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Optimisation and Reliability for Geometrical Tolerance Value against Positional Characteristic in Rotational Shaft System

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Abstract: ***In the process of manufacture and installation, geometrical dimensions and tolerances (GD&T) should be taken into consideration to improve reliability and reduce the adverse impact on critical parts of the rotating system. GD&T must be considered by manufacturers and assembly worker. This paper presents an analysis of geometrical tolerance (GT) values in rotational shaft using the genetic algorithm (GA) method. GA optimization uses a geometric mathematical model. Mathematical models were developed using the offset and algebraic methods to calculate the ideal geometric features that best fit a set of positioning points based on the standard equations criteria. The calculation using the Matlab software application will use the optimal GA parameter. There is a combination of four genetic parameters associated with size population, crossover, mutation and stop state will develop algorithm performance which will produce optimum GT value. The geometric tolerance value for the position characteristic was analyzed to determine and predict the probability and reliability shaft in rotational system. Comparative values of each GT value are compared to find out the reliability values obtained can be used and verify the GT value requirements require mathematical representation. Tolerance analysis at the design stage to evaluate and predict quality by considering the probability of failure rates. The Actual value of the radius must be small from the allowable radius ($R_{act} < R_{allow}$) to cope with the high failure rate throughout the operating period. Due to dynamic nature of the shaft round and the possibility of a variable size of shafts, the GT value should be analyzed to ensure that the value obtained is correct and can be optimum solution to this problem. The GT value to be considered is at the center of the shaft involved which will affect the relevant components. Impact of GT value on the destruction of system critical component such as bearings, gear and couplers as benchmark for review for the optimization of shaft geometric tolerances in rotating machines to overcome the problem and improve concentricity shaft. The contribution of this study is to examine the effect of shaft size and the value of geometric tolerance on system reliability. Estimating and predicting levels of reliability more accurately improves system life, knows the system's impact accurately, knows the security level of a rotating system and also knows the quality of the mechanism at the design level.***

Keywords: Rotational shaft component, Geometrical Tolerance Value, Genetic Algorithm Optimization, Failure rate, Probability, Reliability.

I. INTRODUCTION

Defects and irregularities in geometry and materials can damage the shaft at high-speed rotation system in a short time [1]. The two main causes of vibrations in the rotating system are unbalances and misalignment that can destroy critical components in the system [2]. The design of high precision systems requires consideration of component geometry tolerance to obtain operational efficiency that will directly impact the performance of the rotating system. The study of rotational center accuracy is an important part of the tolerance analysis method to improve the performance of the rotating system [3]. The evaluation location of center rotating of shaft such as concentricity and positional tolerance are importance for the precision in rotating system [4]. Tolerance synthesis is widely used in conventional optimization, quality engineering and based on genetic algorithms methods. Geometrical dimensioning and tolerance (GD&T) use a mathematical model to determine acceptable variations in the assembly [2]. Dimensional and geometric inspection has a key role in process control and product quality evaluation. Coordinate measuring technology is used actually on large scale in industrial environment for unitary determination of part precision, being applicable on any kind of product typology. Coordinate metrology is using a representative finite set of probed points on part features, each point being recorded thru its coordinates into coordinate system. Thus is not possible to evaluate directly the dimensional and geometric precision without to use an analytical model of part obtained mathematically [5].

Genetic algorithms (GA) are stochastic optimization methods using models which mimic biological evolution process, algorithms [6]. The association process between the set of points and ideal feature represents a mathematical optimization problem. Based on optimization criteria could be obtained different solution which fulfils international or local standards requirements depending by drawing requirements. To obtain the solution of the problem mainly are used mathematical methods or geometric computational methodologies. The method of mathematical modeling is a very effective method for tolerance analysis [7].

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GA uses objective function and corresponding fitness value to determine the search direction where probabilistic is used for the selection of high quality solutions by using randomized search methods defined for optimal solutions [8]. A more robust GA developed to improve the quality of solutions to production planning and scheduling problems with various production lines. With new chromosome encoding, crossover operation, mutation and modified selection, and modified algorithm structure. Advanced GA is used to find global optimum solutions with a very high level of success. In the process of optimization using the GA method requires the elements in the process to make it a potential solution ie to create a popup settlement population, an objective function for verifying capabilities and potential solution operators to alter the initial and subsequent potential solutions. GA method function is to select the correct binary encoding scheme for design variables called chromosomes or individuals. Select individual from individual subpopulation based on objective function value or call fitness function. Another individual and two others will be chosen to create two new ones with probabilities given, known as the probability of crossover. For each individual, use the mutation with the possible mutation [9].

In today's competitive world, company reputation is closely linked to product reliability and is a major focus of every industry sector. Companies will gain a good reputation if high product reliability is achieved. Reliability should be addressed with the concept of probability [10]. Engineering design aims at providing minimum levels of serviceability and improve safety during lifetime [11]. Reliability is related to the consistency of a measurement. Reliability estimates are used to evaluate the stability of different movements from the same system, standards, and tests [12]. Components that complete the operating system must have the same reaction each time the test is completed. Although it does not obtain the exact value of the reliability calculations, it can be achieved through various steps [6, 7]. The process of developing and validating instruments is largely focused on reducing errors in the measurement process [12]. The probability of functional failure can be evaluated in the context of reliability analysis [5]. Sensitivity analysis functions are used and reliability-based design to identify the relationship between reliability change and the highest uncertainty variables that will have the greatest impact on reliability [8]. The reliability analysis method provides a theoretical framework to consider uncertainty in a comprehensive decision scheme with the ultimate goal being to evaluate the ability of the system or component to stay safe and operate during their lifecycle [9]. Tolerance design is an important process for quality factors and depends on different parameters in determining the reliability of mechanical systems. The component or system has two conditions, either operating in perfect condition or having failed completely. Probabilistic reliability theory and mechanical vibration theory are fundamental to conventional reliability analysis approaches as these values can directly determine the failure zone [13]. The calculation of a mechanical system's reliability depends on the volume, completeness, and precision of the statistical data regarding the basic parameters of the mathematical model that describes the limiting states [14]. Mathematical expressions are used in the analysis of tolerance for installation and functional requirements are intended to identify all acceptable deviations in tolerance [15, 16]. The reliability of the shaft in the system can be defined as the probability of the system to perform well throughout its life using a mathematical model with its constraint conditions being used. Estimating the probability of failure or reliability can be used to make decisions about the design or planning of inspection, maintenance and repair [17]. Tolerance analysis methods are needed by industry to improve product quality and to reduce manufacturing costs [18]. In addition, it can reduce the failure of components of the engineering system in production and meet customer requirements [10].

II. CONCENTRICITY AND POSITION EVALUATION

Position tolerance is geometrical chracteristic defined as the number of variations allowed by the actual position used with MMC or LMC to be very useful controls on the axis, point or plane to determine how many variations of the characteristics can be obtained from the specified location by reference in ASME Standard with size feature that can control location, orientation and feature size all at once. MMC for a shaft maximum size and LMC for a shaft minimum size for positional location to maintain functional control. Concentricity and position refer from tolerance accepted shaft position (Four possibility position). True position is the accurate coordinates determined by the basic dimension that represents the nominal value to the extent of the location of your feature may change from "true position". Usually when determining the exact position, a datum is referred to as delta-x and delta-y coordinates. Locations are often positioned with two or three datum to find the right reference location. For this study only use one datum where important is the concentricity of the datum shaft diameter and the centerpiece shaft that is usually mounted bearing. The shaft represents a circular or cylinder shape where the GT value will affect the bearings or other components used for shaft rotation. The search space is the area provided by the concentricity profile where the initial population center candidate is selected for the algorithm the installation data. GA functions to retain a central population candidate which is the solution for focusing and positioning issues. The middle candidate is represented by a chromosome that is a delta-x and a delta-y coordinate. GA operates on delta-x and delta-y coordinates to represent individual inheritance traits through genetic control. Generation genetic operators are used to select the central candidates of the current population to create the new generation. The area is round but the crossover operators use delta-x and delta-y to coordinate parents to generate a rounded child [19]. The search space includes a global optimal solution to find the error center and its location. The center of the circle is the approximate center of the concentricity and its position as the mean value of the delta-x and delta-y coordinates of the sample point [20]. Optimizing the performance of the algorithm depends on the parameters specification involved in the calculation. GA in the actual code is performed by the crossover operator and the reproduction used for the population is therefore not used because the proposed algorithm is powerful and effective.

III. METHODOLOGY

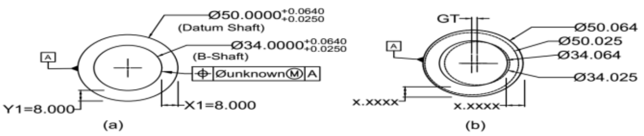
A. *Design Parameter*

The method determines value of the GT linear relationship between the input deviation of the mapping point and the installation output. This method is useful in the modeling and tolerance analysis for GD & T represented by the input deviation at the point at the location. The typical and relatively complex representation of GD & T in the manufacture of the product, ie 2D position tolerance together with size tolerance [21]. The mathematical formula describes the process of modifying the input or shaft characteristics. Table 1 show the design parameter shaft and Figure 1 design spesification shaft without GT value (a) Shaft dimension (b) Shaft possibility illustrated.

Table - I: Design parameters for Shaft

Size (mm)		Basic size Shaft, (Diameter, mm)	Lower Limit (mm)	Upper Limit (mm)
0.025	0.064	50.000	50.025	50.064
0.025	0.064	34.000	50.025	50.064

Figure – I: Design Spesification shaft without GT value (a) Shaft Dimension with fit limit tolerance (b) Shaft possibility illustrated



B. *Mathematical Model*

1) *GT value using algebraic method*

The construction of zones with model variations for tolerance developed using algebraic constraints. Variable models of tolerance have been developed using algebraic constraints by proposing methods that describe geometric semantic tolerance in the form of algebra [22, 23]. Figure 2 show the Schematic representation of a transform for position characterictic.

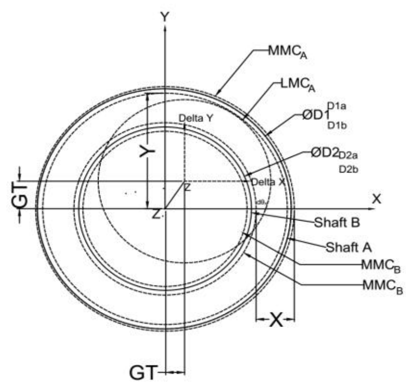


Figure - II: Schematic representation of a transform for position characterictic

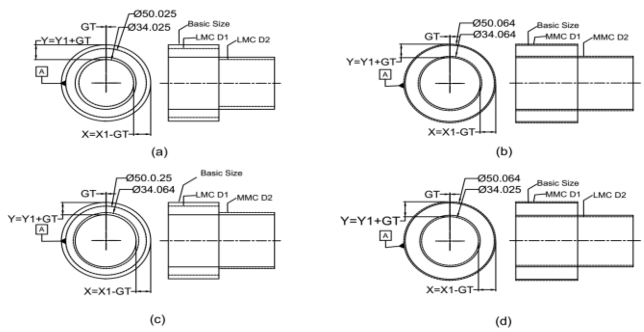
Variable models for tolerance were developed using algebraic constraints. The algebraic constraints for the position-x and position-y variables are defined by inequality. The tolerance zone is obtained by balancing the dimensions with LMC and MMC values corresponding to GT values. Equation (1) is derived from the mathematical model using the algebric method and get the GT value 212 mic@0.0212mm.

$$GT = 2R_{allow} - (MMC_B - LMC_B) \; * \text{Coefficient} \qquad (1)$$
$$= 2(0.0278)-(34.064-34.025)*1.28$$
$$=212 \text{ mic@}0.0212\text{mm}$$

2) *GT value using offset method*

Offset models are one of the earliest methods for establishing Area tolerance. Mathematical Techniques to represent section variations based on the zone of tolerance approach that uses offset operation to produce the tolerance zone [23, 24]. A tolerance zone is defined as a region that must be located within the minimum of the boundaries and objects obtained by balancing the objects with equal quantities on each nominal side. Shaft Possibility position is defined as the variation allowed by the characteristic of the possible shaft position analysis. Position in terms of axis, point or plane determines how many feature variations can be obtained from the specified actual location. The position usually uses the maximum material condition (MMC) or the lowest material condition (LMC) and it becomes a very useful control. MMC to control maximum size of shaft and LMC to control minimum shaft size and position location to maintain function control. Shown in Figure 3 Shaft Possibility position (a) Both Shaft Diameter Are LMC (b) Both Shaft Diameter Are MMC (c) Datum Shaft Diameter Are LMC and B shaft Diameter MMC (d) Datum Shaft Diameter Are MMC and B shaft Diameter LMC (ASME Y14.5M-2009) Dimensioning and tolerancing, (Application Analysis & Measurement).

Figure – III: Shaft Possibility position (a) Both Shaft Diameter Are LMC (b) Both Shaft Diameter Are MMC (c) Datum Shaft Diameter Are LMC and B shaft Diameter MMC (d) Datum Shaft Diameter Are MMC and B shaft Diameter LMC



The correct position has size features and can control location and orientation. Usually when determining the exact position, a datum is referred to as Delta-x and delta-y coordinates. The actual position is usually called as a diameter to represent a 2-dimensional tolerance zone that surrounds the actual location. Equation (2) is derived from the mathematical model using the *offset* method get the GT value 209 mic@0.0209mm.

$$GT = (2(R_{allow}) - (MMC \, ø - Act_{Shaft} \, ø))/2 * \text{Coefficient} \qquad (2)$$
$$= ((2(0.0195) - (50.064 \, ø - 50.069 \, ø))/2) * (0.95)$$
$$= 209 \text{ mic@}0.0209\text{mm}$$

C. *GA Parameter*

Genetic operators and parameters for GA are shown in Table 2. The parameter selection is to obtain a good fitness function value for a generation rated with optimum solution. Mathematical models are a very effective method for tolerance analysis [25]. Population size 100 with 100 generations, probability of crossover 0.7, probability of mutation 0.6. These parameters and range for the required shaft specifications are included in the genetic algorithm method [26]. In the process of making and installing there are several dimensions that interact with other dimensions and have an effect on assembly function. This parameter is used in Matlab analysis to get the best fitness function value.

Table - II: Genetic operators and parameters for GA

Genetic Operator	Parameter	Remarks
Objective function, f(x); i. GT = 2R- $(M_B - L_B)$* C; ii. GT = 2R - (Mø – S)/2 * C		Fitness Function
Population size	100	Population size = 100
No. of iteration	50	
Cross-over probability (pc)	0.7	One Point Cross-over of the (pc) x pop parents genes (i.e. coordinates) for each generation
Mutation Probability (mp)	0.6	Converting a gene that is a coordinate with a random value can modify the mp x pop
Distribution index for cross over	10	
Distribution index for mutation	100	
Stop criterion	N	The algorithm to calculate the last generation N is the best rounded error evaluated to the fourth decimal digit (0.1 µm)

1) *Genetic Programming*

The fitness function is a specific type of objective function as a equation (1) used to obtain a merit figure where the closest value for the design solution proposed by Matlab analysis. Fitness functions are used in genetic algorithms and genetic programming to guide simulations toward optimal design solutions by representing them as numbers. Figure 4 shown the Genetic programming for shaft analysis using Algebriac Methaod and Figure 5 show the Genetic programming for shaft analysis using offset Methaod.

a) Algebric method

GT $= 2R - (M_B - L_B) * C$
f(x) =Objective function
f(x) = GT Value (Geometrical Tolerance Value)
R = R_{allow} (Radius Allowable)
M_B = MMC (Maximum Materials Condition)
L_B = LMC (Least Materials Condition)
C = Coefficient

```
function Y=GT(x)

% Y = Fitness value
% x = Variable Vector
% R = Rallow
% M = Max.Mat.Cond(MMC Dia)
% L = Least.Mat.Cond (LMC Dia)
% C = Coefficient
% Where R=(0.0275:0.0280), M=(30.025:30.064), L=(30.025:30.064) and
% C=(0.78:1.30)

R=x(1,1);% Variable 1
M=x(1,2);% Variable 2
L=x(1,3);% Variable 3
C=x(1,4);% Variable 4

Y=R*2-(M-L)*C; % This is objective function for maximis
```

Figure - IV: Genetic programming for shaft analysis using Algebriac Methaod

b) Offset method

GT = 2R - (Mø – S)/2 * C
f(x) =Objective function
f(x) = GT Value (Geometrical Tolerance Value)
R = R_{allow} (Radius Allowable)
M ø = MMC (Maximum Materials Condition)
S = Act_{Shaft} ø (Actual shaft diameter)
C = Coefficient

```
function y=GTB(X)

% Y = Fitness value
% x = Variable Vector
% R = Rallow
% M = Max.Mat.Cond(MMC Dia)
% S = Act Shaft Dia
% Where R=(0.019:0.02),M=(50.025:50.064), S=(50.025:50.064) and
% C=(0.79:0.96)

R=X(1,1); % Variable 1
M=X(1,2);% Variable 2
S=X(1,3);% Variable 3
C=X(1,4);% Variable 4

y=R*2-((M-S)/2)*C; % This is objective function for maximis
```

Figure - V: Genetic programming for shaft analysis using Offset method

D. *The role of reliability shafts prediction*

FORM (First Order Reliability Method) is one of the most effective basic reliability methods. This method is used as a procedure at products for structural and system reliability analysis [5, 27]. Reliability prediction is one of the most common methods of reliability analysis in predicting component failure rates and overall system reliability. These predictions are used by assessing the feasibility of design, comparing design alternatives, identifying areas of potential failure, trade system design factors and improving reliability improvements. Reliability prediction has many roles in the engineering reliability process. The effect of design changes proposed based on reliability is determined by comparing the prediction of existing and proposed design reliability. Design ability is used to maintain an acceptable reliability level. The reliability of machines is an important characteristic of manufacturing production, It is determined by the reliability of their components and subassemblies [28].

In this study factors and specifications related to shaft were considered in method to estimate shaft reliability based on position and concentricity characteristics with the geometrical tolerance values obtained.

1) Calculate the probility shaft

There are many reliability tools and techniques methodologies available for failure of plant components [11]. Here, in this section, the Calculate of the shaft probability failure is presented. Calculate act tol and calculate R_{allow} then result must be $R_{act} < R_{allow}$. Least material condition (LMC) shaft is 50.025 mm and maximum material condition (MMC) shaft is 50.064 mm for shaft diameters from 34.025 mm to 34.064 with reference to selection of fits for shaft base system. Geometric Tolerance (GT) values obtained from conventional calculations and Matlab for algebriac method and offset method are the basis of calculation for failed items.

2) Calculate the Failure rate and Reliability

This maintenance should be monitored in a set of indicators that come mainly from the system reliability and the functional safety of equipment. Once the system reliability has been mathematically modeled, appropriate simulations can be performed towards the prediction of RAMS (reliability, availability, maintainability and safety) parameters for the period specified [29]. The term reliability in engineering refers to the probability that a product or system performs a function designed under a set of operating conditions for a specified period of time in which it is also known as the probability of survival. The failure behavior over time is to examine the failure rate as the rate of change in the probability of failure according to the function of time. From the failure rates, we can get clues about the factors that influence the control and the time it controls. Table 1 shows the prediction of the operating hour per years for shafts operating for 24 hours a day. Equation (3) shown the failure rate equation.

Table - III: Operating hour per years

No of Month	Operating per year (24 hour/Day)	Operating Hour	
1	30 day/month	720	jam/month
2	60 day/month	1440	jam/2 month
3	90 day/month	2160	jam/3 month
4	120 day/month	2880	jam/4 month
5	150 day/month	3600	jam/5 month
6	180 day/month	4320	jam/6 month
7	210 day/month	5040	jam/7 month
8	240 day/month	5760	jam/8 month
9	270 day/month	6480	jam/9 month
10	300 day/month	7200	jam/10 month
11	330 day/month	7920	jam/11 month
12	360 day/month	8640	jam/12 month

$$\text{Failure rate } \lambda = \frac{Items \quad Failed}{Total \quad Operating \quad Time} \tag{3}$$

The probability of a product surviving until time (t) is given by the equation (4).

$$\text{Reliability at time (t)} = e^{-\lambda t} \tag{4}$$

IV. RESULT AND DISCUSSION

A. *Result genetic programming for shaft analysis*

The decision for each analysis will be influenced by the value of the parameters used for initial population, probability of mutation and number of generations. Set the maximum number of generations to 1000 and count objective function for cases where the Initial population size is 100. By increasing the probability of mutation probability does not contribute to better fitness results. For each percentage of mutation each point in the range will be calculated and from here the best value for fitness function will be recommended. The results show an increasing number of generations, the more diversity in random populations is generated and the best solution proposed in the population is expected to be close to the optimal solution where the system will suggest a smaller value than random population value. Figure 6 shows the best value of fitness function using Matlab for Algebriac Method is 0.0210mm@210micron, Figure 7 shows the best value of fitness function using Matlab for Offset Method is 0.0207mm@207micron and the deviation value calculate using variable method as shown table 4. GT value for Algebric Method using calculation 0.0212mm @21.12 Micron, GT value for Algebric Method using Matlab 0.0210mm @21.10 Micron, . GT value for Offset Method using calculation 0.0209mm @20.9 Micron and GT value for Offset Method using Matlab 0.0207mm @20.7 Micron.

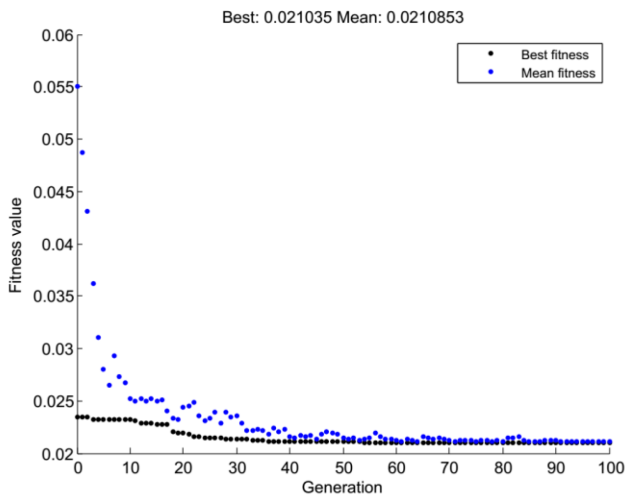


Figure - VI: Fitness Value result using Algebriac Method

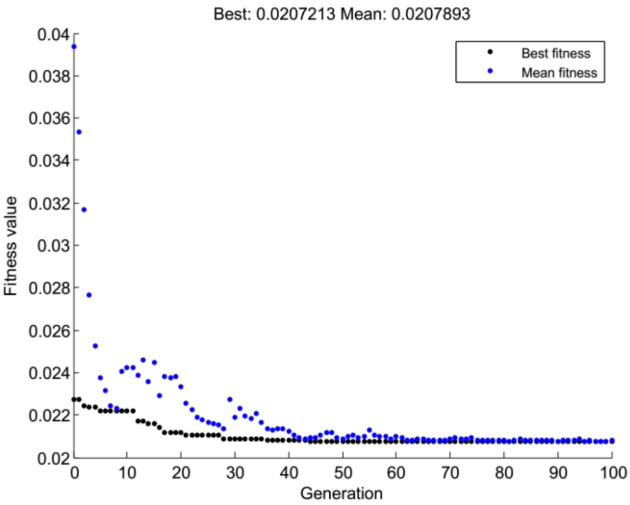


Figure - VII: Fitness Value result using Offset Method

Table - IV: Result for GT Value using variable method

Basic Size Shaft (Datum Shaft, mm)		Basic Size Shaft (B Shaft, mm)		GT value using Algebric Method, GT = 2Rallow - (MMCB – LMCB) * C		GT value using Offset Method, GT = (2(Rallow) - (MMC ø – ActShaft ø))/2 * C	
				Calcu-lation	Matlab	Calcu-lation	Matlab
Over	T0	Over	T0	0.0212	0.0210	0.0209	0.0207
50.025	50.064	30.025	30.064				

B. *Probability Shaft failure*

Probability is a mathematical branch with the purpose of application in each area. the probability of failure occurring within the shaded area, explains the breakdown can only occur if the product has survived from the beginning of installation to maximum operating time. Therefore, the probability of a product failing in time to change is that the rate of change in probability is the failure rate at the maximum operating time. GT values obtained from various methods are the basis for calculating failure rate values. Result the calculate the Act tolerance and calculate R_{allow} and then result must be $R_{act} < R_{allow}$ [30, 31]. R_{actual} value difference $<R_{allow}$ is a failed item.

1) Failure rate and Reliability

The reliability of shaft and bearing is the probability that the components involved in the system are expected to function without failure in certain circumstances and periods. The concept of probability can be understood through the concept of a reliable belief that the ability of the product, equipment and system to function as expected for a given period of time under certain operating conditions. Table 5 shown failure rate and reliability shaft for each actual diameter with different GT values for each LMC and MMC. From the data it was found that the reliability value decreases as the shaft size increases. Table 5 Shown the failure rate per size and reliability per size. MMC shaft(A) is 50.064 mm and LMC shaft(A) is 50.025 mm, MMC Shaft (B) is 34.064mm and LMC shaft(B) 34.025mm with reference to selection of fits for shaft base system. The shaft size (B) of the LMC is decreased failure rate and increase reliability, the shaft size (B) of the MMC is increased failure rate and decrease reliability.

Table 5 Failure rate and reliability for shaft

	LMC = 50.025mm Diameter to MMC = 50.064mm Diameter							
	Offset method (GT Value = 0.0209mm)		Algebraic method (GT Value = 0.0212mm)		Offset method from Matlab (GT Value = 0.0207mm)		Algebraic method from Matlab (GT Value = 0.0210mm)	
Act. Diameter	Failure Rate	Reliability	Failure Rate	Reliability	Failure Rate	Reliability	Failure Rate	Reliability
34.025	1.1271E-04	0.9221	1.1371E-04	0.9214	1.1195E-04	0.9226	1.1301E-04	0.9219
34.026	1.1466E-04	0.9208	1.1566E-04	0.9201	1.1389E-04	0.9213	1.1496E-04	0.9206
34.027	1.1674E-04	0.9194	1.1774E-04	0.9187	1.1597E-04	0.9199	1.1704E-04	0.9192
34.028	1.1896E-04	0.9179	1.1997E-04	0.9172	1.1819E-04	0.9184	1.1926E-04	0.9177
34.029	1.2132E-04	0.9164	1.2234E-04	0.9157	1.2055E-04	0.9169	1.2163E-04	0.9162
34.030	1.2385E-04	0.9147	1.2486E-04	0.9140	1.2307E-04	0.9152	1.2415E-04	0.9145
34.031	1.2654E-04	0.9129	1.2755E-04	0.9123	1.2576E-04	0.9134	1.2684E-04	0.9127
34.032	1.2939E-04	0.9110	1.3041E-04	0.9104	1.2862E-04	0.9115	1.2970E-04	0.9108
34.033	1.3244E-04	0.9091	1.3344E-04	0.9084	1.3167E-04	0.9096	1.3274E-04	0.9089
34.034	1.3567E-04	0.9069	1.3667E-04	0.9063	1.3491E-04	0.9074	1.3597E-04	0.9067
34.035	1.3910E-04	0.9047	1.4010E-04	0.9041	1.3835E-04	0.9052	1.3940E-04	0.9045
34.036	1.4275E-04	0.9023	1.4373E-04	0.9017	1.4200E-04	0.9028	1.4304E-04	0.9021
34.037	1.4662E-04	0.8998	1.4759E-04	0.8992	1.4589E-04	0.9003	1.4691E-04	0.8996
34.038	1.5073E-04	0.8972	1.5169E-04	0.8965	1.5001E-04	0.8976	1.5102E-04	0.8970
34.039	1.5510E-04	0.8943	1.5603E-04	0.8937	1.5439E-04	0.8948	1.5537E-04	0.8942
34.040	1.5973E-04	0.8914	1.6064E-04	0.8908	1.5903E-04	0.8918	1.6000E-04	0.8912
34.041	1.6464E-04	0.8882	1.6552E-04	0.8876	1.6397E-04	0.8886	1.6491E-04	0.8880

34.042	1.6986E-04	0.8849	1.7071E-04	0.8843	1.6921E-04	0.8853	1.7011E-04	0.8847
34.043	1.7540E-04	0.8814	1.7622E-04	0.8808	1.7477E-04	0.8818	1.7564E-04	0.8812
34.044	1.8128E-04	0.8776	1.8206E-04	0.8771	1.8068E-04	0.8780	1.8151E-04	0.8775
34.045	1.8753E-04	0.8737	1.8827E-04	0.8732	1.8697E-04	0.8741	1.8775E-04	0.8736
34.046	1.9417E-04	0.8695	1.9486E-04	0.8691	1.9365E-04	0.8699	1.9438E-04	0.8694
34.047	2.0124E-04	0.8651	2.0187E-04	0.8647	2.0076E-04	0.8654	2.0143E-04	0.8650
34.048	2.0876E-04	0.8604	2.0934E-04	0.8601	2.0833E-04	0.8607	2.0893E-04	0.8603
34.049	2.1678E-04	0.8555	2.1728E-04	0.8552	2.1640E-04	0.8557	2.1693E-04	0.8554
34.050	2.2532E-04	0.8502	2.2575E-04	0.8500	2.2501E-04	0.8504	2.2545E-04	0.8502
34.051	2.3445E-04	0.8447	2.3478E-04	0.8445	2.3419E-04	0.8448	2.3455E-04	0.8446
34.052	2.4419E-04	0.8388	2.4443E-04	0.8386	2.4402E-04	0.8389	2.4426E-04	0.8387
34.053	2.5462E-04	0.8325	2.5475E-04	0.8324	2.5453E-04	0.8325	2.5466E-04	0.8325
34.054	2.6580E-04	0.8258	2.6580E-04	0.8258	2.6581E-04	0.8258	2.6580E-04	0.8258
34.055	2.7779E-04	0.8187	2.7766E-04	0.8188	2.7791E-04	0.8187	2.7775E-04	0.8187
34.056	2.9069E-04	0.8112	2.9039E-04	0.8113	2.9093E-04	0.8110	2.9060E-04	0.8112
34.057	3.0458E-04	0.8031	3.0410E-04	0.8034	3.0496E-04	0.8029	3.0444E-04	0.8032
34.058	3.1958E-04	0.7945	3.1889E-04	0.7948	3.2012E-04	0.7941	3.1937E-04	0.7946
34.059	3.3581E-04	0.7852	3.3489E-04	0.7857	3.3652E-04	0.7848	3.3553E-04	0.7854
34.060	3.5341E-04	0.7753	3.5222E-04	0.7760	3.5433E-04	0.7748	3.5305E-04	0.7755
34.061	3.7255E-04	0.7647	3.7106E-04	0.7656	3.7372E-04	0.7641	3.7210E-04	0.7650
34.062	3.9344E-04	0.7533	3.9159E-04	0.7543	3.9488E-04	0.7525	3.9288E-04	0.7536
34.063	4.1631E-04	0.7410	4.1405E-04	0.7422	4.1808E-04	0.7401	4.1563E-04	0.7414
34.064	4.4145E-04	0.7277	4.3870E-04	0.7292	4.4358E-04	0.7266	4.4062E-04	0.7282

Figure 8 illustrates increase in failure rate of the shaft and figure 9 illustrates decrease in reliability of the shaft. Efficiency or performance of the components assessed decreases with respect as well as the utilization period. The regression model obtained is found useful in monitoring, predicting and simulating the component unreliability. It was found that the failure rate for LMC was lower compared to MMC values. It is also found that higher GT values will result in higher failure rate values so it is important to determine the optimum GT value for the system.

For GT Value 0.0212mm @ 212micron gives an optimum value for shaft (B) size of 34.025mm, then failure rate 1.1371E-04, reliability shaft value 0.9214 @ 92.14% after one month, GT Value 0.0209mm @ 209 micron gives an optimum value for shaft (B) size of 34.025mm, then failure rate 1.1271E-04, reliability shaft value 0.9221 @ 92.21% after one month, GT Value 0.0210mm @ 2110micron gives an optimum value for shaft (B) size of 34.025mm, then failure rate 1.1301E-04, reliability shaft value 0.9219 @ 92.19% after one month and GT Value 0.0207mm @ 207micron gives an optimum value for shaft (B) size of 34.025mm, then failure rate 1.1195E-04, reliability shaft value 0.9226 @ 92.26% after one month.

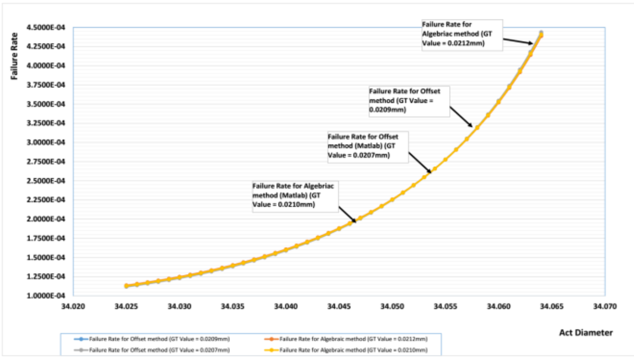


Figure - VIII: Failure Rate for the variable GT value using variable method

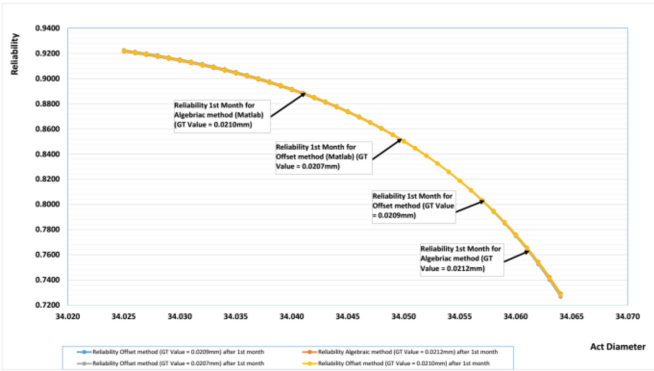


Figure - IX: Reliability for the variable GT value using variable method

Table 6 Shown the failure rate per size and reliability per year. In this paper total operating time is 8760 Hours and total hour for every month as shown at table 3. MMC shaft(A) is 50.064 mm, LMC shaft(A) is 50.025mm and sampel using size LMC shaft(B) 34.025mm. The shaft size (B) of the LMC is decreased failure rate, increase reliability, the shaft size (B) of the MMC is increased failure rate and decrease reliability within one year.

Table 6 Reliability shaft per year

	LMC = 50.025mm Diameter to MMC = 50.064mm Diameter, Actual Diameter 34.025							
Operating Time (Month)	Offset method (GT Value = 0.0209mm) after 12th month (1 Year)		Algebriac method (GT Value = 0.0212mm) after 12th month (1 Year)		Offset method (Matlab) (GT Value = 0.0207mm) after 12th month (1 Year)		Algebriac method (Matlab) (GT Value = 0.0210mm) after 12th month (1 Year)	
	Failure Rate	Reliability	Failure Rate	Reliability	Failure Rate	Reliability	Failure Rate	Reliability
1st	1.1271E-04	0.9221	1.1371E-04	0.9214	1.1195E-04	0.9226	1.1301E-04	0.9219
2nd		0.8502		0.8490		0.8511		0.8498
3rd		0.7839		0.7822		0.7852		0.7834
4th		0.7228		0.7207		0.7244		0.7222
5th		0.6665		0.6641		0.6683		0.6658
6th		0.6145		0.6119		0.6165		0.6137
7th		0.5666		0.5638		0.5688		0.5658
8th		0.5225		0.5195		0.5247		0.5216
9th		0.4817		0.4786		0.4841		0.4808
10th		0.4442		0.4410		0.4466		0.4432
11th		0.4096		0.4063		0.4120		0.4086
12th		0.3776		0.3744		0.3801		0.3767

Figure 10 shown reliability system for each month of the year with different GT values for each LMC and MMC. It was found that the value of reliability decreases every month. For GT Value 0.0212mm @ 212micron gives an optimum value for shaft (B) size of 34.025mm, then failure rate 1.1371E-04, reliability shaft value 0.9214 @ 92.14% after one month and 0.3744@37.44% after twelve months, GT Value 0.0209mm @ 209 micron gives an optimum value for shaft (B) size of 34.025mm, then failure rate 1.1271E-04, reliability shaft value 0.9221 @ 92.21% after one month and 0.3776@37.76% after twelve months, GT Value 0.0210mm @ 2110micron gives an optimum value for shaft (B) size of 34.025mm, then failure rate 1.1301E-04, reliability shaft value 0.9219 @ 92.19% after one month and 0.3767@37.67% after twelve months and GT Value 0.0207mm @ 207micron gives an optimum value for shaft (B) size of 34.025mm, then failure rate 1.1195E-04, reliability shaft value 0.9226 @ 92.26% after one month and 0.3801@38.01% after twelve months.

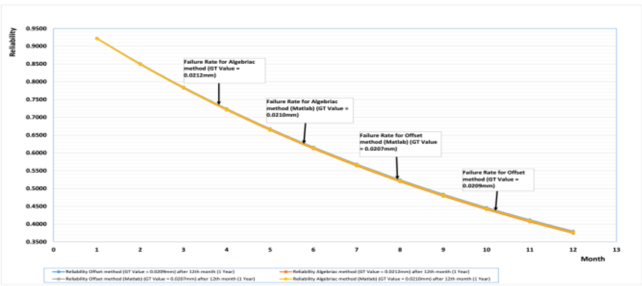


Figure - X: Reliability for the variable GT value using variable method after 12th month (1 Year)

The reliability of the system series is implemented when the

Rs = R1 x R2 x ……x Rn

system components are arranged in series. System reliability is also the product reliability of each component assuming that each component's reliability is not tied to the reliability of the other components as an equation (3). The series system is the failure of any element that leads to structural failure for the system [17]. Reliability assessment was used in tests containing a series of items with the aim of measuring the same attributes [6]. The serial system where all components are required for the system to work as shown in Figure 11 with a simple series system of two components. Calculation Reliability system using standard reliability value for component. Failure time is the time for the first component to occur failure, it can be expressed with structural. From the data it was found that the reliability system for MMC was higher compared to LMC values. It is also found that higher GT values will result in low reliability shaft values so it is important to determine the optimum GT value for the system.

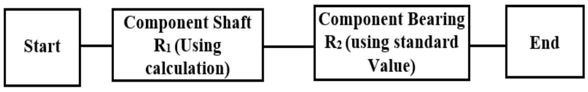


Figure - XI: Block for reliability system

V. CONCLUSION

In this research paper developed an algorithm for scope of 2D tolerance analysis and presents the method for obtaining geometrical tolerance values using GA method and analyzed using application matlab and tests on values obtained using several methods including FEA. The basic steps of the algorithm nevertheless remain the same for all application definitions of the product parametric model with help. The GT value obtained must not affect the component of stress and pressure. Found that the smaller the actual size shat value is easier to meet the $R_{allowable}$ radius and less impact on components such as shaft because the value obtained is less than the tolerance component value for Shaft. To get smaller GT values is difficult in the manufacturing process. Found to be less impact on components such as shaft because the value obtained is less than the tolerance bearing value. From the results obtained it is found that GA from Matlab for Algebriac method recommends the value of GT is 0.0210mm @ 21 micron, offset method recommends the value of GT is 0.0207mm @ 20.7 micron. The GT value obtained depends on the diameter of the shaft diameter and the larger the shaft size is the greater the value of the GT.

For the developed algorithm structure, long-chromosome length changes, modified genetic operations and algorithm parameters will be calculated per value generated by Matlab's analysis. GA's suggested values can effectively address integrated optimization problems. Experimental results show that GA's proposed structure is better than conventional calculations. GA methods in simultaneous design provides beneficial in many ways. Due to this, the need for assembly tolerance is given to a certain extent for critical components, resulting in increased product reliability. These benefits enable the creation of high quality tolerance designs, starting from the early stages of product development.

The reliability and validity of a system is an important consideration for researchers and designers considering the ongoing failure rate to produce quality products. Reliability must be considered early in the design project taking into account the impact of the shaft and other components on the rotating system. In this paper, we study the relationship between geometric tolerance values and design accuracy that affect dynamic geometry for spinning systems as it is a specific concern in competitive product design. The reduction in reliability with the same increase in the study interval, as well as the increase in uncertainty with the corresponding increase in the study interval should be noted for all components of the shaft considered in the research work. The reliability and technique of the adopted approach is a model-based concept to monitor and predict regulatory factors that influence failure, component quality and cost implications. However, in practical applications especially when considering multiple component failure components or complex failure systems, straightforward applications of such reliability tools and techniques may be difficult to provide good consideration of the reliability of components. System reliability is determined by the reliability of components and subsystems that are estimated as the system security measures used in the decision-making process for low reliability values can be accepted as measurements in optimal reliability-based design problems. Higher levels of reliability will be obtained by analyzing the same systems designed after design practice. Estimates and predictions the reliability of the system lifecycle will be taken into account in solving the decision problem and the component failure rate will be used to determine the value of geometric tolerance in the design process. From the reliability values obtained, it is found that the value of the obtained geometric tolerance value can be used as it does not produce significant damage in the short term to the system. However higher reliability values will be considered in design and installation. Tolerance Analysis is a key step in the design phase of a high rotating system. The tolerance value that will be used will affect the system and it will be rather difficult to produce a good system and installation without tolerance.

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