International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No.04, April 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

Improvement of quality and yield of miniature circuit breakers by six sigma

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ABSTRACT

A Miniature circuit breaker is an automatically operated electrical switch designed to protect an electrical circuit from damage caused by overload and short circuit. Its basic function is to detect a fault condition and, by interrupting continuity, to immediately discontinue electrical flow. Unlike a fuse, which operates once and then has to be replaced, a circuit breaker can be reset (manually) to resume normal operation. This is very basic question to control magnetic testing failure of miniature circuit breakers. The main aim of this paper to find out root causes responsible for magnetic failure and prepare action plan to reduced failure and to improve business chain with customer.

Keywords — six sigma DMAIC, Circuit breaker, current-limiting, interruption process, magnetic release, magnetic threshold

I.INTRODUCTION

This technical article focuses on the widely used miniature circuit breakers rated for 240 V or less. These are smaller and lower-rated versions of industrial-grade molded case circuit breakers rated for 600 V or less. These miniature breakers, called air circuit breakers, are based on thermal, magnetic, or combined thermal-magnetic principles. They are now almost exclusively installed in all new residences, small businesses, and offices as well as updates of existing older electrical systems. They are rated for amperes, voltage, and short-circuit or fault-current interruption. Miniature circuit breakers perform the dual functions of a switch and a fuse. They can open a circuit for safety or maintenance reasons simply by switching their toggle levers to the OFF position. As substitutes for fuses, they provide automatic circuit protection and need not be replaced after a dangerous overcurrent has passed or a short circuit has been corrected

MCB Rating

The ampere rating defines the maximum current the circuit breaker can carry without tripping. For typical miniature circuit breakers this rating is 2 to 125 A. In residential applications, single-pole breakers protect 20V branch circuits, and two-pole breakers protect 240V branch circuits. The voltage rating of a circuit breaker can be higher than the circuit voltage, but never lower. The fault current interruption rating (or short-circuit interrupting rating) is the maximum available fault current that could be expected from the overhead or pad-mounted distribution transformer outside a residence. If the

transformer can produce 10,000 A of current, each breaker in the load center should be rated for at least 10,000 A. Each miniature or branch circuit breaker, as shown in the cutaway view Figure 1 below, includes a bimetal strip or element. When this strip is heated to its threshold temperature, it bends enough to unlatch a mechanism and open the breaker's electrical contacts. When the contacts open, the toggle on the circuit breaker automatically switches to the OFF position. This, in turn, opens the branch circuit. These small circuit breakers can be reset manually after they have tripped. As with fuses, the ampere rating of the breaker must match the capacity of the circuit it protects. These circuit breakers are also called plug-in breakers, because they are connected to the load center by plugging them into the bus bar tabs or stabs. Under simple overload conditions, the deflection of a bimetal thermal sensing element within the circuit breaker causes the circuit to open when a pre-set temperature threshold is reached. Rising temperature in a bimetal element is caused principally by load current (I2R) heating.

Some thermal circuit breakers rated for 5 A or lower contain heater coils adjacent to or in series with the bimetal element. These heater coils compensate for the lower anticipated heating action of a fault in a low-current circuit. They augment element self-heating to maintain the temperature of the thermal element closer to the priest threshold temperature, to speed up the trip response in the presence of overcurrent.

Some miniature thermal circuit breakers also contain a magnetic element to accelerate tripping in the presence of an exceptionally fast rising overload. That condition increases current flow fast enough to create a magnetic field in a small electromagnet or solenoid that pulls in a mechanical linkage to unlatch the contacts and trip the breaker before the bimetal element can respond and deflect. The basic elements of a thermal-magnetic circuit breaker are shown in the simplified diagram Figure

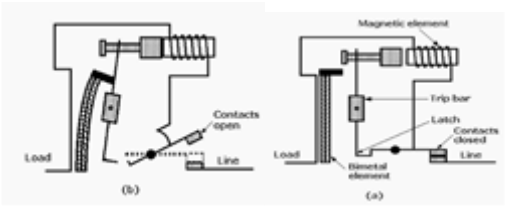

Fig.1. Thermal-magnetic circuit breaker trip latch operation: (a) normal; (b) overcurrent condition.

II.HOUSE OF USE

2.1 Breaker definition

A breaker is a device designed to isolate a circuit during an overcurrent event without the use of a fusible element. A breaker is a resettable protective device that protects against two types of overcurrent situations; Overload and Short Circuit

A slow and small overcurrent situation that causes and temperature of the circuit to gradually increase over time. This type of event is characterized by a slight increase in the load on the circuit and is interrupted by the thermal trip unit of the breaker.. The Magnetic trip unit protects against a short circuit. The magnetic trip unit is comprised of an electromagnet and an armature.

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III. EXPERIMENTAL WORK

3.1 Six sigma project findings

a. Six sigma is both a methodology for process improvement and a statistical concept that seeks to define the variation inherent in any process. The overarching premise of six sigma is that variation in a process leads to opportunities for error; opportunities for error then lead to risks for product defects. Product defects- whether in a tangible process or a service-lead to poor customer satisfaction. By working to reduce variation and opportunities for error, the six sigma method ultimately reduces process costs and increases customer satisfaction.

b. At the most basic definition, Six sigma is a statistical representation for what many experts call a "perfect" process. Technically, in a six sigma process, there are only 3.4 defects per million opportunities. In percentages, that means 99.99966 percent of the products from a six sigma process are without defect. At just one sigma level below-5 sigma or 99.97 percent accuracy-processes experience 233 errors per million opportunities. In simpler terms, there are going to be many more unsatisfied customers.

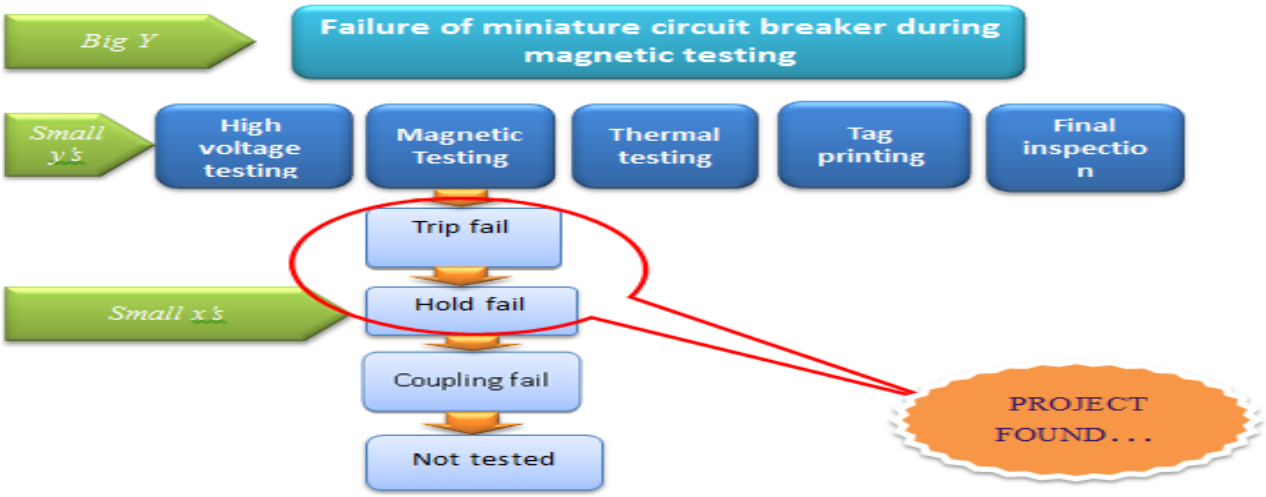

Fig.3 six sigma findingpure

B. The SIPOC is process contains

C. Process Name: Magnetic failure of miniature circuits breakers

D. Starting point: complain opened in find Rejection control root causes of magnetic testing.

E. End point: complain closed in find Rejection control root causes of magnetic testing.Mix Design

supplier	Inputs	process	process	customers
customers	Rejection in final testing and low product quality	find Rejection control root causes of magnetic testing	Rejection of miniature circuit breakers in B curve and D curve from rating 6A to 63A	Larsen and Turbo Limited production product testing department
Larsen and Turbo Limited production product testing department	Solution	MCB wedding group component manufacturing ,welding assembly method ,MCB assembly process	MCB wedding group component manufacturing ,welding assembly method ,MCB assembly process	Process and quality control department Or process engineering department
Process and quality control department Or process engineering department	find Rejection control root causes of magnetic testing	Magnetic testing rejection control by Root analysis and improve yield and quality of MCB,S	Work on welding group assembly process ,final assembly and magnetic rejection like trip fail and hold fail reasons to control MCB rejection	Larsen and Turbo Limited production product testing department

3.2 Magnetic test procedure

- Switch ON the main supply with the help of MCB provided on panel near the automation
- Procedure to start bin loading and unloading conveyor
- Procedure to start the hold magnetic testing
- Procedure for reset of pick unit mechanism
- Procedure to start trip magnetic test panel

3.3 Magnetic testing failure main reasons

Miniature circuit breakers are failing in magnetic testing in following main reasons so we fully concentrated on these fail reasons to find out main root causes.

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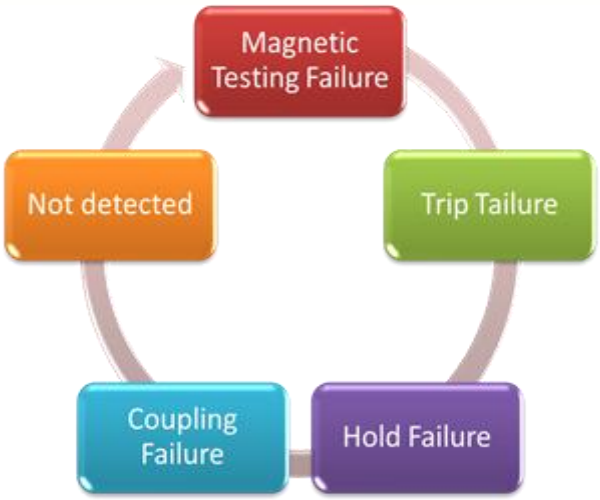

Fig 3 Magnetic testing failure main reasons

IV. DATA COLLECTION AND REPRESENTATION OF MAGNETIC FAILURE DPM

Data collected only magnetic trip, hold, not detected, coupling

Failure	Data frequency DPM
Trip failure	1323
Hold failure	314
Not detected	59

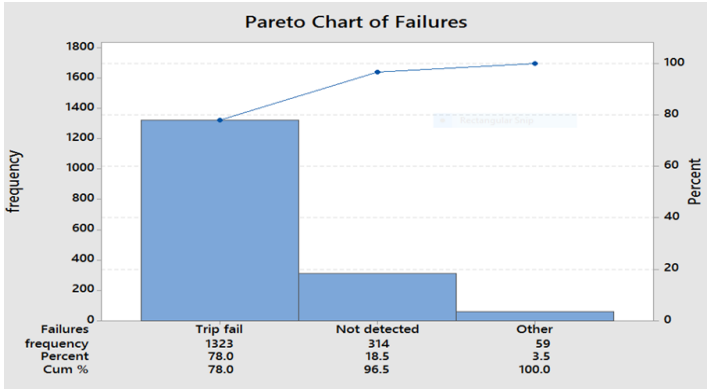

Fig.4 Pareto chart of magnetic failures

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IJARSE
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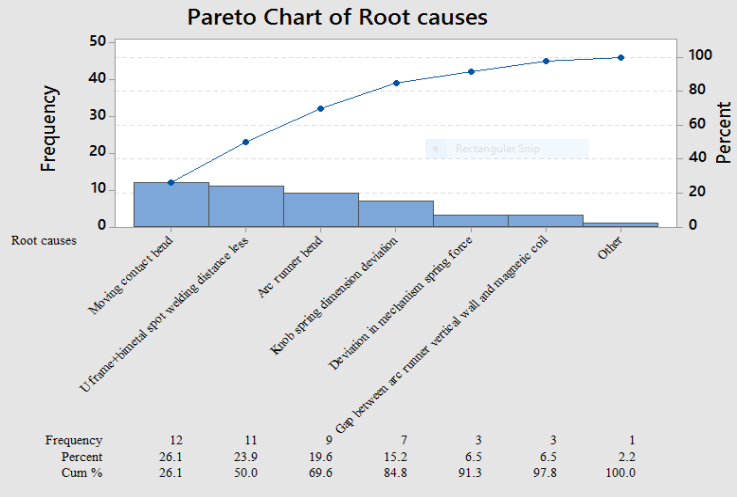

Fig.5 Pareto chart representation of root causes

V. FISHBONE DIAGRAM FOR ROOT CAUSE ANALYSIS

A fishbone diagram also called a cause and effect diagram or ishikawa diagram, is a visualization tool for categorizing the potential causes of a problem in order to identify its root cause. Dr. Kaoru Ishikawa, a Japanese quality control expert, is credited with inventing the fishbone diagram to help employees avoid solutions that merely address the symptoms of a much larger problem.

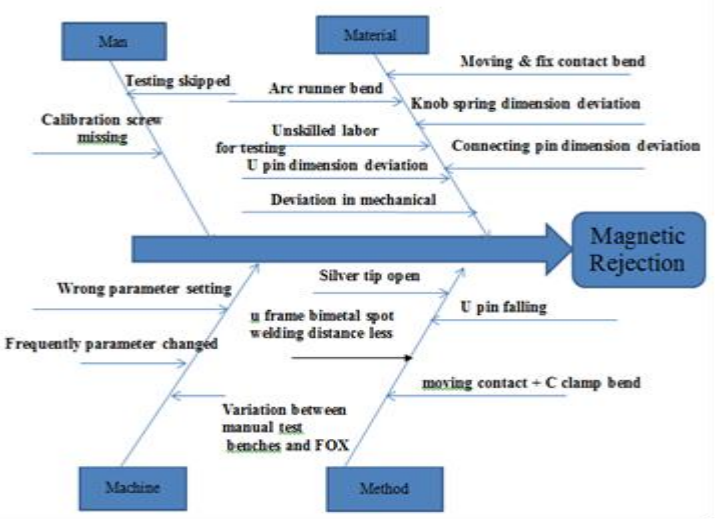

Fig. 5 Fishbone diagram for root cause

VI. PROCESS CAPABILITY STUDY AND MEASUREMENT SYSTEM ANALYSIS

Expressing data in a manner so that meaningful conclusions can be drawn. E.g. Parato, bar chart, trend chart, control chart Measurement system is the collection of instruments or gages , standards, operations, methods,

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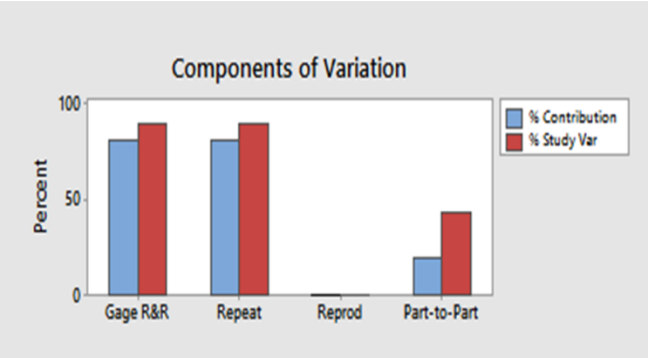
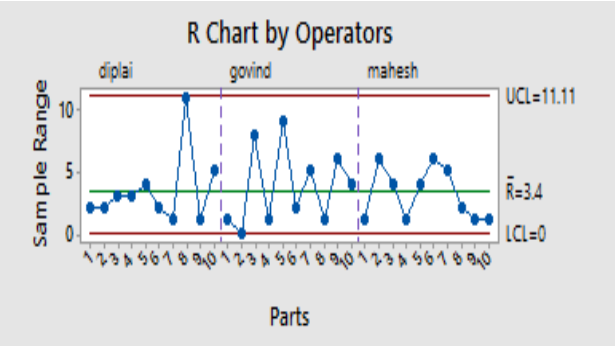
Run order	Parts	operator	Result	Run order	Parts	operator	Result
1	8	DIPLAI	11	31	3	DIPLAI	8
2	1	DIPLAI	9	32	6	DIPLAI	7
3	10	DIPLAI	10	33	7	DIPLAI	5
4	2	DIPLAI	7	34	4	DIPLAI	7
5	3	DIPLAI	11	35	8	DIPLAI	0
6	9	DIPLAI	5	36	1	DIPLAI	11
7	7	DIPLAI	6	37	5	DIPLAI	8

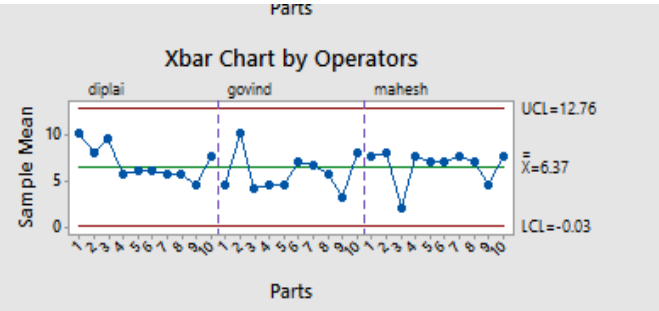
fixtures, software, personnel, environment and assumptions used to quantify a unit of measure or fix assessment to the feature characteristic being measured, the complete process used to obtain measurement.

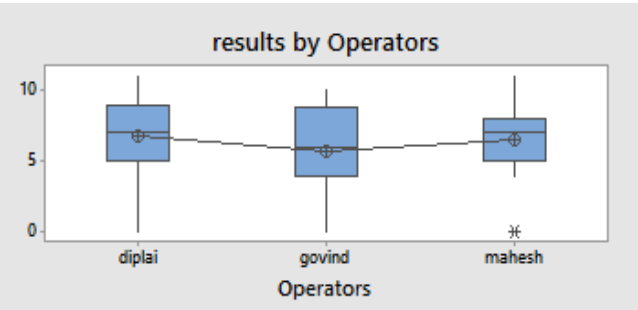
Collecting the data related to measurement system, quantifying the variation in measurement system and taking decision on measurement system.

Table 3









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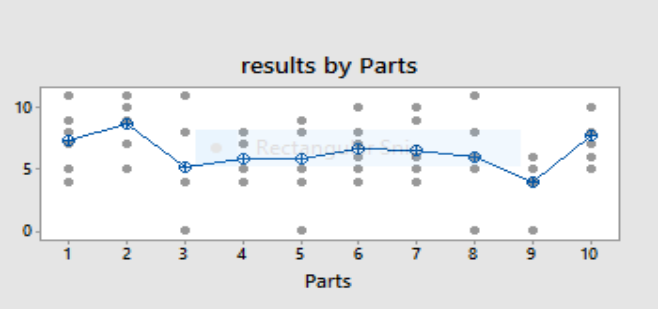

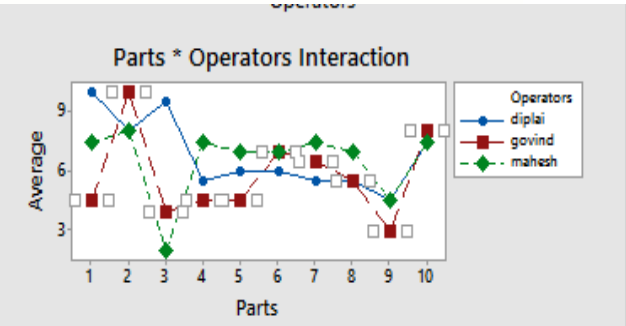

Source	StdDev (SD)	Study Var (6 × SD)	%Study Var (%SV)
Total Gage R&R	3.01317	18.0790	89.90
Repeatability	3.01317	18.0790	89.90
Reproducibility	0.00000	0.0000	0.00
Part-To-Part	1.46794	8.8077	43.80
Total Variation	3.35172	20.1103	100.00

%R&R

%P/T

VII.CONCLUSION

The objective of the present work is to find out root causes and their reasons responsible for magnetic test bench rejection

And identify the process capability and analysis of measurement system analysis.

1. Improve the yileld and quality of miniature circuit breakers
2. process capability and measurement system is calculated
3. level of six sigma is determined by using this study

VIII.ACKNOWLEDGEMENT

I would like to express my special thanks to Mechanical Department, which provide platform to present my work through this research paper. However, it would not have been possible without kind support and help of many individuals and organization. I would like to extent my sincere thanks to guide and all of them who helped me directly and indirectl

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