Cycle time consists of set up time, machine processing time, quality inspection time, transportation or move time and waiting time for loading in machine to machine.

The possibilities of manufacturability will be enhanced by emerging technology and new breakthroughs as artificial intelligence, robotics, Internet of Things, autonomous vehicles, 3-D printing/ additive manufacturing etc. They collect huge amounts of data from smart sensors through cloud computing for manufacturing of critical components and Industrial internet of things-IIoT which helped the manufacturing system to improve the efficiency of manufacturing design, machinability, supply chain of raw material and semi-finish components on machines and manufacturing production by time reduction and cost reduction. The applications of Industry4.0 and lean that have changed the manufacturing world. We have used it for aerospace manufacturing components also and found the results in data analysis later. A reduction in time and cost can emerge the opportunities for enhancing the productivity and emerging global business of aerospace manufacturing sector.

Productivity is the reduction of wastage in resources of men, machine, material, method, money, space etc in functional and operational premises. It is the ratio of output and input in same parameter of resources as man performance or man efficiency in term of man hour or standard man hour and machine performance or machine efficiency or machine utilization in term of utilized time w.r.t available standard time. We are more focused and concentrated in manufacturing time and cost reduction through optimizing the processing time, movement time, queuing time, inspection time during manufacturing. We have reduced both time and cost during manufacturing process and have improved the quality also.

Rational of study: At present scenario, the operational cycle time of components ofhelicopter, aircraft, satellite and rockets is very challenging. The components which are installed for functioning in different critical stage of helicopter, aircraft, aviation machines under critical conditions of functional run. Critical components are long cycle items; it takes more time to manufacture than other components. The significance of Critical components is much higher than other components with respect to functional sustainability and bear ability. More than 50% of total time of any aerospace flying machine is concentrated in manufacturing of critical and long cycle components; these are very high in weight, huge in volume and big in dimension & size. Thus operational cycle time is directly involved as a high gradient factor in term of time elapsed for aerospace flying machines. These components are very important during manufacturing because these have to work under high tension, compression, rotary dynamics and thrust condition. So its cost-effectiveness manufacturing is also required essentially to propel aerospace business. Every nation in the world is currently fighting with challenges in aerospace manufacturing. Every country has more and more demand of aerospace flying machines as aircraft, helicopter, satellite, rocket, space shuttle etc. Our aerospace industries are not able to match the supply of requisite demand of customers as of different nations. We know even all world class aerospace manufacturers as Boeing, Air bus, Euro copter, Bell, Rolls Royce, Lockheed Martin, Bombardiers, HAL etc. are far behind of their demand to supply to their customers. This is because of not able to manufacture these detailed and critical components on time as per demand of assembly line and spare demand for maintenance.

The raw materials which are loaded on machines to machining, manufacturing, fabricating as per design and drawing of intricate dimension with tolerance. As we know manufacturing depend on their manufacturing cycle time, manufacturing cycle cost, quality, risk to design and re-design for manufacturability as of having different contours and profiles with sophisticated dimension and tolerance. Component's manufacturing is the back bone of aerospace industries. The reduction in manufacturing time and manufacturing cost with maintaining the standard aerospace quality to mitigate the risk during manufacturing in material flow line.It is a propelling force for productivity of flying machines such as helicopters, aircrafts, satellite, rockets, space shuttles etc in aerospace manufacturing industries.

Literature Review: A lot of literature review has been done on manufacturing time, cycle time, lead time reduction as:

This framework provides an easy tool to industrial practitioner; they can use to determine a course of action to reduce manufacturing throughput time per part in their own plants by Danny

J. Johnson, 2003 [1].The framework is detailed to provide a direction and guidance to manufacturers to reduce throughput time. A flexible manufacturing system (FMS) consists of a set of workstations, capable of performing a number of different operations, interconnected by a transportation mechanism, (Joseph G. Kimemia, 1983 [2]. The setup time of machine, processing time on part, and move time of material or work in progress are independent of each other (i.e., a reduction in move time does not affect setup time or processing time per part, and so on), changes in any of these components of times, can affect the waiting time by Hyer and Wemmerlöv 2002 [3]. Waiting time is usually the largest of the four components, accounting for as much as 90% of manufacturing lead time in some systems by Houtzeel 1982 [4]. In Setup Time Reduction, the dedication of Workstation and family scheduling can also reduce the number of setup and its setup time of machines. Further information on improving setup procedures can be found in works by (Shingo, 1985 [5]. In Arrival variability, when workstation's machine utilization is low then departure variability is reduced as by increasing the number of identical resource at the workstation by Hopp and Spearman, 2001 [6]. By applying 5s, waste can be reduced. Waste could be in the form of scrap, defects, excess raw material unneeded items, old broken tools, and obsolete jigs and fixtures by Monden, 2012 [7]. The establishment of quality improvement efforts during manufacturing sector are delineated by Juran, 1999 [8]. Review on Cycle Time Reduction in Manufacturing Industries by Hiten Patel & Sanjay C. Shah, 2014 [9]. The initiation of effective preventative maintenance programs can be implemented for machines availability by Schonberger, 1996 [10] Reductions in manufacturing throughput time increases flexibility and respond to customer orders supply on time by Raj Mohan R & V.Senthil Kumar, 2013 [11]. Time to be measured as per operation or activities where machine and man are working, Taylor, 1985 [12]. "Industry 4.0 is the fusion of these technologies [AI, big data, IoT] and their interaction make the Fourth Industrial Revolution", World Economic Forum Klaus Schwab.[13]. Cost reduction by work study, method study,time study, bottlenecks of work study and work sampling or activities sampling are used in textile industries where similar machines, similar works on similar tasks are employed, Gopalakrishnan,

P. P. (1992),[14].Today global competitive environment has enforced manufacturing practitioners to deliver low-cost, high-quality products. Ghodsi, R. (2012),[15].Costing the value stream through lean manufacturing, Patrix, J. L. (2013)[16]. Overall Equipment Effectiveness is used as the measure of success of TPM implementation and losses for associated equipment effectiveness All the pillars of TPM are implemented in a phased manner eliminating the losses and thus improving the utilization of CNC machines. Singh, R. (2013),[17].Global market and increased competitiveness have driven companies to seek methods and tools that make them more competitive and have forced the manufacturing systems to able to react to demand changes to improve the production system through the reduction of time and costs. Helleno, A. L. (2015),[18].The extensive field of cost estimation for aerospace composite production, describing the basic methods of how to perform cost estimation and introducing some of the existing models for aerospace composite manufacturing with several strength, Ch. Hueber, K. H. (2016),[19].Aviation capital assets are characterized by huge Capital, long pay-off period, deep technology and maintenance intensive over their life cycle. Capital Investment Strategies for Target Revenue Generation under Performance Based Contracting for Aviation Assets through use of evolutionary algorithms, Vagrecha., G. S. (2016), [20]. The optimization in VSM is often verified by computer simulation (CS) before actual implementation in the factory. The two approaches imply in a different underlying way as a deterministic flow of material against a conceptual model of production stochastic queuing network. Dario Antelli, D. S. (2017),[21]. Product, operation, and route flexibility, as well as the starting-up and development flexibility assurance methods are described. The manufacturing systems classification based on the combination of different flexibility forms and its level is provided. Kapitanov, A. (2017),[22]. Lean manufacturing is an optimum approach for the reduction and elimination of waste within an organization. K.P. Lusiba, M. D. (2018),[23]. MOVE Measure was the new metrics that determined the transportation efficiency in terms of availability, performance and quality, all the factors being expressed in percentage. Cornelia, M. (2018),[24]. Line balancing was done to improve the cycle efficiency by reducing the no of work stations and thereby decreasing the manpower required. Sreekumar. (2019),[25]. The role of Industry 4.0 technologies on the relationship between lean production (LP) and operational performance improvement within Brazil, a developing economy context. LP practices help in the installation of organizational habits and mindsets that favor systemic process improvements, supporting the design and control of manufacturers' operations management towards the fourth industrial revolution era. Tortorella, G. L. (2019),[26].The applications of Additive Manufacturing (AM) have been grown up rapidly in various industries in the past few decades. Among them, aerospace has been attracted more attention due to heavy investment of the principal aviation companies for developing the AM industrial applications. Annamaria Gisarioa, M. K. (2019),[27].

GAP-1- Most authors have done work in different field such as automobile, steel plant, supply chain etc but not much in aerospace manufacturing as per available literature.

GAP-2: Being critical aerospace components, many more processes are involved than manufacturing of other sectors as automobile, agriculture, steel plant, food processing etc

GAP-3: There are not much available literatures which are focusing on time –cost conversion in aerospace field and also for critical components manufacturing area. This is for conversion of time into cost of activities/operations in manufacturing management system as on material flow from raw material loading on machine to finished product.

Research objective:

1) Analysis of manufacturing cycle time and cost for each operation.
2) Analysis of manufacturing cycle time of a component along all operations.
3) Analysis of manufacturing cycle cost to manufacture the entire components operations wise.
4) Analysis of queuing time and queuing cost.
5) Analysis of processing time and processing cost.
6) Analysis of inspection time and inspection cost.
7) Analysis of move or transportation time and transportation cost.

Research Methodology/ Data Collection/ Proposed Tool and Analysis:

Data collected for components of an aerospace machine of ABC aerospace industry and apply different approaches and methodologies towards objective of research.

Approaches/Tool/ Methodologies:

- Lean Manufacturing concept (5'S & 8-Waste)
- GT-Group Technology
- U-cell formation
- Toyota production system
- Industry4.0 (Robotics, automation, IIOT used on advance machines through satellite servers for manufacturing).

- CAD/CAM/CAE application
- TPM- Total production maintenance
- Resource effective utilization

Correct scheduling, material planning and operational planning is required to reduce the preparation time. More quantity of same kind of components in size and profile whose operation is same or similar, which have less number of batches and set up times are required to design to use for similar manufacturing processes. It may lead to consume less operational cycle time by self- inspection of machine operator, inspection done by machine itself as CMM-co-ordinate measuring machine, one piece flow concept, U-cellular concept in cell, a progress-person are available for immediate movement of parts/materials etc. It helps to reduce queuing time. An inspector at last of U-cell is arranged to inspect final product as well.

On above fixed condition, we have observed the existing manufacturing cycle times which are reduced to as arrived manufacturing cycle time against all operation and activities through observation before tool applied and after tool applied on conventional machines. The tool technology and con-current method engineering are applied to reduce the operation cycle time by using high version of machines which uses industry 4.0 tools, server data and cloud computing data. Unit set up time is reduced by advance programing in machines. Manufacturing operation time is reduced as per feasible design with ease manufacturing for complicated contour and profile of components. We have used below formula to find unit set up time during manufacturing. It will be used to calculate unit set up time of machines and found value which are in data table.

Manufacturing unit set up time= [{(Programing time + tool set up time) x No of batches change}/Total quantity].

We have used the above formula in data collection, data analysis and interpretation of results. It is developed as below analytical logic.

1) Unit set up time is reduced, if quantity is increased,
2) No of set up's time is reduced, if we use CNC machine instead of conventional machine,
3) Programming time is reduced, if we use CNC machine instead of conventional machine/ Numerical controlled machine.
4) No. of passes based on material grains and its dimensional size for cutting or machining. It is required for rough cutting and achieving final dimension as per drawing. The more pass is required for achieving final dimension of critical components.

The philosophy of productivity can be improved by creative and innovative design with low cost manufacturing with high quality and low rejection of detailed and critical components. Each and every renovating and innovative step are advancing productivity in aerospace manufacturing and growing business of aircrafts, helicopters, satellites, rockets, space shuttles etc. All requisite influencing factors are as time, cost, quality, risk mitigation which thrust productivity and business growth in competitive market of aerospace sector across the world. Most effective utilization of resources as men, machines, materials, money, process, methods with latest and cutting edge technologies thrust to the manufactured aerospace flying machines business.

It addresses to objective of research in aerospace industries with efficient and effective utilization of tools and techniques. The entire requisite as of Self-reliance, contemporary concurrent engineering tools and techniques, technology and skill men power with self-ability will increase levels of aerospace manufacturing capability. The creative design, least space utilization for installation of machine etc. that can also add value to yields high rate of revenue generation. We are using different technical method to improve productivity via value stream mapping of man, machine and process of machining operations. We are highly focused on time utilization of men and machines properly by job analysis, job evaluation, merit of methods, men and machines. The technology based methods which are as CAD, CAM, CAE, JIT, GT, TQM and Robotics etc. It helped in cost effective manufacturing and high rate of manufacturing production. The higher productivity will ensure the stability of aerospace and aviation industries in future. The higher volume of production increases rate of production and high revenue generation through business. The time reduction and cost reduction of components manufacturing will be happened by applied tool technology, high version machines and skilled man power.

We have applied different tools to enhance the productivity and business growth as below.

- Suitable product design for high vision so that not happen frequent product change.
- Standardization of material and product.
- Optimal machining parameter of machines is as speed, feed and depth of cut.
- Proper machine layout and plant layout to restrain unnecessary and avoidable movement of machine and material.
- Visionary, standardized method, standardize process to manufacture the components.
- Product varieties should be limited because if demand fails, it cannot run through high salvage cost of labour and material due to their non-matured design and non-standard process of manufacturing.
- Industry should run through not shortage of material, jig and fixture etc.
- High reliable manufacturing machine, associated devices to avoid frequent failure of machines in manufacturing management system.
- Control the idleness of men and machines, power failure of electricity, mechanical break and electrical break down of machines.
- Energy saving in machine shop means not consume energy unnecessary as a waste.
- Hygienic, ergonomic and safety covered manufacturing and working environment.

Data are collected at machine shop from ABC aerospace companies, associated suppliers & vendors and are morphed. The following data are taken for manufacturing of Rod Piston which is a critical component of hydraulic system for pressure transmission to operate and close to the system. It is used in the most of systems of aerospace, aviation and aeronautical machines. Therefore a similar part family components can be manufactured as per optimized way to reduce total cost of aerospace machines and this could be cost effective and time reductive way in manufacturing process by manufacturers across world and tools can be applied for any components.

1. Rod Piston : Conventional machine +Tools apply)

Machines, Bench	Operations	Set up time (Min)	After tool apply, Set up time (Min)	Machine run time (Min)	After tool apply, Machine run time (Min)	Existing Manufacturing Time = Set up time + Machine run time (Min)	Arrived Manufacturing time against m/c & operation after tools applying.(Improvement in Existing manufacturing system) (Min)	Difference between Existing time and Arrived time	MHR or Machine Hour Rate (Rs/ Hr)	Existing Manufacturing cost= Existing manufacturing time (in Hrs) X MHR (in Rs) or Existing operational cycle cost (In Rs)	Arrived Manufacturing cycle cost= Arrived operational time X MHR (in Rs)	Cost reduction =[Existing cost-Arrived cost] (In Rs)	% Cost reduction = [(Existing cost-Arrived cost)/ Existing cost]*100 (In %)
Cold Saw Lath	Cut as per requisite length	30	20	6	5	36	25	11	246	148	103	45	31
Conventional Lath	Hold in chuck and turn as per IS.	60	45	26	16	86	61	25	246	353	250	103	29
Conventional Lath	Hold in soft jaw and turn as per IS.	60	46	35	20	95	66	29	246	390	271	119	31
Deep hole drill	Gun drill of different dia as per IS	75	55	60	45	135	100	35	552	1242	920	322	26
Conventional Lath	Hold in soft jaw and form changes as per IS.	60	48	50	35	110	83	27	246	451	340	111	25
Conventional Lath	Hold in soft jaw and turn as per IS.	60	47	105	85	165	132	33	246	677	541	135	20
Conventional Lath	Hold between centers and turn as per IS	60	46	35	25	95	71	24	246	390	291	98	25
Conventional Lath	Hold in soft Jaw and turn as per IS.	60	49	10	8	70	57	13	246	287	234	53	19
Center hole Grinder	Clean Centers as per IS.	60	44	11	7	71	51	20	591	699	502	197	28
Cylindrical grinding	Grind as per IS	60	48	120	90	180	138	42	591	1773	1359	414	23
Drilling m/c	Load in drill Jig and carry out as per IS.	60	45	32	22	92	67	25	224	343	250	93	27
Bench	Form chamfer as per IS.	10	8	50	40	60	48	12	80	80	64	16	20

Vertical Milling	Hold in fixture and mill slot as per IS.	60	46	20	15	80	61	19	254	339	258	80	24
Bench	Deburr and mixed up steps.	5	4	35	21	40	25	15	80	53	33	20	38
Center hole Grinder	Clean center and facilitate further operations.	60	48	15	9	75	57	18	591	739	561	177	24

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Vertical Milling	Hold in fixture and mill as per IS.	60	47	12	8	72	55	17	254	305	233	72	24
Bench	Deburr and mixed up the sharp edges in the slot.	60	45	20	14	80	59	21	80	107	79	28	26
Center hole Grinder	Clean centers.	60	46	15	9	75	55	20	591	739	542	197	27
Cylindrical Grinding	Hold in split bush and grind.	60	47	165	140	225	187	38	591	2216	1842	374	17
Cylindrical Grinding	Hold in split bush and grind as per IS.	60	48	30	21	90	69	21	591	887	680	207	23
Bench	Debur and break sharp edges.	10	8	20	12	30	20	10	80	40	27	13	33
Bench	Part numbering	5	4	3	2	8	6	2	80	11	8	3	25
TOTAL		1095	844	875	649	1970	1493	477		12266	9388	2878	23

We have done data analysis from tables and modeling charts to see the result as per objective as below:

Table-1	Time & Cost
Set up time (Min)	1095
After tool apply, Set up time (Min)	844
Machine run time (Min)	875
After tool apply, Machine run time (Min)	649
Existing Manufacturing Time= Set up time + Machine run time (Min)	1970
Arrived Manufacturing time against m/c & operation after tools applying.(Improvement in Existing manufacturing system) (Min)	1493
Difference between Existing time and Arrived time	477
Existing Manufacturing cost= Existing manufacturing time (in Hrs) X MHR (in Rs) or Existing operational cycle cost (In Rs)	12266
Arrived Manufacturing cycle cost= Arrived operational time X MHR (in Rs)	9388
Cost reduction =[Existing cost- Arrived cost] (In Rs)	2878
% Cost reduction =[(Existing cost- Arrived cost)/Existing cost]*100 (In %)	23

Chart-1

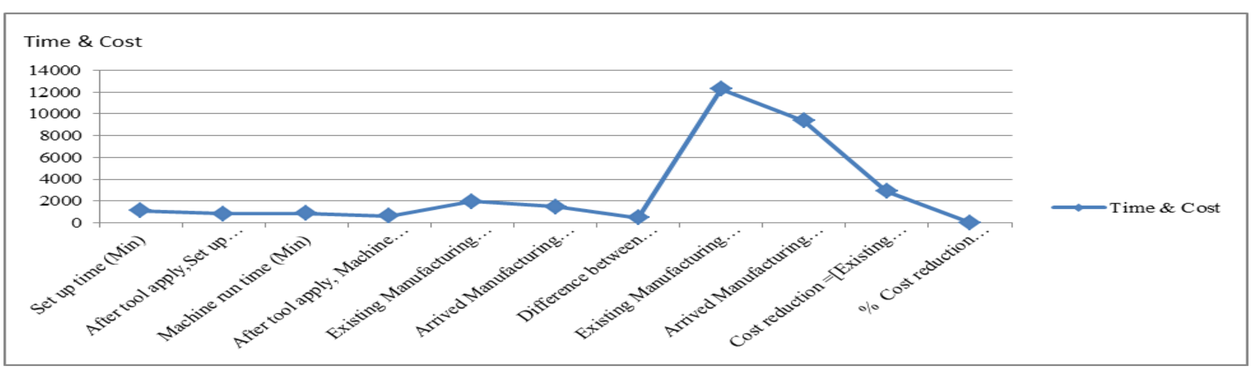


Table-2

	Existing	Arrived after tool apply
Set up time (Min)	1095	844
Machine run time (Min)	875	649
Manufacturing Time= Set up time + Machine run time (Min)	1970	1493
Manufacturing cost= Existing manufacturing time (in Hrs) X MHR (in Rs) or Existing operational cycle cost (In Rs)	12266	9388

Chart-2

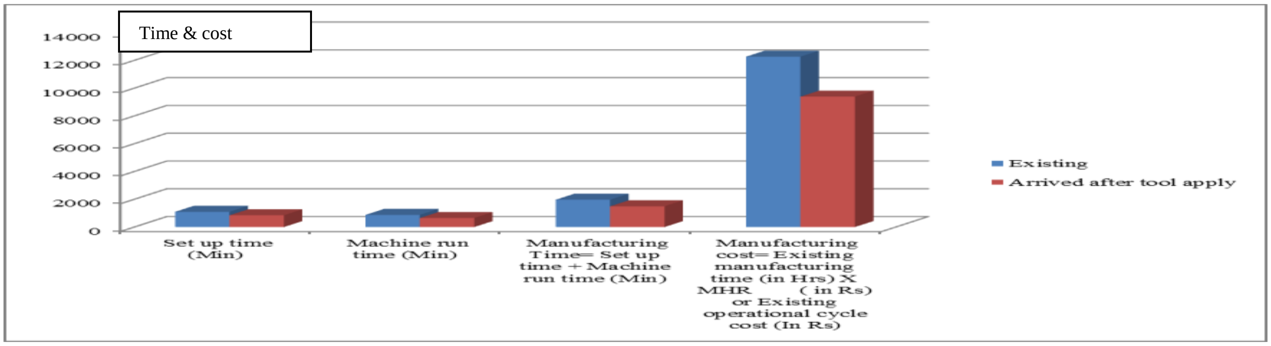


Table-3

	Time (Min)
Existing Manufacturing Time= (Set up time + Machine run time) (Min)	1970
Arrived Manufacturing time against m/c & operation after tools applying.(Improvement in Existing manufacturing system) (Min)	1493
Difference between Existing time and Arrived time	477
% of Average Time reduction = [(Existing time- Arrived time)/Existing time]*100 (In %)	24

Chart-3

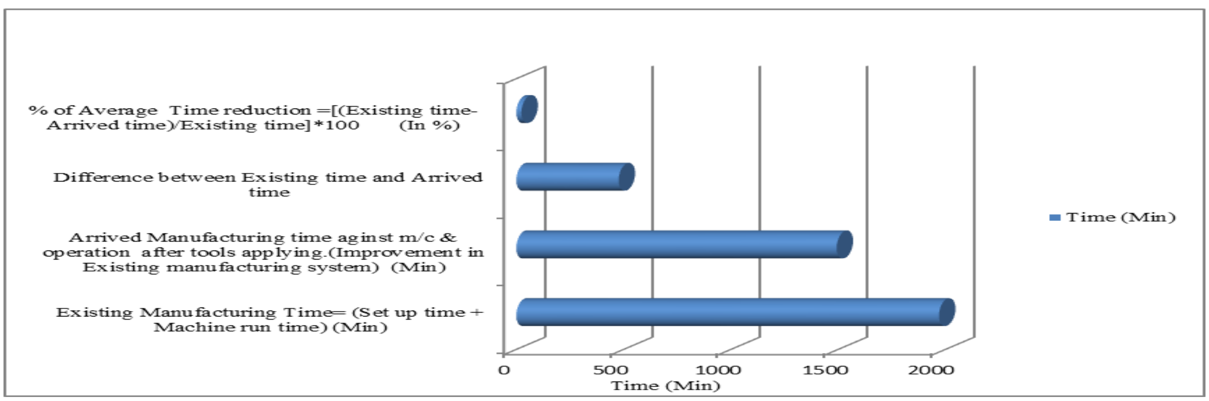
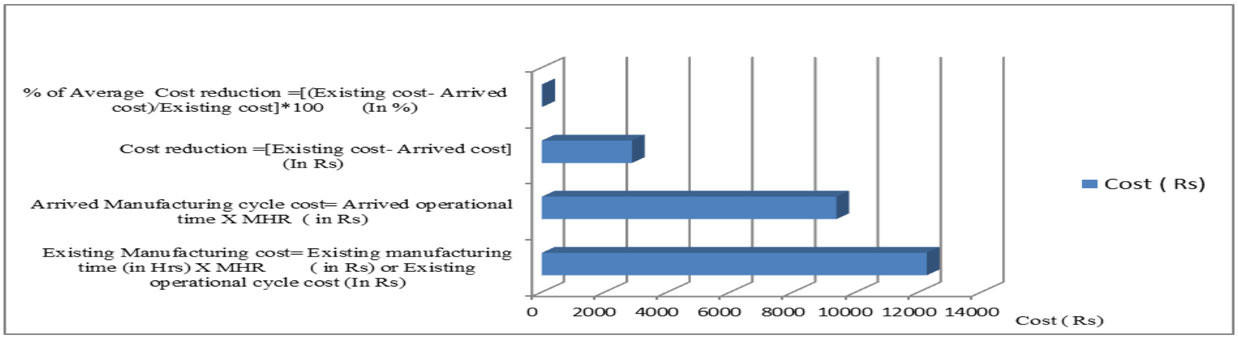


Table-4

	Cost (Rs)
Existing Manufacturing cost= Existing manufacturing time (in Hrs) X MHR (in Rs) or Existing operational cycle cost (In Rs)	12266
Arrived Manufacturing cycle cost= Arrived operational time X MHR (in Rs)	9388
Cost reduction =[Existing cost- Arrived cost] (In Rs)	2878
% of Average Cost reduction = [(Existing cost- Arrived cost)/Existing cost]*100 (In %)	23

Chart-4



We have measured the time and established a correlation with basic machining time by observation of activities as movement time (M=@30% of B.T), Queue time (Q=@25%of B.T), Inspection time (I=@20%of B.T).where B.T is basic time. This is based on after measuring the value and established the relation among them.

Table-5

Operations / Activities	Existing	Arrived after tool apply
Total Manufacturing operation Cycle Time= (Total machine set up time+ Total machine run time) (In Min)	1970	1493
Movement time= @30% of Basic total time (In Min)	591	448
Queue time or Waiting time = @25% of Basic time (In Min)	493	373
Inspection time = @20% of Basic time (In Min)	394	299
Total MCT (In Min)	3448	2613

Chart-5

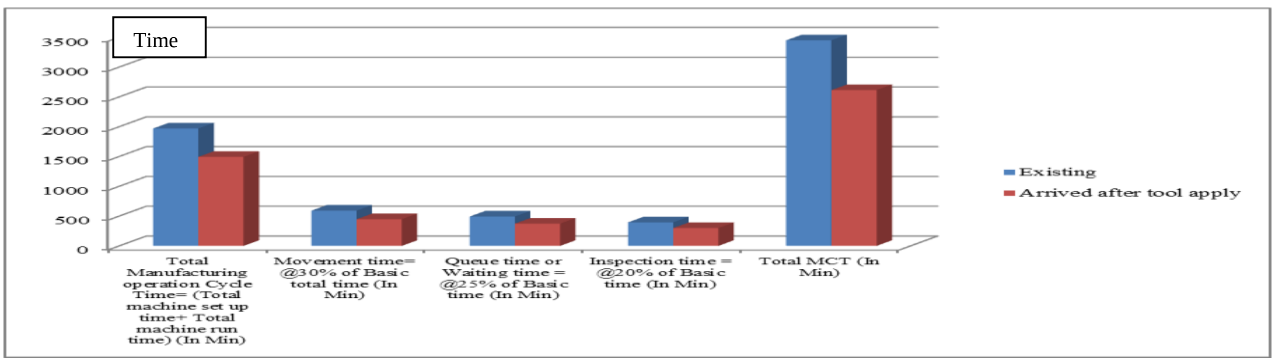


Table-6

Operations / Activities	Existing	Arrived after tool apply
Manufacturing Cycle Cost (MCC) (In Rs)	12266	9388
Movement Cost = Movement time/60 x SMHR @ Rs 1020	10047	7614
Queue Cost or Waiting Cost = Queue or Waiting time/60 x SMHR @Rs 1020 (In Rs)	8373	6345
Inspection Cost = Inspection Time/60 x SMHR @ Rs 1020 (In Rs)	6698	5076
Total MCC (Rs)	37383	28424

Chart-6a

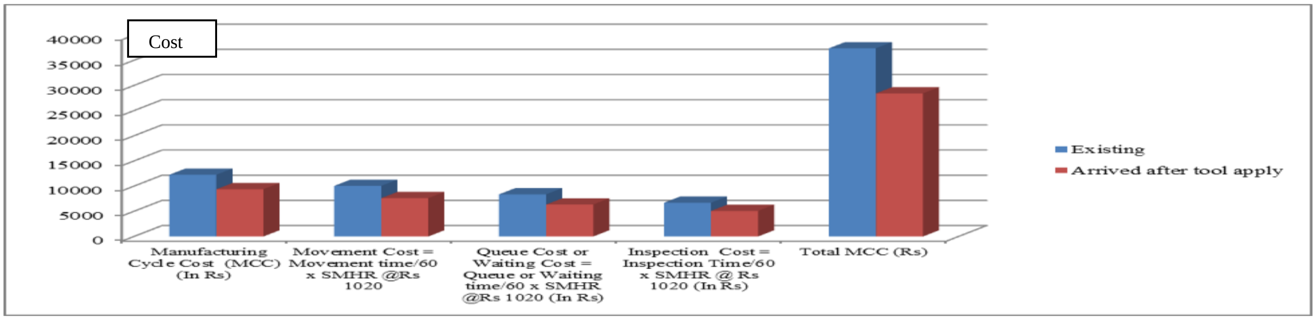


Table-7

Time & Cost	Existing	Arrived by tool apply
Total MCT (Min) = (Manufacturing time+ Movement time + Queue time + Inspection time)	3448	2613
Total MCC (Rs) = (Manufacturing operation cost + Movement cost + Queue cost + Inspection cost)	37383	28424

Chart-7

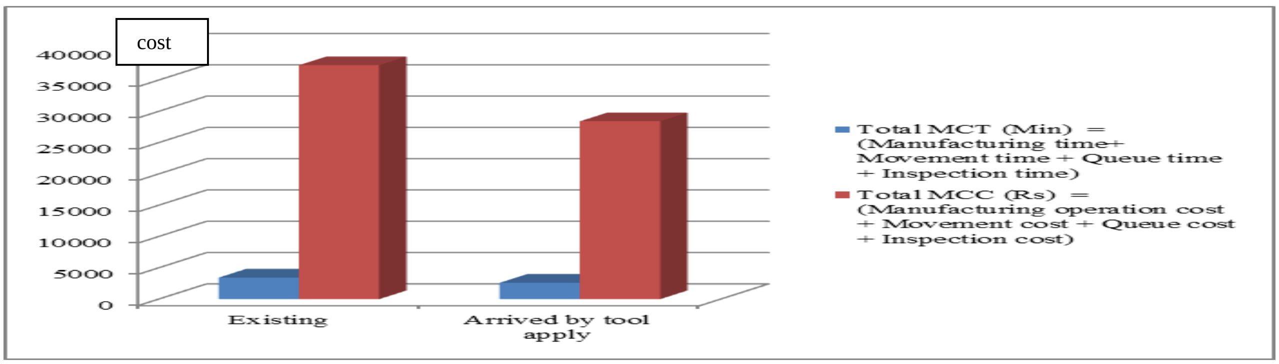


Table-8

Operations	Existing time (In Min)	Arrived Time after tools applying (In Min)	Existing cost (In Rs)	Arrived cost after tool apply (In Rs)
Total Manufacturing Time & Cost by Machines as (MCT & MCC) (In Min & Rs)	1970	1493	12266	9388
Movement Time & Cost (In Min & Rs)	591	448	10047	7614
Queue Time & Cost (In Min & Rs)	493	373	8373	6345
Inspection Time & Cost (In Min & Cost)	394	299	6698	5076
Total MCT & MCC (In Min & Rs)	3448	2613	37383	28424

Chart-8

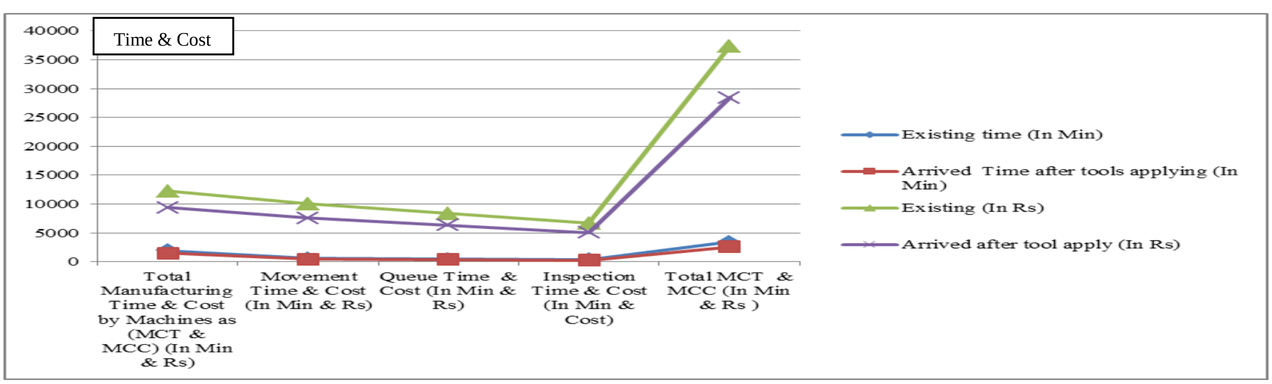


Table-9

Operations	Existing time (In Min)	Arrived Time after tools applying (In Min)	Existing cost (In Rs)	Arrived cost after tool apply (In Rs)
Total MCT & MCC (In Min & Rs)	3448	2613	37383	28424

Where- [MCT-Manufacturing Cycle Time, MCC-Manufacturing Cycle Cost] The productivity w.r.t time and cost is occurred as:
Productivity w.r.t time = [Existing Manufacturing Cycle Time/Arrived Manufacturing Time].
=3448/2613 = 1.32 = [1+0.32].
It means manufacturing productivity is increased by 32% w.r.t time.
Productivity w.r.t Cost = [Existing Manufacturing Cycle Cost/Arrived Manufacturing Cost].
= 37383/28424 = 1.32 = [1+0.32].
It means manufacturing cost productivity is increased by 32%. In another word, we can say the amount of reduced time produces extra component by 32% so that the reduced cost can boost business growth by 32%.The amount of cost reduction in manufacturing enhance the revenue generation for extra portions towards business growth.

Findings/ Results/Inferences:

1) The manufacturing cycle cost is reduced.
2) The operational cycle time is reduced.
3) Enhanced productivity and business growth of components as well as integrated aerospace machines.
4) Reduced the idle time of man and machines during manufacturing activities and stages.
5) Man power is reduced for prefixed existing load on machines.
6) The movement of components is reduced.
7) To deliver the components as aerospace machines to customer on time or in less time.
8) Reduced the movement time and movement cost.
9) Reduced the queue time and queue cost.
10) Reduced inspection time and inspection cost.
11) Reduced total manufacturing cycle time and total manufacturing cycle cost.

Limitations:

1) High capital is involved to execute the layout change, revival of old machines and purchasing high capital machines.
2) Space constraint is there in cell or near to machine shop, to set up the low cost and small sized heat treatment shop and processing shop.
3) Skilled operators are required for CNC machine.
4) Heat treatment shop & process shop should be in order or just near to machine shop to reduce the movement time of material for concerned operation.
5) Provisioning of high cost machines.
6) Lack of budget allocations for new technology and advance machines.

Significance of study and Contribution to nature of research:

1) It gives a model of philosophy and awareness to focus on details/critical components to optimize entire activities during manufacturing w.r.t time & cost reduction, quality improvement and waste reduction.
2) Requirement of focusing on initial design phase of aerospace components w.r.t manufacturability which can refrain from 80% loss of cost by immature designed in aerospace sectors.
3) Cost reduction and time reduction is occurred.
4) Timely delivery of aviation components is possible to customers.
5) Quality can be enhanced by applying CAD, CAE & CAM technology.
6) To reduce and control the excess hours which are used in conventional machine or older machine of all kinds.
7) Improve productivity of aviation and aerospace machines production.
8) Lead time reduction for components and assembled aircraft/helicopter/satellites/rocket in industries.
9) Reduce engineering personal requirements in organization.
10) Reduced manufacturing cost of entire assembled flying machines or their detail components.
11) Enhanced the productivity and sustainability of business growth in aerospace industries due to manufacturing cycle time reduction and cost reduction of critical components and non-critical components.

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