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PROCESS CAPABILITY IMPROVEMENT IN PUMPING ELEMENT MANUFACTURING

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Abstract
In modern automotive industries, specifications for products have been continuously improved due to performance competition. Pumping element is an important component of a Diesel fuel injection system this project was carried out in Bosch Ltd. Utilizing Process capability, Pareto analysis, cause and effect diagram and Histogram to improve the nature of manufacturing procedure of Plunger, Barrel and Elements. Optimization strategy is presented to enhance the performance of the process in concurrent engineering environment. Value Stream Mapping (VSM) tool helps in identifying critical time lag factors in process functioning is a major deterrent in process efficiency. This work focuses on Process capability improvement in VSM.

Introduction
Diesel engines are robust with advanced Fuel efficient technology which could be achieved by the best performance of pumping elements this crucial elements is being manufactured in Bosch Ltd and it used in heavy duty vehicles and equipments such as trucks, tractors, passenger vehicles marine engine, generators, etc.
As the diesel is one of the most efficient and energy dense fuels which is decreasing these today. Nevertheless, the diesel engine has several great advantages, the quality production and maintenance of critical components of engine system has become yet a challenging task. The quality of the product has become the dominant criteria to acquire the global market. Bosch Production System is the leader in quality production by deploying advanced quality measures in its manufacturing processes and thus, satisfying the customer.

Critical characteristics selection
In Element manufacturing two different parts are manufactured called Plunger and Barrel. Barrel's main Characteristics are Top face length (total length) and parallity out of these two, Total length (TL) is taken as a critical Characteristics for the case study.

Methodology
1. Process capability improvement involves 5 main steps as follows:
2. Resolution
3. Gauge Capability
4. Gauge Repeatability and Reproducibility
5. Machine capability
6. Process capability

Characteristics variables are selected based on the Priority of process as shown in fig1, Operations on all five capability analysis is carried for all machines in Value Stream Mapping

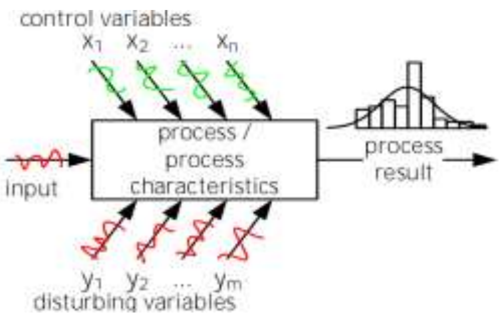

Fig 1.Process analysis

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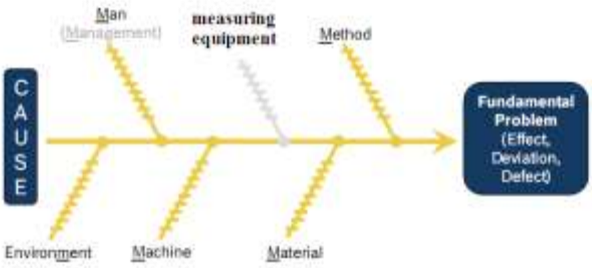

Fig 2 .Cause and effect diagram

Root cause found from analysis is plotted on cause and effect diagram. In this work one machine in each process is undertaken to drive this project. In current VSM 108 machines are spread on plant and 45 different characteristics are found for the case study only one characteristic is selected

Resolution

Resolution is the ability of a measuring instrument to recognize a reproducible difference between two measured values .The evaluation of the resolution is performed with the entire indicating measuring device in manufacturing Elements and 0.001mm is used

$$\text{Resolution} = \frac{\text{scale graduation value}}{\text{tolerance value}} \leq 5\% - (3.11)$$

Before any analysis of the measuring instrument can take place, its resolution need to be assessed according to Bosch standards "Smallest distinguishable difference between two indications of an indicating device

Gauge capability

The measurement capability has the goal determining the systematic and random deviation of a measuring system using a standard. They are described with the aid of the two standard properties Cg and Cgk using selected Characteristics

$$\text{Cg} = \frac{0.2\ T}{6 * S_g} ---------------- (3.21)$$

$$\text{Cgku} = \frac{\left(\overline{\overline{X}}_g - (X_m - 0.1\ T)\right)}{3 * S_g} ---------(3.22)$$

$$\text{Cgkl} = \frac{((X_m + 0.1\ T) - \overline{\overline{X}}_g}{3 * S_g} ---------(3.23)$$

$$\text{Cgk} = \min(\text{Cgkl}, \text{Cgku}) -----------(3.24)$$

Where,

X_m - is the Characteristic value of the standard

X_g - is the Mean value of the standard

S_g - is the standard deviation

T is the given tolerance

A measuring instrument is deemed suitable when the calculated properties Cg ≥ 1.33 and Cgk ≥ 1.33.There is no uniform definition for the calculation of the values Cg and Cgk

Gauge repeatability & reproducibility(R AND R)

Repeatability and reproducible precision are mainly used to determine the influence of the user in order to calculate these characteristics, measured values from different operators must be available .Thus R and R provides as estimated composite values for the Repeatability and reproducibility of a measuring system. For a measuring instrument to be classified as suitable, the following condition must be satisfied

Data Collect reading of 20 parts measured by 3 different operators

Operator 1-20reading (20 samples)

Operator 2- 20reading (same 20 samples as operator 1without changing order)

Operator 3 – 20 reading (same 20 samples as operator 2without changing order)

Conditions:

- %GRR <= 10% : capable
- 10% < %GRR<= 30%:conditional capable

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%GRR > 30% : not capable

Machine capability

Data Collection is done by setting the machine to mean condition without disturbing setting 50 pieces reading value is taken for analysis

$Cm = \frac{T}{6*S_{total}}$ -------------(3.31)

$$Cmk = \frac{USL - \overline{X}}{3 * S_{total}} -------------(3.32)$$

$$Cmk = \frac{\overline{X} - LSL}{3 * S_{total}} -------------(3.33)$$

$$S_{total} = \sqrt{\frac{1}{n-1} * \sum_{i=1}^{n} (X_i - \overline{X})^2} ------(3.34)$$

$$\overline{X} = \frac{1}{n} * \sum_{i=1}^{n} X_i -------------- (3.35)$$

Cmk = min (3.32, 3.33)

Conditions:

Cm ≥ 1.67 and Cmk ≥ 1.67 machine is capable

Process capability

The process capability study is a long-term study that is conducted over an extended operating time and includes sources of variation external to a machine. These sources are typically summarized under the headings of Man, Machine, Material, Method and Environment.

Process capability Cp is a measure of the capability of a process to deliver parts inside the tolerance specification. Assuming the process average is in the mean of the tolerance range, the actual process variation is compared against the specified tolerance.

Data collection: machine as to set to mean condition than every one hour 10 or 5 readings continuous till 125 readings 3 shifts can be covered Cp and Cpk are calculated by using below formulas

Condition: Cp ≥ 1.33 and Cpk ≥ 1.33

$$Cp = \frac{USL - LSL}{6 * \sigma} -------------(3.51)$$

$$Cpu = \frac{USL - \mu}{3 * \sigma} -------------(3.52)$$

$$Cpl = \frac{\mu - LSL}{3 * \sigma} -------------(3.53)$$

$$Cpk = \min(Cpu, Cpl) ---------- (3.54)$$

Where,

USL-upper specific limit

LSL- lower specific limit

Case study

This project is carried out at MFE/BanP for elements manufacturing process which involves 45 different characteristics in the manufacturing Process of element, Plunger and Barrel. In this work for case study Total length of barrel is considered for analysis

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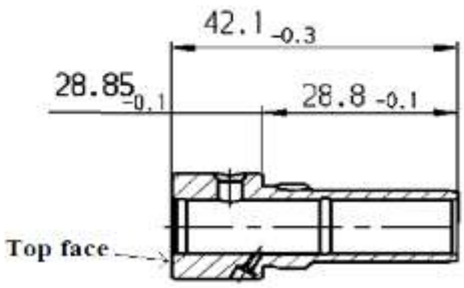

Fig 3.Barrel sectional view

Table 4.1 Process capability analysis comparison

Part	Process	Characteristic	GRR%	Cg	Cgk	Cm	Cmk	Cp	Cpk	
Barrel			30%	1.33	1.33	1.67	1.67	1.33	1.33	
Trail 1	Top face Grinding	Total length	**20.56%**	**1.38**	**1.4**	**2.79**	**1.49**	**1.3**	**1.17**	**Fig 4**
Trail 2	Top face Grinding	Total length	**20.56%**	**1.38**	**1.4**	**2.65**	**1.7**	**1.3**	**1.28**	**Fig 5**

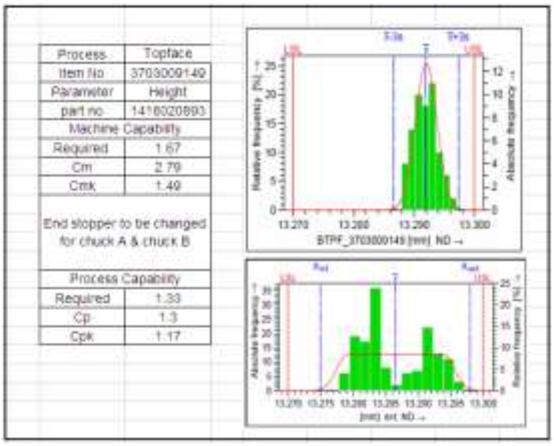

Fig 4 .Trail 1 Report

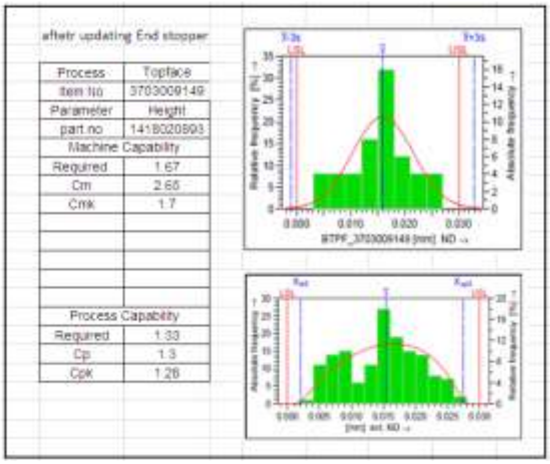

Fig 5 .Trail 2 Report

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Result

Process capability investigation conveyed for the barrel in first trail Cmk,Cp and Cpk neglects to meet the prerequisite by the studying X-bar diagram and Normal distribution graph parts crushing variety as mirrored the issue is on the Chuck A and Chuck B End stopper the variety is plainly indicated in Table 4.1

Conclusion

It is shown Quality of gathering of barrels can be upgraded by enhancing machine passes by SQC framework if this technique is superposed with Value stream frameworks, quality assortment making variables like Man, Machine, Material, Method and Environment can be controlled

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