Application Of Taguchi Method For Improvement Of An Industrial Product----A Study On Quality Engineering

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Abstract : Quality engineering function deals with improvement of product design in which Taguchi method considered as robust design system to eliminate the design hazards and defects in joints,shapes and tolerances of product. The process accomplished taking care of special emphasis on customer satisfaction in such improvement and thus achieving superiority over other competitive product. The present study aims at eliminating the noise factors as far as possible for both internally and externally as admissible. This shapes considered after selection of the competitive product group for analysis of product performance. The project will be helpful for determining similar product designs on the background of analysis of various noise factors.

Keywords: Quality Engineering, Taguchi Method, tolerances, noise elimination

1.0Introduction : Quality engineering proposes a broad range of engineering and operational activities with the purpose of ensuring a product's quality characteristics at their nominal or targeted values. A number of concepts and techniques have been developed to aid the product design function. The field of quality engineering owes much to Genaichi Taguchi(1983) who had attempted to develop this specific areas of design as off line quality control involving both product design and process to achieve the parameters. The method is primarily based on engineering field rather than concentrating on advanced statistical quality control. The difference between Taguchi method and other conventional methods is that Tguchis' experiments orthogonal arrays are used to assure the reproduction of the efforts of the parameters. Another difference is that in Taguchi's study of various types of signal to noise(S/N) ratios are used to measure variability around the targeted performance(Taguchi and Clausing,1990) .Taguchi also proposed the robust design or parameter design for quality improvement (Cabera-Rios et al-2002).It is a cost effective measure for reducing variation in product's dimension or product design. Present paper deals with two of the Taguchi's methods. These are (1) robust design and (2) the Taguchi Loss function. In the present paper the idea applied to a blower fan industry for a selective product, an important Taguchi principle is used to set specifications on product and process parameters with tolerance to create a design that resist failure or reduced performance in the face of variation. These variations are known as noise factors.

1.1 Definitions: Quality of a product defined by American Society of quality control(1983) as " the totality of features and characteristics of a product service that bear on its ability to satisfy user's given needs. A robust design is one in which the function and the performance of the product or process are relatively insensitive to variation in any of the above noise factors. In product design robustness means that the product can maintain consistent performance with minimal disturbances due to variations in uncontrollable factors in its operating environments. The Taguchi Loss function is an useful concept in tolerance design which defines the poor quality as the loss a product costs society time to time, the product is released for shipment. Loss includes costs to operate, failure to function, maintenance to repair costs, customer dissatisfaction, injuries caused by poor design and similar costs.

1.2 Noise Factors : A noise factor is a source of variation which is very difficult to control and that affects the functional characteristics of the product. The three types of noise factors are identified as follows: (a) Variational Noise Factors : These are inherent random variations in the process and product caused by variability in raw materials, machinery and human participation. They are associated with production process resolving statistical control.(b) Internal Noise Factors: These source of variations are internal to the product or process. They include (1) time dependent factors such as wear of mechanical components, spoilage of raw materials and fatigue of metal parts and (2) operational errors such as improper settings on the product or machine tool(c) External Noise Factors : An external noise factor is a source that is external to the product or process, such as outside temperature ,humidity, raw materials supply and input voltage. Internal and external noise factors constituted assignable variables. Taguchi differentiates between internal and external noise factors as external noise factors are more difficult to control. The value of the loss function is transformed into S/N ratio The S/N ratio for each design parameter level is computed based on S/N analysis. Regardless of the performance characteristics category, a larger S/N ratio corresponds to a better performance characteristics. Therefore, the optimal design parameter level is the level with highest S/N ratio. Optimizing multiple performance characteristic is much more complicated than optimizing a single performance characteristics .(Korpelaet al2007,Nearchou,2006) .The attempt should always be made to eliminate noise factors of input side as signal from the output should be free of it as the primary target.

2.0 Research Methodology: Loss occurs when a product's functional characteristics differs from its nominal or targeted value. Although functional characteristics do not translate directly into dimensional features, the loss relationship is most readily understood in terms of dimensions. When the dimension of the blower deviates from its nominal value.the component function is adversely affected resulting in some loss function.

2.1 Measurement of Taguchi Loss : The loss increases at an accelerating rate as the deviation grows, according to Taguchi. Let x= the quality characteristics of interest and N= its nominal value, then the loss function will be U-shaped curve. Taguchi uses a quadratic equation to describe the curve.$L(x)=k(x-N)^2$ where L(x)=loss function, x=constant of proportionality, and x and N are defined above. At some level of deviation(x2-N) = -(x2-N) , the loss will be prohibitive, and it will be necessary to scrap or reverse the product. The quality characteristic, particularly the dimension may be close to the nominal value or close to one of the tolerance limits, which is acceptable. Proceeding to visualize this approach in terms analogous to the preceeding relation we obtain the discontinuous loss function,

2.2 Research objective : Taguchi applies experimental design method in determining signal to noise ratio that are generally measures over noise factors setting that analyze experiments with both sample mean and standard deviation.In the present study the observation restricted to internal and external noise factors and run the experiments to a numbers of observations from which response calculated to find the average value of the responses. Ratings of the noise factors done suitably to represent the tolerance level.

2.3 Steps followed in experimental procedure : 1. Listing of the parts manufactured by firm and the bought out components from the supplier.(2)Basic quality control system already existing in the organization.(3)Setting orthogonal arrays in Taguchi's table presenting variables.(4) Determine internal controllable variables with respect to process variables (5) Determine noise variables in the process design.(6)Run the experiments for minimum 8 nos of observations(8) Find the average response value and plot the reading for various factors(9) Conclusion.

3.0 Different parts of the fan: The company depends on the subcontracting for most of its parts. The different parts of the fan are listed as follows: 1 Casing with sealing plate 2.Inlet cone 3. Pedestral 4.Impeller 5. Shaft with bearing 6. Coupling with guard 7 Cooling disc and 8 Motor. In the workshop of the company fan and blower casings are being fabricated. In case of any defects located by inspecting the system the same is being rectified by TIG or MIG welding. Among the indicated parts majority of the items are being procured from the outside vendors of which the parts noted primarily are 1Inlet Cone 2Pedestral 3 Impeller 4 Shaft with bearing 5 Coupling with guard6 Cooling disc 7Motor.

Table 1 : **Components of the industrial Fans HA SERIES 1**

1	Casing with inlet box	It houses rotor and inlet cone	Manufactured part
2	Base Frame	It supports casing,inlet box,bearing pedestral and motor	------DO-----
3	Bearing Pedestral	This part is for mounting of bearing housing	--Bought out part--
4	Bearing and bearing housing	Accommodating shaft and rotating part	-----Do-------
5	Inlet Cone	It guides the entry of flow media towards the impeller	-------Do------
6	Rotor Assembly	This comprises of impeller shaft,hub,bearing and bearing housing.	Bought out components.The Impeller blades are backward curved vanes.
7	Motor	It is a variable speed induction motor running impeller .	Bought out Components

3.1Quality Control System Of the Organisation: The bought components are inspected normally on 100% inspection basis. Acceptance control chart is being used for the manufactured components However for product defects control to be exercised on sample standard deviation .After completion of production the bought out components are assembled with casing, frame and housing and various types of tests are being carried out for achieving the target performance in the present range of upto 500 cfm. Company maintained the standards established by BIS AS ISO: 9001.Regarding establishing quality control within the organization our enterprise aims at checking the products through stagewise inspections during the production and rejecting the defectives and substandard products so that industrial requirements can be maintained as per customer's choice.

3.2 Setting orthogonal arrays in tables presenting controllable and uncontrollable variables: Application of Taguchi's method discussed at 2.1.For practical purpose Taguchi emphasized that it is not possible to concentrate upon all possible combination of interaction effect among a number of variables. We have decided to focus among the important few and neglecting the trivial ones. Taguchi created standard tables called the ORTHOGONAL ARRAYS of various dimensions(no of rows and columns)in which the columns can be used to represent the variables and therefore select a few from important contribution. We can rate the variables at three levels viz; 1.Low 2 Medium 3.High.Similarly the mixed combination of variables also can be measured in terms of two or more levels o of ratings. In our observation various welded joints of the casing and frame has been considered in inner and outer array and the relationship of the response variables Z has been tested by us through signal to noise(S/N)rating.

3.3 Determination of internal variables and also identification of noise variables : Internal or controllable variables on tolerance of design specifications and defects in machine sections of the factory: 1Fabrication and cutting of sheets (A) 2. Welding problems (B) 3 Curling and Bending (C) 4 Balancing of the defects (D) .Regarding external or uncontrollable variances which is also known as Noise Factors are: 1 Defective raw material supply (E) 2 Problems in dispatch and packing (F) 3.Interruption /Fluctuation of power supply interrupting the process. Regarding each of the controllable variances at three levels are 1 Low 2 Medium 3. High Orthogonal arrays(O.A) created by Taguchi as standard tables of variables and running the test in 1,2,3……8 times Similarly orthogonal arrays can also be constituted for variables E, F and G. The variables acting on the process can be categorized in two categories viz controllable and uncontrollable or noise factors .In fact the noise variables can be controlled under test conditions, though the factors are uncontrollable under real conditions. Conclusion may be drawn on the basis of Taguchi's methods that controllable and noise variables should be designed in the experiment as may be noted in the run as controllable variable in inner array and noise variables in outer arrays. The different stages of experiments repeatedly checked for accuracy of the datas as far as possible .The datas from test run regarding S/N is enclosed in the annexure at the end of the paper. The result of the test plotted in the Z graph drawn on the basis of monthly breakdown forecasting to find the trend and S/N graph are as shown below with corresponding values for A,B,C and D :

Table 2 : **AVERAGE RESPONSE Z CURVE**

Serial No	Level Average Z	A	B	C	D
1	Low	69.208	72.833	71.5	72.958
2	Medium	73.5	70.958	70.541	70.666
3	High	72.916	71.833	73.583	72

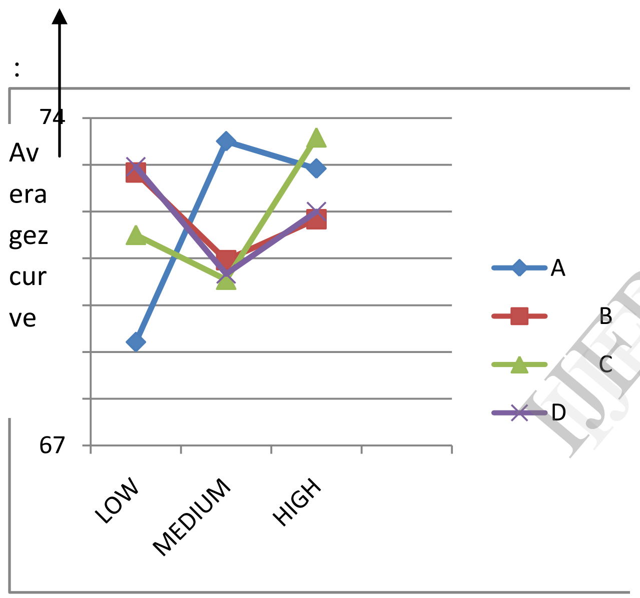
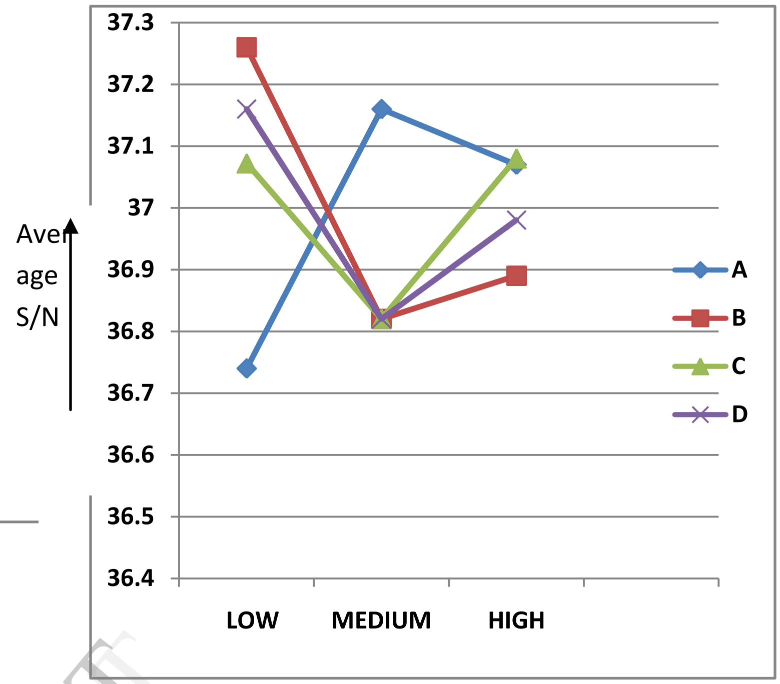


Fig 1: Average response Z curve

Serial No	Averaage S/N LEVEL	A	B	C	D
1	LOW	36.74	37.26	37.07	37.16
2	MEDIUM	37.16	36.82	36.82	36.82
3	HIGH	37.07	36.89	37.08	36.98

Table 3: **AVERAGE S/N CURVE**



4.0 Result Analysis : The mean of the datas taken for both Z graph and S/N graph and it has been observed that mean for A,B,C and D is 71.87 approximately for Z and 36.99 for S/N ratio which indicates that over the run fluctuation is practically negligible.This implies that operation and process control for machining through CNC lathe is accurate and both dimensionally and factorwise there is no variation. While considering noise factors the factors taken care of are (1) Fatigue of the materials and (2)Error in setting of the machine if any and % defect in dimensional tolerance occured due to such defect. Regarding the external noise factors we may ignore temperature and humidity as those are not having much effect on production parameters. But uncontrollable operating noise factors like(a) Raw material supply(b) fluctuation of power supply or power failure influence the datas. Further Analysis of Variances(ANOVA)and F-tests can be carried out to determine whether some other factors affect the process significantly or not. Besides the results obtained depict that the sample value should be controlled as far as possible around the Z value of 36.99 and S/N value as 71.87

5.0 Conclusion : The Taguchi Method can effectively be used for inspection and quality control of both controllable and uncontrollable variances. Setting mean level for operations will helpful for establishing effective quality engineering cell. Present study will prove helpful in developing product quality adopting change of material and and compatible design for customers. Idle time of the line can be judged with Taguchi method to overview the variables like power failure, material loss and human factor engineering .Developing robustness in the design ,minimizing losses due to tolerances as well as controlling the quality of the incoming materials like raw materials, spare parts and consumables. Training of operators and feedback from customers are the vital link in the process of development following Taguchi Method as guide line.

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ANNEXURE : 1

Table for Test Datas

						OUTER	ARRA Y	(OA8)						
				E	1	1	1	1	2	2	2	2		
				F	1	1	2	2	1	1	2	2		
				G	1	2	1	2	1	2	1	2		
	INNER	ARRAY	(OA9)											
RUN	A	B	C	D	VALUE	OF RE	SPON S	E VAR	ZE	ZI			AV.RES VAR ZE	
1	1	1	1	1	73	65	84	79	64	66	71	65	70.875	
2	1	2	2	2	83	55	70	56	59	73	70	60	65.75	
3	1	3	3	3	80	70	74	65	60	77	70	72	71	
4	2	1	2	3	70	72	54	74	70	84	82	80	73.25	
5	2	2	3	1	71	78	69	74	72	78	76	85	75.375	
6	2	3	1	2	60	65	85	78	72	70	60	85	71.875	
7	3	1	3	2	75	70	70	85	80	70	65	80	74.375	
8	3	2	1	3	82	85	60	73	55	75	74	70	71.75	
9	3	3	2	1	85	78	55	64	77	80	77	65	72.625	
RUN	A	B	C	D	VALUES	OF	1/Zi²						∑I/Zi²	
1	1	1	1	1	0.0002	0.00 02	0.000 1	0.0002	A2	A2	A2	A2	0.0015	37.26
2	1	2	2	2	A1	A3	A2	A3	A3	A2	A2	A3	0.0019	36.24
3	1	3	3	3	A2	A2	A2	A2	A3	A2	A2	A2	0.0017	36.72
4	2	1	2	3	A2	A2	A3	A2	A2	A1	A1	A2	0.0015	37.26
5	2	2	3	1	A2	A2	A2	A2	A2	A2	A2	A1	0.0015	37.26
6	2	3	1	2	A3	A2	A1	A2	A2	A2	A2	A1	.0016	36.98
7	3	1	3	2	A3	A2	A2	A1	A2	A2	A2	A2	.0015	3 7.26
8	3	2	1	3	A1	A2	A3	A2	A2	A2	A2	A2	.0016	36.98
9	3	3	2	1	A1	A2	A3	A2	A2	A2	A2	A2	.0016	36.98
	A1=0.	0001	A2=		0.0002	A3=0.0	003							
					A	B	C	D						
		AVER AGE	LOW		69.208	72.833	71.5	72.95 8						
			MEDI UM		73.5	70.958	70.54 1	70.66						
			HIGH		72.916	71.833	73.58	72						

							3							
		S/N	LOW		36.74	37.26	37.07	37.16						
			MEDI UM		37.16	36.82	36.82	36.82						
			HIGH		37.07	36.89	37.08	36.98						