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Process Capability Estimation with Non-Normal Distribution Case Study: Resonance of Pivot

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Abstract
This paper present about Pivot resonance which dynamic data and non-normal distribution basis and must be transform data to be normal distribution before estimate Ppk. The study on Pivot resonance characteristics that is dynamics data while measuring resonance frequency and it has non-normal distribution. The FEM (Finite Element Method) was use to analysis the data on two pivots with different ball bearing position to represent ball movement while measuring the resonance frequency of Pivot to be used data for Ppk estimation. FEM was used to gather 32 modes to verify the resonance frequency. Result shows that there is dynamic data which difference in resonance frequency on mode 1-19. And there become to be static data which no difference was observed on mode 20. Based on the data and analysis, this paper demonstrates the proposal of setting the measuring mode of resonance frequency at a minimum of mode 20 to get static data for Pivot size 3.138 x 8.9 mm. With this methodology, the data would be normally distributed and no need to transform data for estimates Ppk.

Keywords:*Ppk, Resonanceof pivot, FEM (Finite Element)*

I. INTRODUCTION

In the present, P_{pk} (Process Performance index) is used in Electronics industry for process improvement and considering about risk assessment. Basically, data is used to estimate P_{pk} should be static data which has normal distribution. To avoid an error and will be affected to misunderstanding and wrong decision so the characteristic of data that there is statics or dynamics and it is normal or non-normal distribution should be known before estimate P_{pk}. This study on Pivot resonance characteristics to represent dynamics data and it has non-normal distribution and use FEM (Finite Element Method) to simulate resonance frequency of Pivot.

1.1 Pivot or Cartridge or Actuator Axis is a part of HDD (Hard Disk Drive) that it is rotate while HDD is working. Pivot will be called in this paper. Figure 1-3 are illustrations of Pivot.

- Figure 1 shows Pivot location on HDD. See red arrow.
- Figure 2 shows Pivot structure that two bearing were assembled with shaft.

Study on Pivot size 3.138 x 8.9.

- Figure2 Bearing structure, Axial clearance Play and Radial clearance Play.

Study on Bearing which Axial and Radial Play are 10 micron.

Figure1 Pivot located on HDD

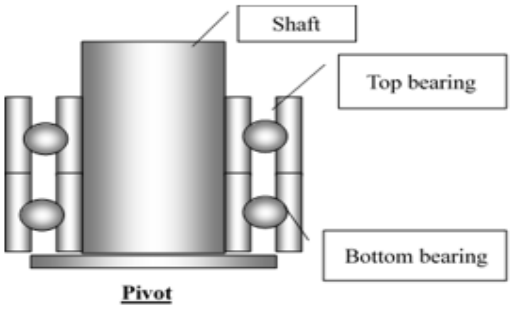

Figure2 Pivot structure

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Figure3 Bearing structure

1.2 Resonance Measurement PMDM is used to measure resonance frequency of Pivot. The PMDM was developed by NMB Minebea in Germany (Precision Motors Deutsche Minebea GmbH) which consist with below part. See Figure 4.

• A vibrator to apply vibration in axial direction to Pivot while measure resonance frequency.

• Laser is origin of light to focus position which resonance will be measured.

• A Monitor, the resonance processing, to check graph and resonance frequency value.

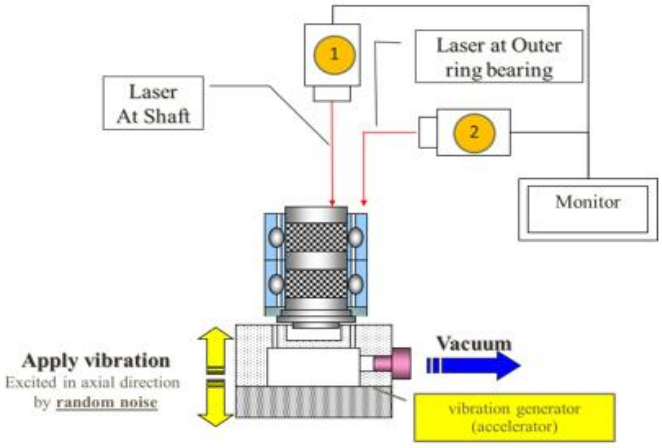

Figure 4 PMDM Resonance measurement

1.3 Process Capability [1], process capability means "the measured, inherent variation of product turned out by a process" that characteristic of data is Static can be estimated normal shape of inherent variation.

1.4 Finite Element Method (FEM) [2], Finite element methodology is a numerical method for estimating the approximate problems by dividing the boundary of problem to be sub-parts called elements, then create equation of each elements to related with differential equation of . The elements are connected at connection point is called Node which is the position we want estimation of approximate solutions.

1.5 Dynamics [3] is "thing will be changed according to time so Dynamics force is force Directions and / or position changed according to time. And affected to respond in dynamics too. For example, inside force and shape changed.

II. Problem Discussion

Due to resonance of Pivot shows P_{pk} trend per figure 5 shows P_{pk} is totally difference between P_{pk} from estimation by generic formula and by transformation data before estimate P_{pk}, even Mean and Standard Deviation are not difference.

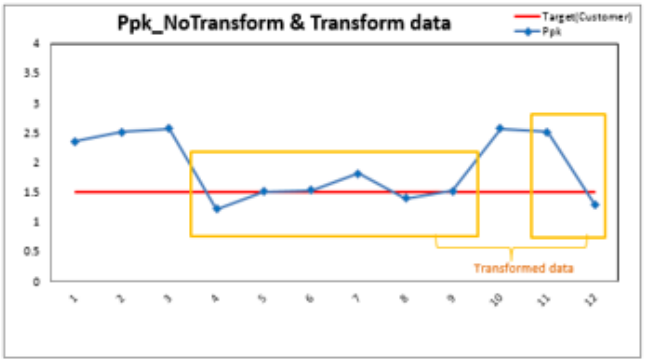

Figure 5-1 P_{pk} trend for Resonance of Pivot

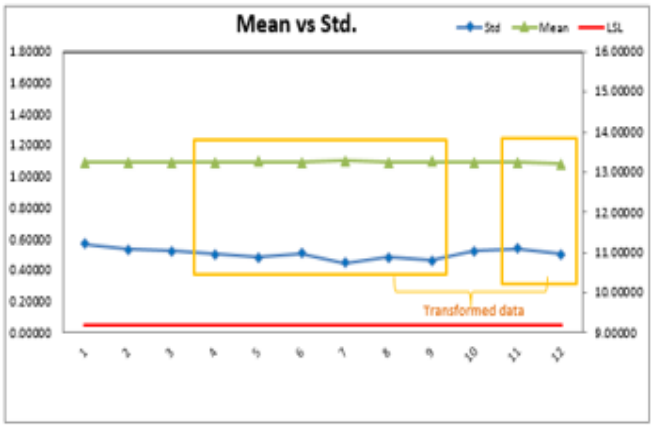

Figure 5-2P_{pk} trend for Resonance of Pivot

So characteristic of resonance was studied to finding the solution for this problem. According to figure 2 and figure3 show a Pivot has two bearings assembled with 7 balls located inside the pocket. And

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each ball has clearance between ball surface and pocket. (Clearance is 10 microns which drawing was defined.) When axial vibration was applied while measuring resonance, the balls will have movement as well. See figure 6 for clearance and ball movement.

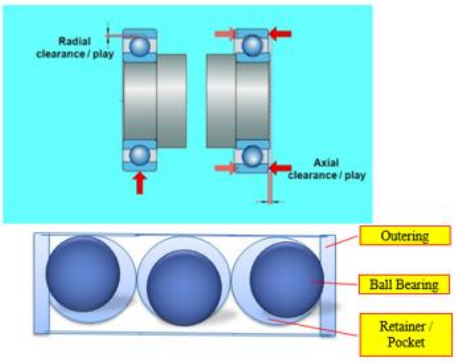


Figure 6 Example for Ball movement

Since balls have movement while resonance measurement or Pivot is working, so ball position is not be the same and different structure of Pivot too. That means one Pivot will has resonance value more than one value. Based on Pivot structure, resonance of Pivot should be dynamic data. So this study on resonance characteristics of Pivot to finding the solution and estimate the accurate P_{pk}.

III. Simulation and Result

3.1 Simulation, FEM was performed by using Solidworks2017 with different ball bearing position on two Pivots per below

- Pivot 1, all balls of top and bottom bearing are located bottom of pocket (10 microns from top of pocket). See figure 7.
- Pivot 2, all balls of top and bottom bearing are located top of pocket (10 microns from bottom of pocket). See figure 8.
- FEM was used to gather 32 modes to verify the resonance response.

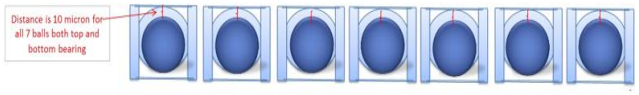


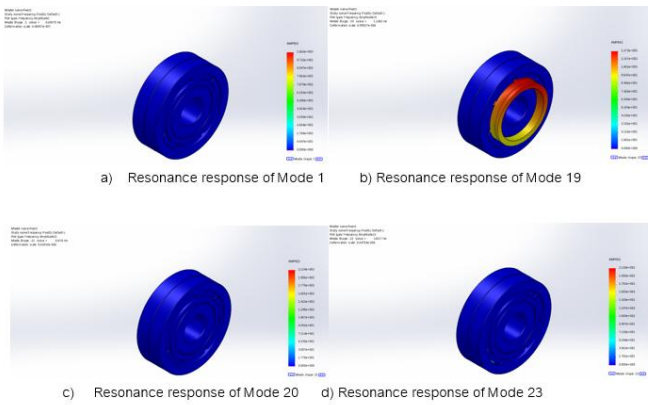
Figure 7 Ball Bearing position for Pivot 1

Figure 8 Ball Bearing position for Pivot 2

3.1 Result shows a resonance response is dynamic data which difference in resonance frequency on mode 1-19. And there become to be static data which no difference was observed at minimum mode 20. See result as Table 1, figure 9 and figure 10.

Table 1 Resonance response of two Pivots

Mode No.	Frequency(Hertz)		Mode No.	Frequency(Hertz)	
	Pivot#1	Pivot#2		Pivot#1	Pivot#2
1	0.69075	0.68942	17	1.20340	1.20190
2	0.70239	0.69852	18	1.22620	1.22610
3	0.74105	0.71396	19	1.22690	1.22660
4	0.77198	0.75220	20	13475	13475
5	0.79514	0.77538	21	13476	13476
6	0.84356	0.80951	22	13610	13610
7	0.87591	0.85137	23	13617	13617
8	0.90712	0.89626	24	18453	18453
9	0.94070	0.93288	25	18459	18459
10	0.96010	0.95675	26	18468	18468
11	1.00460	0.99181	27	18482	18482
12	1.02170	1.00740	28	29855	29855
13	1.05170	1.02700	29	29939	29939
14	1.15530	1.05160	30	29960	29960
15	1.17250	1.19200	31	29968	29968
16	1.19770	1.19860	32	31980	31980



a) Resonance response of Mode 1 b) Resonance response of Mode 19

c) Resonance response of Mode 20 d) Resonance response of Mode 23

Figure 9 Resonance response of Pivot 1 (Example for mode 1, 19, 20 and 23)

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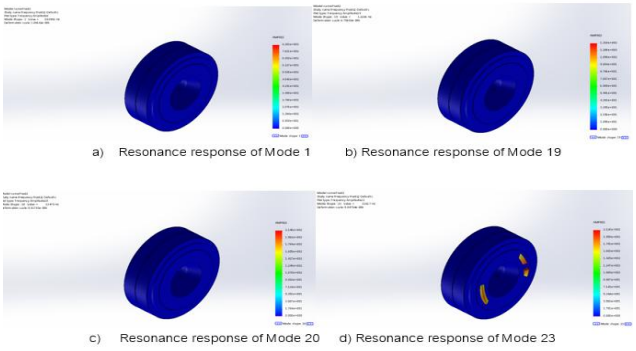

Figure 10 Resonance response of Pivot 2 (Example for mode 1, 19, 20 and 23)

Based on the data and analysis, the result demonstrate the proposal of setting the measuring mode of resonance frequency at a minimum of mode 20 to get static data for Pivot size 3.138 x 8.9 mm. With this methodology, the data would become normally distributed therefore no need to transform data before estimate Ppk.

It is proposed that the setting PMDM machine to measuring and reading resonance value is minimum mode 20 and will be get the minimum resonance response at 13475 Hz.

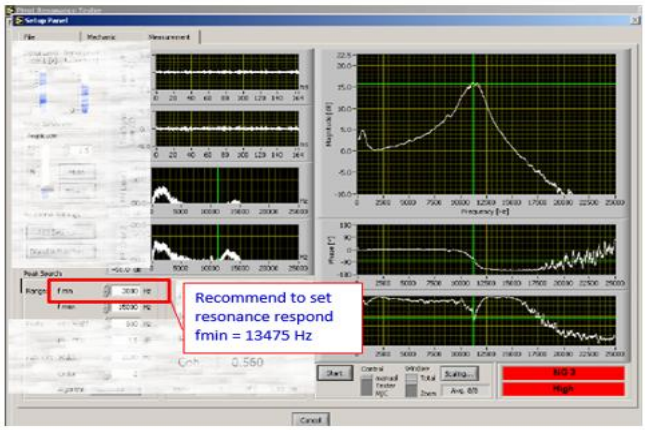

Figure 11 PMDM resonance setting program

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