Study of Parametric Optimization of Microdrilling Operation using Taguchi Method

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CERTIFICATE

*This is to certify that the project work entitled "**Study of Parametric Optimization of Microdrilling Operation using Taguchi Method**" being submitted by* **Fakir Mohan Pati** *to National Institute of Technology, Rourkela is a record of bonafide project work under my supervision and is worthy of the partial fulfillment for the degree of Bachelor of Technology (Mechanical Engineering) of the Institute. The candidate has fulfilled all prescribed requirements and the thesis, which is based on candidate's own work, has not been submitted elsewhere.*

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ABSTRACT

Drilling is a very basic process of machining which is of great importance for the modern world and especially microdrilling plays an important role of it. Therefore optimization of the parameters that control the process of microdrilling is unavoidable to have the best results. In this paper the parametric optimization of microdrilling has been studied using Taguchi Method considering a number of parameters like cutting velocity, feed rate, cutting time, cutting pressure and the hole surface roughness etc. The objective is to study the effect of various factors and their optimization using Taguchi method. An overall study has been made across a number of journals along with the practical results to illustrate the process.

CHAPTER 1

INTRODUCTION

1. INTRODUCTION

Drilling is one of the most fundamental machining technologies and is moving toward high precision/high speed applications for productivity enhancement. One notable drilling technology, micro-hole drilling, is becoming increasingly more prominent in a variety of precision industries, such as the production of automotive fuel injection nozzles, watch and camera parts, medical needles, air bearing, etc. Especially, its applications in the electronics and computer industries are rapidly expanding. It is mainly used in machining of printed circuit boards (PCB) and IC masking. The increase in the degree of integration demands improved technologies for the manufacture of smaller holes with larger aspect ratios for higher density circuit boards. Furthermore, the increasing competition in micro part developments puts an additional impetus on micro-hole manufacturing technologies.

Microdrilling refers to the drilling of holes less than 0.5 mm (0.020 in). Drilling of holes at this small diameter presents greater problems since coolant fed drills cannot be used and high spindle speeds are required. High spindle speeds that exceed 10,000 RPM also require the use of balanced tool holders. Micro-electric discharge machining (micro-EDM) has evolved as one of the prominent processes to generate high-aspect-ratio and accurate micro-structures in many industrial applications. It is shown that a depth of 5.0 mm can be achieved by a 200 μm diameter tool electrode while controlling the regular process parameters, but beyond this length, the process is governed by a number of derived phenomena such as secondary sparking, debris accumulation, etc. instead of the regular processing parameters. The optimum depth of the hole that could be achieved with a good accuracy i.e. a minimum oversize lies between 2.5 and 5.0 mm, the largest depth that could be achieved was 8.33 mm. The highest aspect ratio achieved in this experiment was 15.63.

CHAPTER 2

LITERATURE SURVEY

2. LITERATURE SURVEY

This chapter outlines some of the recent reports published in literature on microdrilling with special emphasis on Taguchi method.

Tokarev, Lopez, Lazare et al.[10] developed an analytical model of multipulse excimer laser drilling in polymers. It was shown that the adequate account of the mechanism of radiation propagation and absorption inside the keyhole was important for the good agreement of theory and experiment. The controlling factors of drilling were revealed. Keyhole profile and depth versus incident infuence were calculated for top-hat beam. The matching conditions for laser ifluence, parameters of optical scheme and material parameters were derived in an explicit analytical form, allowing to produce deep narrow keyholes with practically parallel side walls and aspect ratios as high as 300-600.

Tsao,Hocheng et al. [11] predicted and evaluated the thrust force and surface roughness in drilling of composite material using candle stick drill. The approach was based on Taguchi method and the artificial neural network. The experimental results indicated that the feed rate and the drill diameter were the most significant factors affecting the thrust force, while the feed rate and spindle speed contribute the most to the surface roughness. The objective of their study was to establish a correlation between the feed rate, spindle speed and drill diameter with the induced thrust force and surface roughness in drilling composite laminate.

Tsao, Hocheng et al. [12] also predicted and evaluated the delamination factor used in twist drill, candle stick drill and saw drill. The approach was based on Taguchi's method and the analysis of variance (ANOVA). An ultrasonic C-Scan was used to examine the delamination of carbon fiber-reinforced plastic (CFRP) laminate. The experiments were conducted to study the delamination factor under various cutting conditions. The experimental results indicated that the feed rate and the drill diameter were recognized to make the most significant contribution to the overall performance. The objective was to establish a correlation between feed rate, spindle speed and drill diameter with the induced delamination in a CFRP laminate. The correlation was obtained by multi-variable linear regression and compared with the experimental results.

Gaitonde, Karnik, Paulo Davim et al. [13] presented the methodology of Taguchi optimization method for simultaneous minimization of delamination factor at entry and exit of the holes in drilling of SUPERPAN DECOR (melamine coating layer) MDF panel. The delamination in drilling of MDF was found to affect the aesthetical aspect of the final product and hence it was essential to select the best combination values of the drilling process parameters to minimize it. The experiments were carried out as per L9 orthogonal array with each experiment performed under different conditions of feed rate and cutting speed. The analysis of means (ANOM)was performed to determine the optimal levels of the parameters and the analysis of variance (ANOVA) was employed to identify the level of importance of the machining parameters on delamination factor. The investigations revealed that the delamination can be effectively reduced in drilling of MDF materials by employing the higher cutting speed and lower feed rate values.

Kishore, Tiwari, Dvivedi, Singh et al. [14] found that drilling in composite materials was often required to facilitate the assembly of the parts to get the final product. However they noticed that drilling induced damage drastically affects the residual tensile strength of the drilled components. They investigated and studied the effect of the cutting speed, the feed rate, and the drill point geometry on the residual tensile strength of the drilled unidirectional glass fiber reinforced epoxy composite using the Taguchi method and suggested the optimal conditions for maximum residual tensile strength.

According to S.Basavarajappa, G.Chandramohan, J.Paulo Davim et al.[15] drilling is a metal removal process and is important for the final fabrication stage prior to application. They studied the influence of cutting parameters on drilling characteristics of hybrid metal matrix composites (MMCs)—Al2219/15SiCp and Al2219/15SiCp–3Gr.The Composites were fabricated using stir casting method. The Taguchi design of experiments and Analysis of variance(ANOVA) were employed to analyze the drilling characteristics of the composites. They conducted the experiments to study the effect of spindle speed and feed rate on feed force, surface finish and burr height using solid carbide multi facet drills of 5mm diameter and revealed that the dependent variables are greatly influenced by the feed rate rather than the speed for both the composites. The ceramic–graphite reinforced composite has better machinability than those reinforced with SiCp composites.

According to Man Sheel Cheong, Dong-Woo Cho,Kornel F.Ehmann et al[16], the major difficulties in micro-hole drilling are related to the wandering motions during the inlet stage, high aspect ratios, high temperature, etc. However, of all the difficulties, the most undesirable ones are the increases in drilling force and torque as the drill penetrates deeper in to the hole. This is mainly caused by chip-related effects. Peck-drilling is thus widely used for deep hole drilling despite the fact that it leads to low productivity. A proportional plus derivative (PD) and a sliding mode control algorithm were implemented and compared for controlling the spindle rotational frequency. Experimental results revealed that sliding mode control reduces the nominal torque and cutting force and their variations better than PD control, resulting in a number of advantages, such as an increase in drill life, fast stabilization of the wandering motion, and precise positioning of the holes.

CHAPTER 3

MICRODRILLING

3.1 MICRODRILLING

Microdrilling is characterized not just by small drills but also a method for precise rotation of the microdrill and a special drilling cycle. In addition, the walls of a microdrilled hole are among the smoothest surfaces produced by conventional processes. This is largely due to the special drilling cycle called a peck cycle. The smallest microdrills are of the spade type. The drills do not have helical flutes as do conventional drills and this makes chip removal from the hole more difficult. Drills with a diameter of 50 micrometers and larger can be made as twist drills. Drills smaller than this are exclusively of the spade type because of the difficulty in fabricating a twist drill of this size.

Microdrills are typically made of either cobalt steel or micrograin tungsten carbide. The steel drills are less expensive and easier to grind but are not as hard or strong as the tungsten carbide drills. The drill point angle is based on the material to be drilled. The normal point angle is 118 degrees and 135 degrees is used for hard materials. The larger included point angle provides more strength at the drill point.

The recommended speeds and feeds for microdrilling are as varied as the materials which can be drilled. Microdrilling is not generally a high speed process since dwelling of the drill at the bottom of the hole can cause hardening of the work piece leading to increased drilling forces. For most metals, typical spindle speeds are in the 2000 to 4000 rpm range and feeds are in the range of a micrometer per revolution, or so. Care must be taken when drilling plastics to avoid melting of the material which can lead to adhesion of the plastic to the drill. This can cause drill breakage or poor sidewall smoothness.

The applicability of microdrilling as a complementary process with features produced by lithography and electroplating has been investigated. A cross section of a copper microgear made by lithography is shown. The average roughness of the hub wall is 0.4 micrometers. A microdrilled hole in the same material gave a roughness of 0.15 micrometers over a much longer bore length. Microdrilling can also be used to augment lithography for mesoscopic (millimeter and larger) sized components. Often parallelism of deep holes is of concern. To determine typical values for parallelism of microdrilled holes, glass fibers were inserted into a number of holes drilled with a very slow starting sequence. This is necessary to ensure the drill does not walk on the surface of the part and that the hole axis aligns with the undeflected axis of rotation of the drill. Holes with a length-to-diameter ratio of 8 were drilled at 4000 rpm. The three-dimensional misalignment of the inserted fibers was measured to be 0.08 degrees (1.5 milliradians), which included skewing of the fiber in the hole due to oversize of the hole which was estimated to be 0.5 micrometers.

Microdrilling has one major disadvantage because of the drill geometry. Because of the drill point, a flat-bottomed hole cannot be produced. If one is attempting to produce cylindrical cavities in a micromold, there must be a relatively thick plating base under the mold material, or the structural substrate of the mold could act as the plating base. To fully develop the diameter of the hole, projected onto a plane perpendicular to the drilling direction, requires the drill point to extend 30% of the drill diameter beyond the depth of the fully developed hole. For holes in the 100 micrometer region, requires a thick plating base to be deposited [18, 22].

3.2. Factors affecting Microdrilling

3.2.1. Vibration and sound

Vibration is widely used for condition monitoring of rotating machinery. However, vibration has not been used to the same extent in tool condition monitoring, probably because as a method it is rather sensitive to noise which is present in cutting processes. The advantages of vibration measurement include ease of implementation and the fact that no modifications to the machine tool or the work piece fixture are required. However, the disadvantages reported in the literature include dependency of the vibration signals on workpiece material, cutting conditions and machine structure. Vibration is measured both in the transverse and axial direction. The vibration signals are considered to contain reliable features for monitoring drill wear and breakage for the following reasons: the vibrating drill length in the transverse and axial modes does not change during drilling, thus maintaining a rather constant mode frequency; the natural frequencies of the transverse and axial modes of the work piece– drill system are basically insensitive to drill cross-sectional size, thus simplifying monitoring for a wide range of drill sizes; vibrations in the directions Y and Z are influenced by the torque and thrust force which are the major excitation sources in drilling. However, quite a number of factors influence how the mechanical vibration is transferred and how it takes place at the different frequencies. A higher frequency range from 0.5 to 40 kHz for vibration measurements has been tested with very thin drills. The reason for looking at this kind of frequency range is that the rotational natural frequencies fall into that range since for a drill of 1 mm diameter the natural frequency could be about 25 kHz and for a drill of 3 mm diameter it could be about 7 kHz .

3.2.2 Acoustic emission and ultrasonic vibration:

The use of ultrasonic vibrations (UEs) in the frequency range from 20 to 80 kHz for tool breakage detection in various metal cutting processes including drilling has been tested. The practicality of using ultrasonic vibrations is explained when compared to other vibration techniques. Acoustic emission (AE) is seen to suffer from severe attenuation and multi-path distortion caused by bolted joints commonly found in machine tool structures and restricting the mounting location of the AE transducer to somewhere very near the tool or workpiece. The lower frequency signal used for UE analysis does not suffer such severe attenuation and distortion, and so the transducer can be placed fairly far from the chip forming zone. In the low vibration frequency range, i.e. below 20 kHz, structural modes are prominent. A common strategy is to compare the amplitudes of several frequency bands in this range. Particular variation in the relative strengths of vibration in these bands indicates process abnormalities such as tool breakage or tool wear. This method shares the advantage of remote transducer placement with the UE method but unfortunately is much more sensitive to machine and tooling variations. Since structural modes change in complex ways with machine movement, loading, temperature, and tooling, this approach generally must be tuned empirically each time that the process is changed. In contrast, in the frequency range used for UE analysis the structural modes are so closely spaced that they form a so-called pseudo-continuum. There are no individual resonances to shift out of the analysis band with machine movement, loading, and so on.

3.2.3 Spindle motor and feed drive current

Spindle motor current is in principle a measure of the same feature as torque, i.e. they both enlighten how much power is used in the cutting process and they both also advise about the dynamics of cutting. It is fair to claim that torque is a more sensitive way to measure than is the spindle motor current since the torque sensor is located close to the cutting tool and e.g. the dynamics of the electric motor do not influence it to the same extent that they influence the current measurement. However, measuring torque is more complicated than measuring the current of the spindle motor and therefore the measurement of the current has also been widely tested and used . It is impossible to successfully apply these measurements as tool-monitoring methods, stopping the machining after the increase in one or several signals above a particular limit value before actual tool failure. However, the measurements can be used for tool-breakage detection where the machining operation is interrupted after tool breakage.

CHAPTER 4

TAGUCHI METHOD

4.1 INTRODUCTION TO TAGUCHI METHOD

Dr. Taguchi of Nippon Telephones and Telegraph Company, Japan has developed a method based on “ORTHOGONAL ARRAY” experiments which gives much reduced “variance” for the experiment with “optimum settings" of control parameters. Thus the marriage of Design of Experiments(DOE with optimization of control parameters to obtain BEST results is achieved in the Taguchi Method. "Orthogonal Arrays" (OA) provide a set of well balanced (minimum) experiments and Dr. Taguchi's Signal-to-Noise ratios (S/N), which are log functions of desired output, serve as objective functions for optimization, help in data analysis and prediction of optimum results.

4.2 Design of experiments(DOE)

A well planned set of experiments, in which all parameters of interest are varied over a specified range, is a much better approach to obtain systematic data. Mathematically speaking, such a complete set of experiments ought to give desired results. Usually the number of experiments and resources (materials and time) required are prohibitively large. Often the experimenter decides to perform a subset of the complete set of experiments to save on time and money! However, it does not easily lend itself to understanding of science behind the phenomenon. The analysis is not very easy (though it may be easy for the mathematician/statistician) and thus effects of various parameters on the observed data are not readily apparent. In many cases, particularly those in which some optimization is required, the method does not point to the BEST settings of parameters. A classic example illustrating the drawback of design of experiments is found in the planning of a world cup event, say football. While all matches are well arranged with respect to the different teams and different venues on different dates and yet the planning does not care about the result of any match (win or lose)!!!! Obviously, such a strategy is not desirable for conducting scientific experiments (except for co-ordinating various institutions, committees, people, equipment, materials etc.).

4.3 Taguchi Method

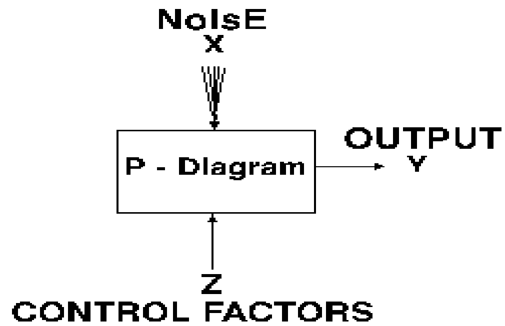
The Taguchi method is a technique to find out the optimum values of the control factors to make the product or process get affected minimally by the noise factors. The Taguchi method is mainly based upon the technique of matrix manipulations. The experimental matrices are special orthogonal arrays, which allow the simultaneous effect of several process parameters to be studied efficiently. The purpose of conducting an orthogonal experiment is to determine the optimum level for each factor and to establish the relative significance of the individual factors in terms of their main effects on the response. Taguchi suggests signal-to-noise (S/N) ratio as the objective function for matrix experiments. The S/N ratio is used to measure the quality characteristics as well as the significant machining parameters through analysis of variance (ANOVA). Taguchi classifies objective functions into three categories such as smaller the better type, larger the better type and nominal the best type. The optimum level for a factor is the level that results in the highest value of S/N ratio in the experimental region[13].

Taguchi Method treats optimization problems in two categories,

[A] STATIC PROBLEMS

Generally, a process to be optimized has several control factors which directly decide the target or desired value of the output. The optimization then involves determining the best control factor levels so that the output is at the the target value. Such a problem is called as a "STATIC PROBLEM".

This is best explained using a P-Diagram which is shown below ("P" stands for Process or Product). Noise is shown to be present in the process but should have no effect on the output! This is the primary aim of the Taguchi experiments - to minimize variations in output even though noise is present in the process. The process is then said to have become ROBUST.



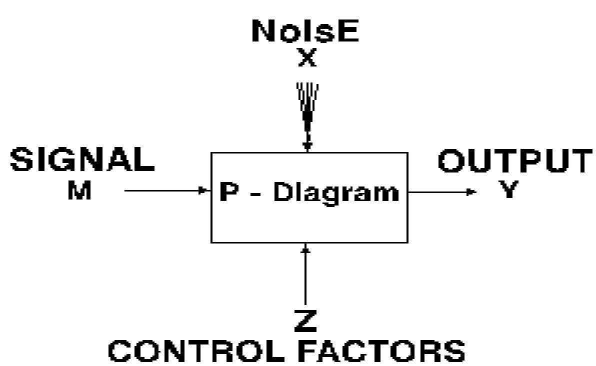
P - Diagram for STATIC problems

(fig-1)[17]

[B] DYNAMIC PROBLEMS :

If the product to be optimized has a signal input that directly decides the output, the optimization involves determining the best control factor levels so that the "input signal / output" ratio is closest to the desired relationship. Such a problem is called as a "DYNAMIC PROBLEM".

This is best explained by a P-Diagram which is shown below. Again, the primary aim of the Taguchi experiments - to minimize variations in output even though noise is present in the process- is achieved by getting improved linearity in the input/output relationship.



P - Diagram for DYNAMIC problems

(fig-2)[17]

[A] STATIC PROBLEM (BATCH PROCESS OPTIMIZATION)

There are 3 Signal-to-Noise ratios of common interest for optimization of Static Problems;

(I) SMALLER-THE-BETTER

n = -10 Log_{10} [mean of sum of squares of measured data] (1)[17]

This is usually the chosen S/N ratio for all undesirable characteristics like " defects " etc. for which the ideal value is zero. Also, when an ideal value is finite and its maximum or minimum value is defined (like maximum purity is 100% or maximum Tc is 92K or minimum time for making a telephone connection is 1 sec) then the difference between measured data and ideal value is expected to be as small as possible. The generic form of S/N ratio then becomes,

n = -10 Log_{10} [mean of sum of squares of {measured - ideal}] (2)[17]

(II) LARGER-THE-BETTER:

n = -10 Log_{10} [mean of sum squares of reciprocal of measured data] (3) [17]

This case has been converted to SMALLER-THE-BETTER by taking the reciprocals of measured data and then taking the S/N ratio as in the smaller-the better case.

(III) NOMINAL-THE-BEST

n = 10 Log_{10} [(Square of mean)/(variance)] (4)[17]

This case arises when a specified value is MOST desired, meaning that neither a smaller nor a larger value is desirable.
Examples are;

(i) Most parts in mechanical fittings have dimensions which are nominal-the-best type.

(ii) Ratios of chemicals or mixtures are nominally the best type.

e.g. Aqua regia 1:3 of HNO_3: HCL

Ratio of Sulphur, KNO_3 and Carbon in gun powder

(iii) Thickness should be uniform in deposition /growth /plating /etching.

[B] DYNAMIC PROBLEM (TECHNOLOGY DEVELOPMENT)

In dynamic problems, we come across many applications where the output is supposed to follow input signal in a predetermined manner. Generally, a linear relationship between "input" "output" is desirable.

For example : Accelerator peddle in cars,

volume control in audio amplifiers,

document copier (with magnification or reduction)

various types of mouldings etc.

There are 2 characteristics of common interest in "follow-the-leader" or "Transformations" type of applications,

(i) Slope of the I/O characteristics

(ii) Linearity of the I/O characteristics (minimum deviation from the best-fit straight line)

The Signal-to-Noise ratio for these 2 characteristics have been defined as;

(I) SENSITIVITY {SLOPE}

The slope of I/O characteristics should be at the specified value (usually 1). It is often treated as Larger-The-Better when the output is a desirable characteristics (as in the case of Sensors, where the slope indicates the sensitivity).

$n = 10 \text{ Log}_{10}$ [square of slope or beta of the I/O characteristics] (5) [17]

On the other hand, when the output is an undesired characteristics, it can be treated as Smaller-the-Better.

$n = -10 \text{ Log}_{10}$ [square of slope or beta of the I/O characteristics] (6) [17]

(II) LINEARITY (LARGER-THE-BETTER)

Most dynamic characteristics are required to have direct proportionality between the input and output. These applications are therefore called as "TRANSFORMATIONS". The straight line relationship between I/O must be truly linear i.e. with as little deviations from the straight line as possible.

$$n = 10 \text{ Log}_{10} \text{ [(Square of slope or beta)/(variance)]} \qquad (7)\ [17]$$

Variance in this case is the mean of the sum of squares of deviations of measured data points from the best-fit straight line (linear regression).

Taguchi method is a scientifically disciplined mechanism for evaluating and implementing improvements in products, processes, materials, equipment, and facilities. These improvements are aimed at improving the desired characteristics and simultaneously reducing the number of defects by studying the key variables controlling the process and optimizing the procedures or design to yield the best results.

The method is applicable over a wide range of engineering fields that include processes that manufacture raw materials, sub systems, products for professional and consumer markets. In fact, the method can be applied to any process be it engineering fabrication, computer-aided-design, banking and service sectors etc. Taguchi method is useful for 'tuning' a given process for 'best' results [17].

Taguchi proposed a standard 8-step procedure for applying his method for optimizing any process,

8-STEPS IN TAGUCHI METHODOLOGY [19]:

Step-1: Identify the main function, side effects, and failure mode

Step-2: Identify the noise factors, testing conditions, and quality characteristics

Step-3: Identify the objective function to be optimized

Step-4: Identify the control factors and their levels

Step-5: Select the orthogonal array matrix experiment

Step-6: Conduct the matrix experiment

Step-7: Analyze the data, predict the optimum levels and performance

Step-8: Perform the verification experiment and plan the future action

CHAPTER 5

PRINCIPAL COMPONENT ANALYIS

5.1. Principal Component Analysis

Principal component analysis (PCA)[24] involves a mathematical procedure that transforms a number of possibly correlated variables into a smaller number of uncorrelated variables called principal components. The first principal component accounts for as much of the variability in the data as possible, and each succeeding component accounts for as much of the remaining variability as possible. Depending on the field of application, it is also named the discrete **Karhunen–Loève transform** (**K.L.T.**), the **Hotelling transform** or **proper orthogonal decomposition** (**POD**).

PCA was invented in 1901 by Karl Pearson and now it is mostly used as a tool in exploratory data analysis and for making predictive models. PCA involves the calculation of the eigenvalue decomposition of a data covariance matrix or singular value decomposition of a data matrix, usually after mean centering the data for each attribute. The results of a PCA are usually discussed in terms of component scores and loadings.

PCA is the simplest of the true eigenvector-based multivariate analyses. Often, its operation can be thought of as revealing the internal structure of the data in a way which best explains the variance in the data. If a multivariate dataset is visualised as a set of coordinates in a high-dimensional data space (1 axis per variable), PCA supplies the user with a lower-dimensional picture, a "shadow" of this object when viewed from its (in some sense) most informative viewpoint.

5.2. Definition and Description[24].

PCA is mathematically defined as an orthogonal linear transformation that transforms the data to a new coordinate system such that the greatest variance by any projection of the data comes to lie on the first coordinate (called the first principal component), the second greatest variance on the second coordinate, and so on. PCA is theoretically the optimum transform for given data in least square terms.

For a data matrix, $\mathbf{X}^{\mathbf{T}}$, with zero empirical mean (the empirical mean of the distribution has been subtracted from the data set), where each row represents a different repetition of the experiment, and each column gives the results from a particular probe, the PCA transformation is given by:

$$\mathbf{Y}^{\mathrm{T}} = \mathbf{X}^{\mathrm{T}}\mathbf{W} = \mathbf{V}\mathbf{\Sigma}^{\mathrm{T}} \qquad (8)[24]$$

where the matrix Σ is an m-by-n diagonal matrix with nonnegative real numbers on the diagonal and $\mathbf{W}\,\mathbf{\Sigma}\,\mathbf{V}^{\mathbf{T}}$ is the singular value decomposition (svd) of **X**.

Given a set of points in Euclidean space, the first principal component (the eigenvector with the largest eigenvalue) corresponds to a line that passes through the mean and minimizes sum squared error with those points. The second principal component corresponds to the same concept after all correlation with the first principal component has been subtracted out from the points. Each eigenvalue indicates the portion of the variance that is correlated with each eigenvector. Thus, the sum of all the eigenvalues is equal to the sum squared distance of the points with their mean divided by the number of dimensions. PCA essentially rotates the set of points around their mean in order to align with the first few principal components. This moves as much of the variance as possible (using a linear transformation) into the first few dimensions. The values in the remaining dimensions, therefore, tend to be highly correlated and may be dropped with minimal loss of information. PCA is often used in this manner for dimensionality reduction. PCA has the distinction of being the optimal linear transformation for keeping the subspace that has largest variance. This advantage, however, comes at the price of greater computational requirement if compared, for example, to the discrete cosine transform. Nonlinear dimensionality reduction techniques tend to be more computationally demanding than PCA [24].

5.3. Properties and limitations of PCA[24].

PCA is theoretically the optimal linear scheme, in terms of least mean square error, for compressing a set of high dimensional vectors into a set of lower dimensional vectors and then reconstructing the original set. It is a non-parametric analysis and the answer is unique and independent of any hypothesis about data probability distribution. However, the latter two properties are regarded as weakness as well as strength, in that being non-parametric, no prior knowledge can be incorporated and that PCA compressions often incur loss of information.

The applicability of PCA is limited by the assumptions made in its derivation. These assumptions are:

- Assumption on linearity

  It is assumed that observed data set to be linear combinations of certain basis. Non-linear methods such as kernel PCA have been developed without assuming linearity.

- Assumption on the statistical importance of mean and covariance

  PCA uses the eigenvectors of the covariance matrix and it only finds the independent axes of the data under the Gaussian assumption. For non-Gaussian or multi-modal Gaussian data, PCA simply de-correlates the axes. When PCA is used for clustering, its main limitation is that it does not account for class separability since it makes no use of the class label of the feature vector. There is no guarantee that the directions of maximum variance will contain good features for discrimination.

- Assumption that large variances have important dynamics

  PCA simply performs a coordinate rotation that aligns the transformed axes with the directions of maximum variance. It is only when we believe that the observed data has a high signal-to-noise ratio that the principal components with larger variance correspond to interesting dynamics and lower ones correspond to noise.

Essentially, PCA involves only rotation and scaling. The above assumptions are made in order to simplify the algebraic computation on the data set [24].

CHAPTER 6

CONCLUSION

Conclusion:

In this paper the parametric optimization of microdrilling has been studied using Taguchi Method considering a number of parameters like cutting velocity, feed rate, cutting time, cutting pressure and the hole surface roughness etc. The desired factors like hole diameter, precision and accuracy of holes, aspect ratio etc. were studied. Principal Component Analysis was studied and found to be a very important method for the above study. An overall study has been made across a number of journals to describe the process.

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