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EFFICIENCY AUGMENTATION IN THE ASSEMBLY SECTION OF POSITIVE DISPLACEMENT COMPRESSORS BYSIX SIGMA-DMAIC METHOD WITH TRIZ CONCEPT

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ABSTRACT: The demands of the ever-evolving markets require constant alteration of client bids. Developing and continuously improving quality and environmental management systems would berequired to predict these changes and thus completely meet each partner's needs and desires, also upholdviablebenefit. One of the ways to achieve operational excellence is through the introduction of various quality assurance programs such as Total Quality Management, Agile & Lean manufacturing, ISO certification, etc. Real life has shown that these initiatives are neither time efficient nor profitable in terms of quality. It has therefore been proven that the introduction and implementation of the Six Sigma methodology provide good results. This research introduces creative solution to improve assembly process in a positive displacementAssembly Unit.Here the Six sigma DMAIC is integrated with TRIZ to enhance the output quantity of positive displacement Assembly Line.

Keywords: DMAIC, TRIZ, Line balancing, Time study, Productivity

I. INTRODUCTION

1.1.SIX SIGMA:

Six Sigma a standardized technique for preventing errors in any operation within six standard deviations between mean and nearby design limit.Six Sigma improves business process capability, rise in efficiency,reduce failures and enhance revenues. This Six Sigma view acknowledges the underlying and rigorous approach known as DMAIC (defining, measuring, analyzing, improving and controlling). DMAIC defines the steps to be taken by a Six Sigma practitioner, beginning with the identification of the problem and end with long-lasting solutions implemented. DMAIC is one of the extensively used methodology of sig sigma.Roadmap of DMAIC in given in Figure.1.

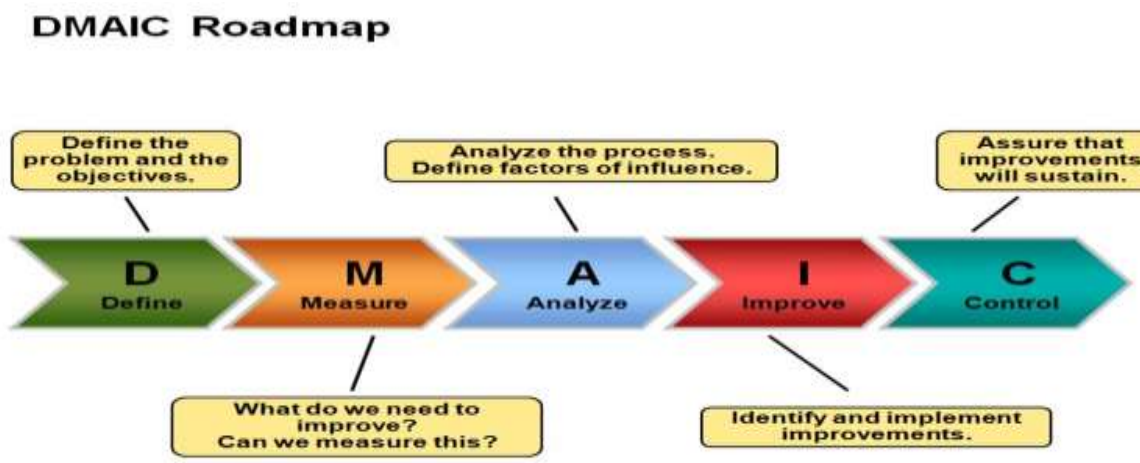

Figure.1:DMAIC Roadmap

1.2TRIZ:

TRIZ (Inventive Problem Solving Theory) employed to recognizeand resolvesnags that makes clear thinking and developing innovative ideas. The inventive problem concerning a contradiction and footpath to a solution which is unknown.

The study has produced three major outcomes:

- There are frequent challenges and approaches across sectors and across sciences
- Repeated patterns of technical evolution.
- The innovations used systematic effects outside the arena in which they were established

TRIZ specialists apply all these judgments in order to produce and to increase products, services, and structures. TRIZ definition is given in Figure 2.

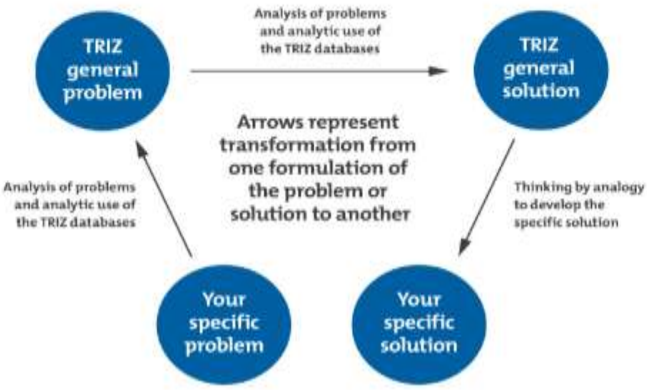

Figure.2:TRIZ Definition

II. LITERATURE REVIEW

The rapidly changing development demands, such as consumer demand for high-quality product, goods range, and global constraints and less task time, etc., have a major impact on manufacturing industries. Six sigma is an accurate technique for reducing wasteful activities in an assembly shop without abandoning efficiency(Krishna Priya S et al., 2019). In the given ongoing process, a sustainable improvement is sought, without interrupting the workflow. Methods for process improvement are Six Sigma, Lean Management, Continuous Improvement (KAIZEN), Total Quality Management (TQM), Business Process Reengineering (BPR). Work Research is a methodology intended to research the work done in an organization and to evaluate the optimal and profitable method of using the existing resources to achieve the maximum possible efficiency (Raghunath G. Kulkarni et al.,2018). The achievement of these improvements depends on many factors that may be related to each company's labor costs and investment capacity (P. Dias, F. J. G. Silva et al., 2019). The problems that lie ahead in the current economic environment are big, demanding cost reduction and improved productivity, without innovation. The only way to address this situation is in product and/or process optimization (Conceicao Rosa et al., 2017).

Process specifications are commonly seen to be not only symmetrical but also asymmetrical, and generally the manufacturing process has unknown parameters. Sampling is therefore necessary for estimation while the samples do not necessarily have normal distributions (Ching-Hsin Wang et al., 2019). Improving value-added practices by growing variability is a fundamental concept, because variance introduces time delays, increased costs and a lesser amount of efficiency to what was previously generated. Development in the methodology can proceed when a Lean Six Sigma initiative is established in a systematic and structured manner and the organization is controlled to enforce the progress and drive the colleagues through the shift appropriately. Remarkably it's about getting together and sharing successes (Carolina Rojas Alfaro et al., 2020). Six Sigma philosophy does have two strategies: DMAIC (D-Define, M-Measure, A-Analyze, I-Improve, C- Control), relevant to aprevailing platform and relevant to new product development or procedures to be constructed and/or proposed in a way which will deliver Six Sigma output (Pugna A et al., 2016).

In recent times, a groundbreaking principle of creative problem-solving methodology (TRIZ) has been widely integrated into product development systems, the results show that the Six Sigma incorporated with TRIZ framework can be used efficiently in the improvement of new Product/Process (Fu-Kwun Wang et al., 2016). TRIZ's value as a tool for finding innovative solutions to problems resides in removing inconsistencies more willingly than using the conventional procedures by concessions (Ismail Ekmekci, EmineElifNebati. 2019). On the other hand, as its success & beauty seem to be on a stabled rise, several functional issues that put together the application of TRIZ methodology especially tricky in action. TRIZ research has mostly ignored those realistic difficulties (Imoh M. Ilevbare et al., 2013). The integration of conventional and programmed approaches increases administrative abilities of specialized routine techniques (Alberto Alfonso Aguilar-Lasserre et al., 2018). The method's success is attributed to its applicability to nominal dilemma, implementation efficiency plus the team's expertise meeting a specific task (ChhabinPokhrel et al., 2015). Finally, it's necessary to reiterate that work on TRIZ's position in Sustainable Product-Service Systems (SSPSS) growth is highly relevant to academics and businesses. Contradictions are usually settled by consensus approaches. However, TRIZ allows reasonably workable of innovative product.

III. RESEARCH METHODOLOGY

Table.1: Tools and Techniques used in DMAIC Phases

PHASE	ACTIVITIES	TOOLS & TECHNIQUES
DEFINE	Define process and its problem	Process Mapping
MEASURE	Data Collection of Existing System	Time Study
ANALYSIS	Root cause of the problem and opportunities for improvement is analyzed.	Brainstorming
IMPROVE	Based upon the outcomes of Analysis phase implementing the necessary tools and techniques to solve the issues	TRIZ
CONTROL	After the implementing the tools and techniques which is presented in improve phase, the sample tests were performed to find out he variability and process improvements	Control Charts

3.1.DEFINE

In this phase the process steps in the Assembly line is given in Figure3. and the activities in each station is given in the Table2.

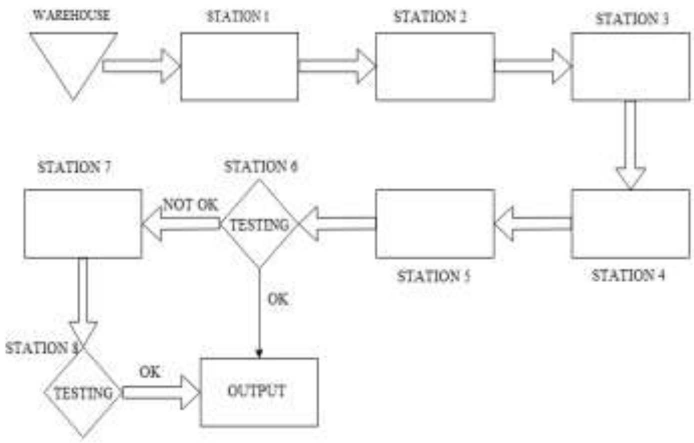

Figure.3: Process steps in Assembly line

Table.2: Activity -Process Chart

S.NO	PROCESS	ACTIVITY
1	WAREHOUSE	STORAGE OF PARTS
2	STATION 1	ASSEMBLY OF MOTOR,TOP BLOCK, STARTER PLATE, JOB CARD, MOTOR TECHNICAL DESCRIPTION PLATE FITTINGS
3	STATION 2	FAN FITTING AT TOP BLOCK ASSEMBLY, BELT ATTACH, STICKERING
4	STATION 3	FITTING OF PRESSURE GUAGE,SOLENOID VALVE, PRESSURE SWITCH, AFTER COOLER PIPE, STARTER SWITCH
5	STATION 4	FAN GUARD , PRESSURE SWITCH COVER OPEN
6	STATION 5	MOTOR WIRING, PRESSURE SWITCH WIRING, AIR FILTER ASSEMBLY, MAINTENANCE CARD STICKERING
7	STATION 6	TESTING
8	STATION 7	REPAIR CENTRE
9	STATION 8	TESTING
10	OUTPUT	FINISHED PRODUCT

3.2. MEASURE

3.2.1. TIME STUDY

Table.4: Time taken at each station.

S.NO	PROCESS	ACTIVITY	MAN POWER	TIME TAKEN IN MINUTES			AVERAGE TIME TAKEN FOR SINGLE PIECE OUTPUT
				OBSERVATION			
				1	2	3	
1	WAREHOUSE	TRANSPORT TO SHOP FLOOR	1	2	2	2	2
2	STATION 1	ASSEMBLY OF MOTOR,TOP BLOCK, STARTER PLATE, JOB CARD, MOTOR TECHNICAL DESCRIPTION PLATE FITTINGS	2	4	5	4	4.33
3	STATION 2	FAN FITTING AT TOP BLOCK ASSEMBLY, BELT ATTACH, STICKERING	3	6	7	6	6.33
4	STATION 3	FITTING OF PRESSURE GUAGE,SOLENOID VALVE, PRESSURE SWITCH, AFTER COOLER PIPE, STARTER SWITCH	2	5	4	5	4.66
5	STATION 4	FAN GUARD , PRESSURE SWITCH COVER OPEN	2	4	5	5	4.66
6	STATION 5	MOTOR WIRING, PRESSURE SWITCH WIRING, AIR FILTER ASSEMBLY, MAINTENANCE CARD STICKERING	2	5	4	5	4.66
7	STATION 6	TESTING	4	8	7	9	8
8	STATION 7	REPAIR CENTRE	5	12	8	11	10.33
9	STATION 8	TESTING	4	8	9	8	8.33
10	OUTPUT	FINISHED PRODUCT TRANSPORT	1	1	1	1	1
TOTAL			26	55	52	56	54.33

100 % PRODUCTION CAPACITY = (MANPOWER X WORKING MINUTES) / (STANDARD ALLOCATED MINUTES (S.A.M))

= (26 X 600) / (54.33)

= 287.13 PIECES PER DAY

3.2.2. ACHIEVED OUTPUT

Table.5: Output data for the month between July to December.

S.NO	MONTH	ACTUAL ACHIEVED OUTPUT	100% OUTPUT CAPACITY	OUTPUT EFFICIENCY IN %
1	JULY 2019	3378	7465	45.25
2	AUGUST 2019	3393	7465	45.45
3	SEPTEMBER 2019	3342	7465	44.76
4	OCTOBER 2019	3365	7465	45.07
5	NOVEMBER 2019	3327	7465	44.56
6	DECEMBER 2019	3359	7465	44.99
	AVERAGE OUTPUT PER MONTH	3361	7465	45.02

IV. ANALYSIS

Figure.4: Why-Why Analysis

V. IMPROVE & CONTROL

5.1 TRIZ

Table 6: Contradiction identified for improving productivity in assembly line

Worsening Feature Improving Feature	Ease of Manufacture (Contradiction No:32)
Productivity (Contradiction No:39)	Principle No: 35 Parameter Changes Principle No: 28 Mechanical Substitution Principle No: 2 Taking out Principle No: 24 Intermediary

The explanations (Altshuller 40 Inventive principles, 1997a) the principles listed above were adopted and the most suitable principle was chosen as Principle Number 28, The Mechanical Substitution, which says to replace a mechanical means, physical fenceand to alert gas leakage with smelling compound also to use electromagnetic fields to interact with entity.

Transformation from inert to mobile fields, from amorphous fields to those having structure.

After extensive analysis and comparisons, followed for all sorts of alternative technologies, it is then recommended that tools be made in a fixed position and that all other machinery be handled by mechanical weight handling devices and motorized machinery. As a result, efficiency can be increased, Automation cuts the time by almost half than the manual.

The major issue for low production output was identified as improper line balancing. The Stop watch Time study clearly shows that the major time consuming stations are 3,7,8,9. So Man power is increased at several stations and their Time study is shown in Table 7.

Table.7: Time Study after Line balancing

S.NO	PROCESS	ACTIVITY	MANPOWER		TIME TAKEN IN MINUTES			AVERAGE
					OBSERVATION			
			BEFORE	AFTER	1	2	3	
1	WAREHOUSE	TRANSPORT TO SHOP FLOOR	1	1	2	2	2	2
2	STATION 1	ASSEMBLY OF MOTOR,TOP BLOCK, STARTER PLATE, JOB CARD, MOTOR TECHNICAL DESCRIPTION PLATE FITTINGS	2	2	4	5	4	4.33
3	STATION 2	FAN FITTING AT TOP BLOCK ASSEMBLY, BELT ATTACH, STICKERING	3	4	6	5	6	5.66
4	STATION 3	FITTING OF PRESSURE GUAGE,SOLENOID VALVE, PRESSURE SWITCH, AFTER COOLER PIPE, STARTER SWITCH	2	2	5	4	5	4.66
5	STATION 4	FAN GUARD , PRESSURE SWITCH COVER OPEN	2	2	4	5	5	4.66
6	STATION 5	MOTOR WIRING, PRESSURE SWITCH WIRING, AIR FILTER ASSEMBLY, MAINTENANCE CARD STICKERING	2	2	5	4	5	4.66
7	STATION 6	TESTING	4	5	6	7	6	6
8	STATION 7	REPAIR CENTRE	5	8	7	6	7	6.6
9	STATION 8	TESTING	4	5	6	5	6	5.66
10	OUTPUT	FINISHED PRODUCT TRANSPORT	1	1	1	1	1	1
TOTAL			26	32	46	44	47	45.66

VI. RESULTS AND DISCUSSION

Table.8: Output comparison after implementation

S.NO	MONTH	ACTUAL ACHIEVED OUTPUT	OUTPUT AFTER IMPLEMENTATION
1	JULY 2019	3378	3784
2	AUGUST 2019	3393	3821
3	SEPTEMBER 2019	3342	3749
4	OCTOBER 2019	3365	3752
5	NOVEMBER 2019	3327	3729
6	DECEMBER 2019	3359	3897
	AVERAGE OUTPUT PER MONTH	3361	3789

The manpower is increases from 26 to 32, The average Time taken for assembly process is reduced from 54.33 to 45.66.The Table.7 clearly shows the difference in output rate before and after implementation. The average output rate is increased from 3361 to 3789 per month. The work can be further continued by analyzing the motion study for each and every activities carried out in each station of assembly line.

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