Product End Quality Assessment using Vibration Analysis Technique

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***Abstract*---In manufacturing industry in production of parts machine tool plays a vital role. Good quality end product depends on condition of the machine. More condition monitoring methods are used to determine condition of the machine like vibration and noise but vibration signal analysis is the best one because by measuring vibration signal majority of machine tool problems can be assessed. Two lathes were selected (PSG A141) for the study one is in good condition (PSG A141A) and other not in a condition (PSG A141B). This work is carried out using shock pulse meter (SPM) to collect vibration level at different operating condition. Then the vibration data is analyzed using statistical tools like Multiple Regression Analysis to check the relationship between vibration level and their parameters, collinearity between dependant and independent variables along with determination of their coefficients. Monte Carlo Simulation in @RISK of palisade©, UK is used for effective analysis for the generated regression model. Process Capability and Capability Index method is used to examine the process condition by which we can check whether product is acceptable or not. In this study, the graphical result shows that whether the vibration level is under control or not by specifying suitable upper and lower specification limits. When the process capability and capability index value is more than 1, it means a better quality product or the process is capable of producing acceptable products.**

***Index Terms*---vibration, analysis, specification limit, frequency, quality.**

I. INTRODUCTION

FFT analyzer and Artificial Neural network technique to conclude and propose the best possible solution to the challenges of error caused during the operation of a machine tool for improved productivity [1]. Control charts were added for the monitoring of machine tool performance parameters. A method of size normalization has been included to compensate for overall performance parameter inter-dependence [2]. The impact of cutting parameters such as depth of cut, speed and feed rate on machining variables is evaluated. Vibration level will increase because the cutting speed, depth of cut and feed rate increases. It was additionally observed that the vibration velocity degree relies upon location of the defect. Vibrations at bearing and in tangential route are notably took place relatively at tool post and in axial direction.[3]. If a product fails to perform its feature in the assurance length; the alternative and repair fees negatively have an effect on income, in addition to advantage undesirable negative interest[4]. Functionality analyses are often said as a part of an ongoing quality program although, regularly, statistics are simply stated and an insufficient amount of consideration for the technical problems surrounding those facts might also take place[5].Statistical methods are effective tools for improving production processes and reducing unscheduled failures [6].This paper emphasizes on quality assessment by using vibration signal and analysis of the result with the help of statistical tools such as regression analysis, Monte Carlo simulation and process capability analysis.

II. EXPERIMENTAL DETAILS

Vibration data is collected from two Lathe machines for different tool and work material with varying speed and constant depth of cut and also for varying depth of cut with constant speed. Shock pulse meter (spm) is a condition monitoring instrument as shown in figure 1 which is portable hand held instrument which is mainly used for vibration monitoring, sped test and bearing condition detection.

Typically the probe is placed on machine housing and bearing housing to measure vibration velocity in rotating machinery the best frequency measure from 3-1000Hz.and possible to take readings in different measures And the readings should be taken manually.

- ✓ Axial measure to check faulty alignment
- ✓ Horizontal measure to check balance condition of machine and
- ✓ Vertical measure to check the structural weakness.

<u>*Key Features of ISO 10816 SPM A2010:*</u>

Features of ISO 10816, Evaluated vibration analysis method (EVAM),

- Time signal analysis,
- Condition parameters,
- Spectrum analysis with 'symptoms,
- Machine specific condition codes and
- Phase measurement

Fig.1. Shock Pulse Analyzer

III. RESULTS AND DISCUSSION

A. Vibration Level for Constant Speed in Lathe 1

From the Fig.2, it is evident that for carbide tip tool with constant speed on brittle material with increase in depth of cut the vibration level remains same at Lower depth of cut and there is unexpected increase in vibration degree at higher depth of cut.

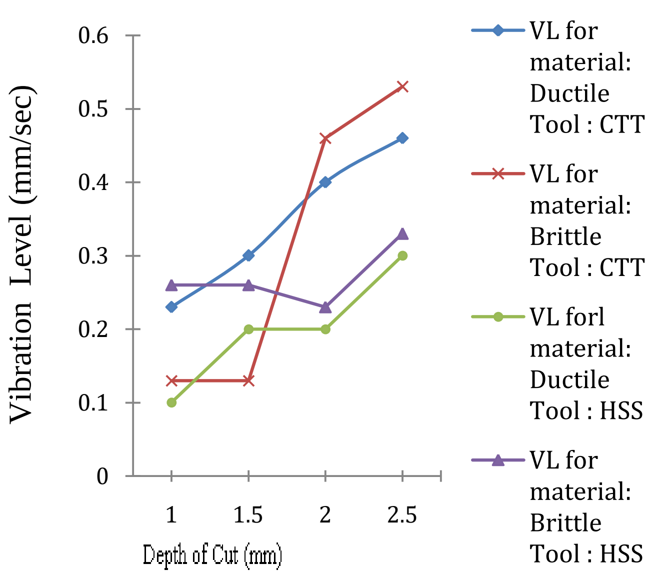

Fig.2. Vibration Level for Constant Speed.

B. Vibration Level for Constant Depth of Cut Lathe2

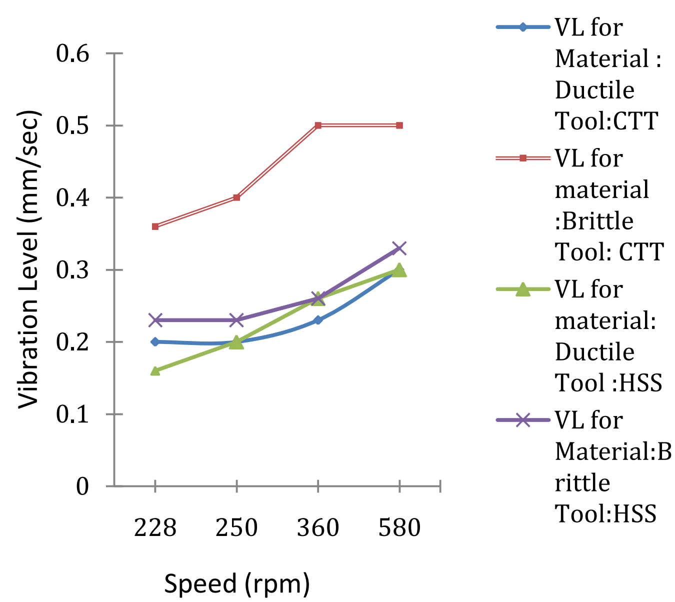

Fig.3. Vibration Level for Constant Depth of Cut

From the Fig.3, it is evident that for carbide tip tool with constant depth of cut on brittle material with increase in speed the vibration level also increases.

C. Vibration Level for Constant Speed Lathe 2

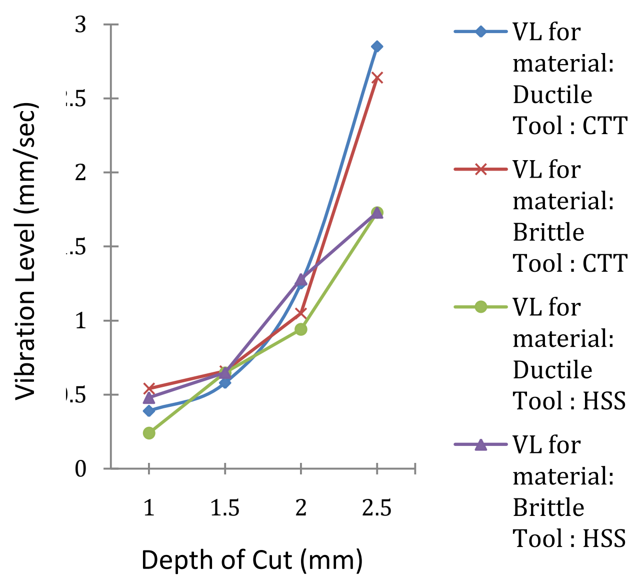

Fig.4. Vibration Level for Constant Speed

From the Fig.4, it is evident that for carbide tip tool with constant speed with increase in depth of cut the vibration

Level increases.

D. Vibration Level for Constant Depth of Cut (2mm) Lathe 2

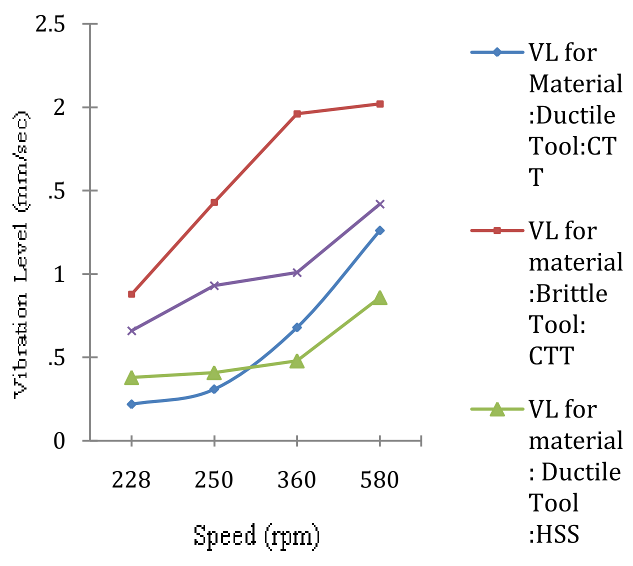

Fig.5. Vibration Level for Constant Depth of Cut.

In Fig.5, we can observe that for carbide tip tool with increase in speed increase in vibration level. The overall result shows that by comparison analysis depth of cut is the main influence to cause vibration with carbide tip tool as cutting tool and brittle work material.

IV. STATISTICAL ANALYSIS

A. Regression Analysis:

Regression analysis is carried out to generate regression model by considering dependent variable as vibration level and independent variables (Work Material, Cutting Tool, Depth of Cut and Speed)

Table.1. Regression Analysis Result of Lathe 1

Predictor	Coef	SE Coef	T	P	VIF
Constant	-0.5185	0.1283	4.04	0.000	
WM	0.12375	0.03245	3.81	0.001	1.5
CT	0.11750	0.03747	3.14	0.004	1.5
Doc	0.15702	0.03196	4.91	0.007	1.0
N	0.0003298	0.0001343	2.46	0.021	1.0

Table.1 shows result of regression analysis and the regression equation for PSG A141-A and the vibration level and their parameter obtained from MINITAB® 14.0.

VL = - 0.518 + 0.124 WM + 0.118 CT + 0.157 DOC + 0.000330 N

Where, VL = vibration level, WM= work material, CT = cutting tool, DOC = depth of cut and **N** = speed

Table.2. Regression Analysis Result of Lathe 2

Predictor	Coef	SE Coef	T	P	VIF
Constant	-0.9646	0.8110	1.19	0.245	
WM	-0.0837	0.2368	0.35	0.726	1.5
CT	-0.4475	0.2051	2.18	0.038	1.5
Doc	1.1266	0.2019	5.58	0.046	1.0
N	0.0020461	0.0008486	2.41	0.023	1.0

Table.2 shows result of regression analysis and the regression equation for PSG A141-B and the vibration level and their parameter.

VL = - 0.965 - 0.084 WM - 0.447 CT + 1.13 DOC + 0.00205 N

B. Monte Carlo Simulation

The obtained data from shock pulse analyzer is used for simulation for the regression model and this simulation is done using the @RISK© [10]. By using this method, it is possible to create a realistic image where one can check what may happen in future.

Simulation Summary of Lathe 1:

Summary Information	
Workbook Name	READINGS distributed.xls
Simulations	1
Iterations	10000
Inputs	128
Outputs	32
Sampling Type	Monte Carlo
Time at simulation started	5/15/2015 10:52
Time at simulation stopped	5/15/2015 10:55
Duration of Simulation	00:02:28
Random Seed	339112394

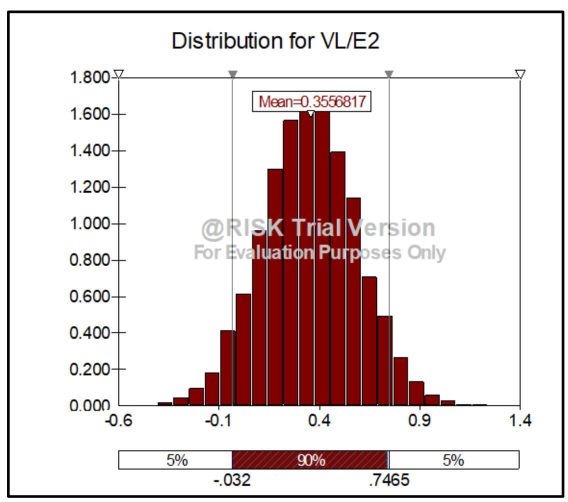

Fig.6. Histogram of Vibration Level

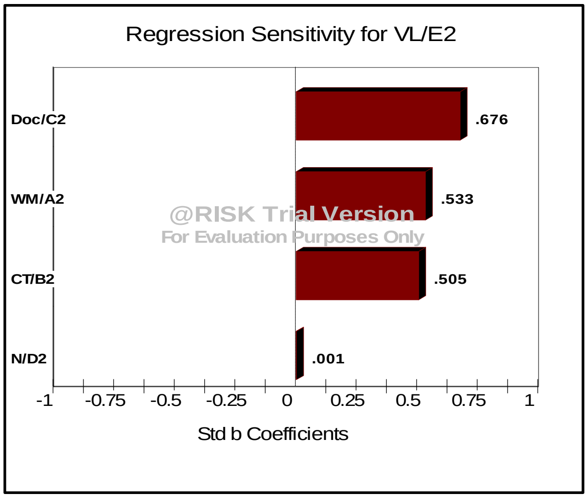

Fig.7. Tornado Graph of Vibration Level

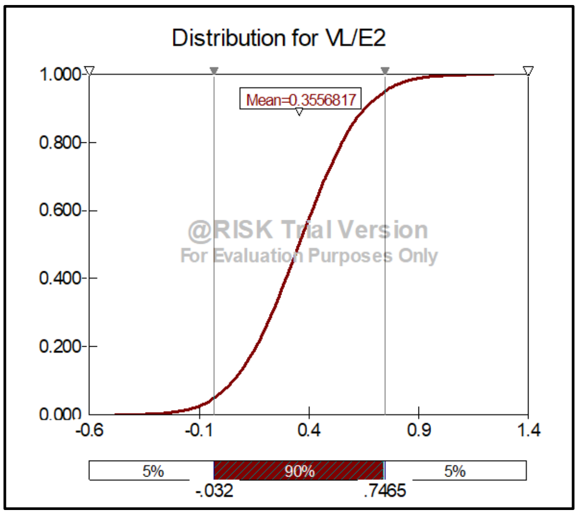

Fig.8. Distribution curve of Vibration Level

Fig.6 and 7 show The graphical illustration of the relative influences of the model enter in terms of their regression coefficients Fig.8 The underlying distribution is estimated using distribution fitting by the 90% of CI, mean value is 0.35568, the right slider is 0.74648 and left slider is 0.03195 this indicates that the estimated probability. Hence the distribution is within a control limit. Evidently the foremost considerably influencing input is that the depth of cut, that includes a positive parametric statistic of 0.676 at the net present value.

- ➢ The result for vibration level is obtained by analyzing for 10000 iterations and it taken 2 minute and 28 seconds.
- ➢ By the sensitivity analysis obtain the result based on ranking parameter here depth of cut is main influencing to cause vibration by observing the mean value of individual vibration level we can analyze that the process is under control.
- ➢ The mean value of vibration level is within specification hence it is a good fit.

Simulation summary of Lathe 2

Summary Information	
Workbook Name	READINGS distributed.xls
Number of Simulations	1
Number of Iterations	10000
Number of Inputs	128
Number of Outputs	32
Sampling Type	Monte Carlo
Simulation Start Time	5/17/2015 0:22
Simulation Stop Time	5/17/2015 0:24
Simulation Duration	00:01:33
Random Seed	370605165

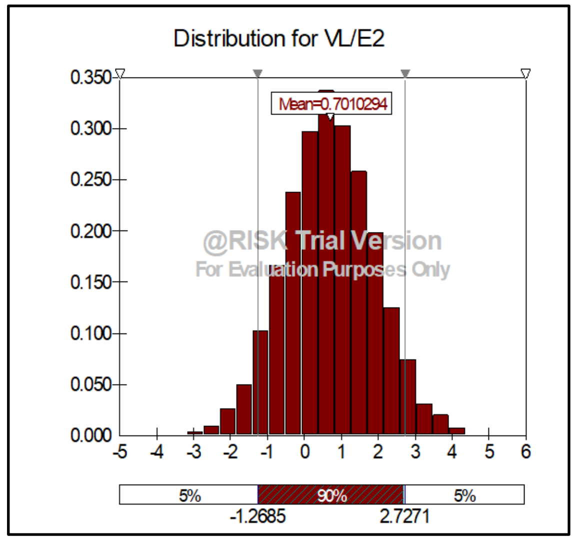

Fig.9. Histogram of Vibration Level

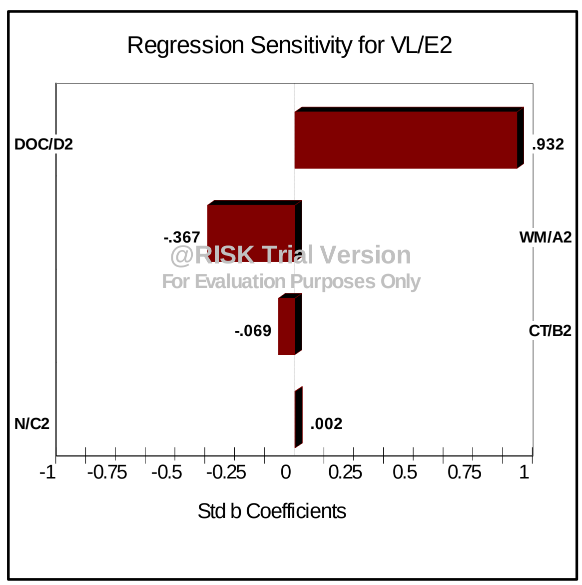

Fig.10. Tornado Graph of Vibration Level

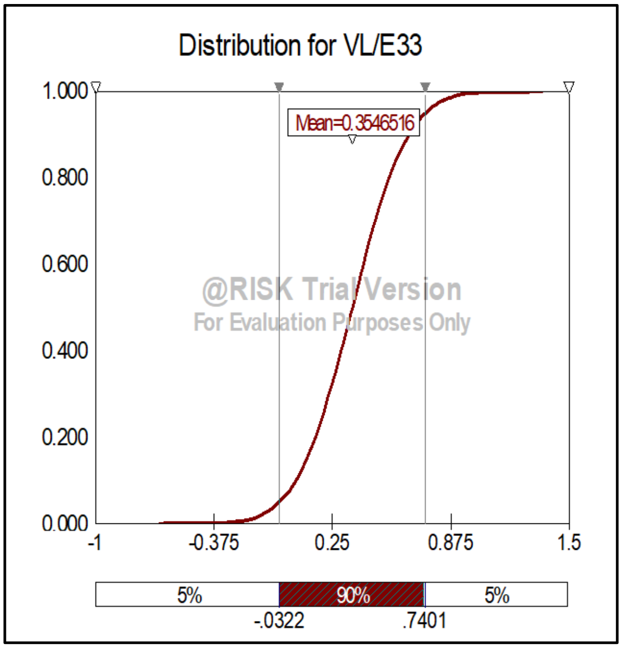

Fig.11. Tornado Graph of Vibration Level

- Fig.9 and 10 show the results for vibration level is obtained by analyzing for 10000 iterations and it takes 1 minute and 33 seconds.
- From the Fig.11 it is evident that the distribution fitting is used to estimate the underlying distribution by the 90% of CI, mean value is 1.9779, the right slider is 4.0014 and left slider is 0.0499 this indicates that the estimated probability. Hence the distribution is not in a control limit.
- Graphical and statistical obtained distribution analysis result we can observe mean value exceeds the control limit and process is not capable.
- By the sensitivity analysis obtained the result based on ranking parameter here depth of cut is the one which is higher sensitive to cause vibration then work material is negatively influencing.
- Finally we need to take measure to control the process because present and future values exceed the mean value in machine 2.

C. Process Capability

There are assumptions to consider when acting process capability analysis, particularly:

- The manner is in statistical control.
- Normal distribution of the process is considered.

If those assumptions are not met, the ensuing records may be fairly unreliable.

Result from Lathe 1(PSG A141-A):

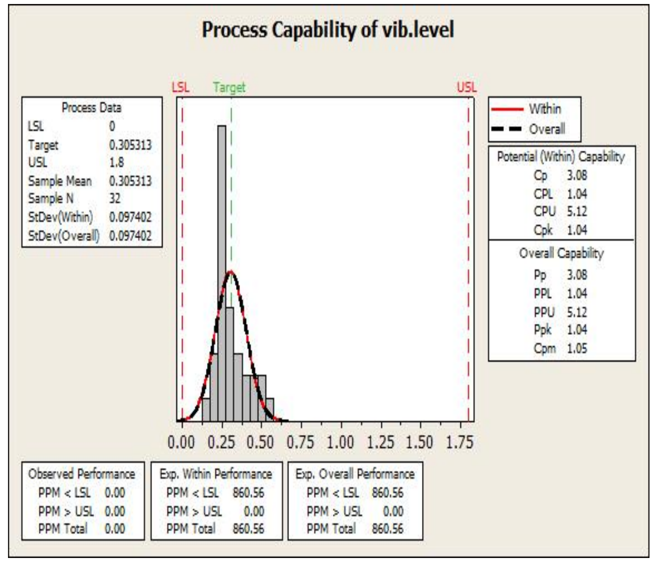

Fig.12. Process Capability of Machine 1

The result shows that process capability analysis C_p is 3.08 and C_{pk} is 1.04 is shown in Fig.12. For the vibration level where:

- $C_p > 2$ means the product is excellent.
- $C_{pk} > 1$ the overall values are within the limit.
- The vibration level is closer to target (mean) value and is within specification limit hence the product is acceptable.

Result from Lathe 2 (PSG A141-B):

From Fig.13. We can observe that

- $C_p < 1$ means that the product is of poor quality.
- $C_{pk} < 1$ means the overall values not in control.

The vibration level is not closer to target value and is out of specification limit; hence the product is not acceptable.

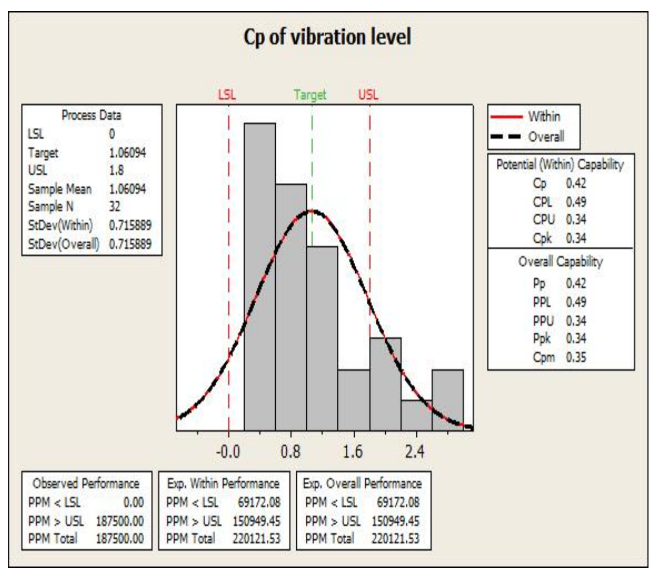

Fig.13. Process Capability of Machine 2

V. CONCLUSION

The study has considered the comparison of two Lathe machines (PSG A141) of same company. The study was carried out by selecting the parameters of material, tool and machine. The vibration data is acquired by maintaining constant DOC with variable Speed and the process is repeated for all the parameters considered. Statistical Analysis Methods such as Regression, Monte Carlo Simulation and Process Capability are used to get the desired results. By sensitivity analysis it is evident that depth of cut is more sensitive to cause vibration. Regression model is developed by regression analysis and hence monte carlo simulation was used where observed depth of cut is influencing to cause vibration. Using capability analysis and by specifying upper specification limit (USL) and lower specification limit (LSL) as per vibration severity criterion of ISO 10816 for class I machine, it is found that machine1 (PSG A141-A) is in good condition and machine 2 (PSG A141-B) is not in a good condition.

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