International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 7, Issue 6, June 2017)

Machine Capability Study of SAW Machine Using Statistical Techniques

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***Abstract*— This research paper consists of machine capability study for Submerged arc welding (SAW) Machine. Basic Machine Capability indices (C_m , C_{mk}) and Taguchi Machine Capability index (C_{mm}) are evaluated for SAW machine, which are effective tools to increase the productivity ,profitability, reliability and improving quality of process. Among these evaluated C_m and C_{mk} found to be excellent, however, C_{mm} Value was reasonably good. In case of current as a machine parameter, the value of C_m was found to be 4.47 and however, C_{mk} and C_{mm} value were found 2.595 and 0.7819 respectively. For Voltage the Value of C_m, C_{mk} and C_{mm} were 8.417, 2.03 and 0.4388 respectively.**

***Keywords*— Machine parameter, Machine Capability indices, Quality improvement, Submerged arc welding (SAW), Specification, Statistical Quality Control (SQC), Taguchi Machine Capability index.**

I. INTRODUCTION

The industry is today working intensively on a goal oriented way towards introducing regular studies in manufacturing. Today, manufacturing industries are increasingly facing new customer demands as well as a tougher market window so, the final product produced to fit each customer's demand. Tough competition creates a demand to improve effectiveness in production. To enable the development of reliable model of a specific existing or an imaginary machining system with the possibility of stimulating the model to achieve the capability index. To decrease the non-conformity in welding like Spatter, Undercut, Merge, Under Flux, Crack and Porosity will be coming. So, to overcome and to come in control we have decided to control the parameter, for this the machine capability to be evaluated. One of the main factors here is to measurement of welding machine. The C_m reveals the number of times the spread of the machine fits into the tolerance limits, however, C_{mm} finds that how machine opts the closest value to the nominal machine parameters. Eva Kurekova [1] discussed three capability indexes in short and recommended the C_{mm} index. She focused on theoretical foundations for determination of the measuring process capability for all the capability indexes.

S. Bangphan, P. Bangphan, T Boonkang [3] focused on process control of a turning manufactured at workshop machines. SPC technique has been adopted for this process to bring process under control through process capability improvement. Parvesh kumar Rajvanshi and Dr. R.M Beloker [2] focused on improving the process capability of a boring operation by application of statistical technique. They evaluated C_p and C_{pk} through SPC. They take the help of Normal probability plot and Histogram for the same. Amitva Mitra [4] discussed the term C_p, C_{pk} and C_{pm} in length and focused on how these three process capability indices are evaluated. Yerriswami wooluru and Swamy D.R.P. Nagesh [5] discussed about process capability indices with various capability ratios. They also take the help of Normal Distribution and Run chart. Although these authors focused on process capability indices, None or Very few authors focused on machine capability indices, Keeping these views attempt has been made by authors to evaluate machine capability indices i.e. C_m ,C_{mk}

II. OBJECTIVE

The objective behind this study is to structure and describe the way of taking a step closer towards producing least non-defective and quality parts .The meaning of non-defective parts is to produce the parts within specification, however meaning of quality here is producing the part as per the customer main desire. If the machining does not produce any Defect/Waste leads to both time and energy is saved. Even a stable process produce with a small deviation from a target value is known as Natural Deviations. In the coming years every machining process will give desired output value i.e. process distribution with a mean value equal to target value and a small standard deviation within tolerance limit. If this will be true than product will be free from defects. If we not producing correct parts, the environment will be less damaged due to less use of energy and less waste. The perfect way to performing machining accurately is by optimizing the process by using machine capability indices.

IJETAE EXPLORING RESEARCH AND INNOVATIONS

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The basic idea is to use a capability index showing the relationship between the results from machining, target value and tolerance limit. Capability indices a statistical way of describing how well a product is machined compared to defined target values and tolerances.

III. METHODOLOGY

A machine capability study concentrates exclusively on the characteristics of the machine i.e. to the extent possible, the influence or effects of variables external to machine are minimized. Some example sources of variation sources are:

Man -Personnel
-Shift Changes

Machine –Speed
-Feed rate
-Tools
-Current
-Voltage

Material –Semi-Finished Product
-Run in (Warm up) time of the machining
-Production Flow

Environment-Relative Humidity
-Vibration acting upon the machining facility
-unusual event

The general Machine Capability study steps as follows:

In first step critical parameters need to be selected i.e. Current characteristics and voltage characteristics may be established from inspection, work instructions. Critical parameters are correlated to machine.

Now second step is to collect data. Assure that the appropriate data is calculated for study. It is preferable to collect atleast 50 data values for each critical value.

In step three calculate machine capability indices (Cm, Cmk) and Taguchi Machine capability Index (Cmm).

After that the step four is analyzing sources of variation involves determining what factors affect the variation. With this knowledge, it may be possible to improve the machine capability.

Where:

USL=Upper Specification Limit
LSL=Lower Specification Limit
$\bar{X}$=Average of observations
σ =Standard deviation Calculated from finite number of samples i.e. Estimated standard Deviation
τ =Standard deviation from the target value

i.e. $\tau = \sqrt{\sigma^2 + (\mu - T)^2}$

Table I
List Of Machine Capability Equations And Their Usage

Estimated Index Equation	Usage
$C_m = \frac{USL-LSL}{6\sigma}$	A common measure for describing the potential of a process to meet specifications.
$C_{mk} = \min\left\{\frac{USL-\bar{X}}{3\,S.D}; \frac{\bar{X}-LSL}{3\,S.D}\right\}$	The parameter that influences machine's ability to produce a conforming product.
$C_{mm} = \frac{USL-LSL}{6\tau}$	Machine opts the closest value to the Nominal machine Parameters.

Note: In case of Machine Capability Index i.e. C_{mk}, Minimum value is preferably taking because mean is centered between the specification limits.

Table II
Commonly Used Capability Requirement And The Corresponding Condition

Machine Capability Index	Estimation of Machine
$C_m = C_{mk}$	Machine is placed exactly at the centre of specification limits.
$C_{m < 1}$	Machine is not adequate.
$C_{m \geq 1.67}$	Machine is satisfactory enough.
$C_{mk \geq 1.67}$	Machine is Satisfactory enough.
$1 \leq C_{mk} \leq 1.67$	Machine is marginally Adequate.

IV. MACHINE CAPABILITY ANALYSIS IN SAW MACHINE

In this Paper, machine capability of SAW machine in XYZ Heavy engineering industry located in Gujarat has been discussed. This illustrates the importance of Statistical Technique and ensuring the product produced is able to satisfy customer's needs and requirements.

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To receive a numerical measure of capability the so-called machine capability indices were calculated.

Table III
Measured Value Of Machine

Number of Observations	Component dimension size (current characteristics)	Component dimension size (voltage characteristics)
1	473	28.9
2	494	29.0
3	481	29.1
4	468	29.0
5	483	29.0
6	460	29.0
7	472	29.1
8	476	28.9
9	465	29.0
10	481	29.0
11	468	28.9
12	476	29.0
13	486	29.0
14	490	29.1
15	479	28.9
16	466	29.0
17	495	29.0
18	470	28.9
19	476	29.1
20	482	29.0
21	463	28.9
22	468	29.0
23	478	28.9
24	489	28.9
25	476	29.0
26	472	28.9
27	481	29.0
28	463	29.1
29	487	29.1
30	492	28.9
31	469	28.9
32	488	29.0
33	491	29.1
34	487	28.9
35	496	29.0
36	469	28.9
37	474	29.1
38	478	28.9
39	485	29.0
40	481	29.1
41	464	28.9
42	468	29.1
43	469	28.9
44	483	29.0
45	489	29.0
46	481	28.9
47	472	29.1
48	471	28.0
49	479	28.9
50	468	29.0

Table IV
Machine Description

Machine: LINCOLN 1000	**Specifications for Current**: 425±125
Operation: SAW	**Specifications for Voltage:** 32±4
Machine Number: ABC	Current Dimensions in **Ampere"** Voltage Dimensions in **"Volt"**

Current Characteristics Specification:

I = 425±125

Therefore,
USL=550
Nominal Value=425
LSL=300
Total No. of Subgroup (N)-50

Voltage Characteristics Specification:

V = 32±4

Therefore,
USL=36
Nominal Value=32
LSL=28
Total Number of Subgroup (N)-50

V. Result And Discussion

Current characteristics-

I= 425±125
Here,
USL=550
Target Value=425
LSL=300

Machine Capability Indices for Current-

$\sigma = 9.47$

$\bar{X} = 477.44$

$$C_m = \frac{USL\text{-}LSL}{6\,\sigma} = 4.47$$

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$$C_{mk} = \min.\left\{\frac{USL-\bar{X}}{3\sigma} ; \frac{\bar{X}-LSL}{3\sigma}\right\}$$

$$=\min.\{2.595; 6.34\}$$

$C_{mk} = 2.595$

So, the machine is found to be capable

Taguchi Machine Capability Index-

$$C_{mm} = \frac{USL-LSL}{6\tau}$$

Here,

$$\tau = \sqrt{\sigma^2 + (\mu - T)^2}$$

Where,

τ = Standard deviation from target value (Nominal Value)
T=Target value
μ=Mean value or Average Value

Therefore,

$\tau = 53.288$
$C_{mm}=0.7819$

It shows very good Taguchi capability index.

Voltage Characteristics-

V=32±4
Here,
USL=36
Target Value=32
LSL=28

Machine Capability Indices for Voltage-

$\sigma = 0.158$

$\bar{X} = 28.966$

$$C_m = \frac{USL-LSL}{6\sigma} = 8.412$$

$$C_{mk} = \min.\left\{\frac{USL-\bar{X}}{3\sigma} ; \frac{\bar{X}-LSL}{3\sigma}\right\}$$

$$=\min.\{6.5585; 2.03\}$$

$C_{mk} = 2.03$

So, the machine is found to be capable

Taguchi Machine Capability Index-

$$C_{mm} = \frac{USL-LSL}{6\tau}$$

Here,

$$\tau = \sqrt{\sigma^2 + (\mu - T)^2}$$

Therefore,

$\tau = 3.0381$

$C_{mm} = 0.4388$

It shows reasonably good Taguchi capability index.

VI. CONCLUSION

The Submerged arc welding machine capability was studied using a statistical approach. Two machine parameters were investigated i.e. current and voltage. This study was conducted in a controlled environment i.e. 28˚C. The initial machine capability (C_m) , machine capability index (C_{mk}) and Taguchi machine capability index (C_{mm}) were evaluated. In case of current as a machine parameter, the value of C_m was found to be 4.47. However, C_{mk} and C_{mm} value were found 2.595 and 0.7819 respectively. For voltage the value of C_m , C_{mk} and C_{mm} were 8.417,2.03 and 0.4388 respectively. As the machine was already in statistical control, corrective actions were not required.

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