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A REVIEW ON OPTIMIZATION OF PROCESS PARAMETERS USING ARTIFICIAL NEURAL NETWORK

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ABSTRACT

In today's manufacturing industries, special attention is given to dimensional accuracy, geometric tolerance and surface finish. Machining is the most important category of material removal processes as it offers excellent dimensional tolerances and the best surface quality. There are three principal machining processes namely, turning, drilling, and milling. From various literatures review surveys that the surface roughness can be further improved by coated inserts instead of using uncoated inserts.

Surface roughness of machined components has a major impact on their functional performances. The model is expected to predict the surface roughness in terms of cutting parameters like cutting speed, feed, and depth of cut. Minimum surface roughness can be achieved by the optimization of the machining parameters on Taguchi's concept using Artificial Neural Network.

Keywords: Surface roughness, cutting parameters, Artificial Neural Network.

1. INTRODUCTION

In recent times, modern machining industries are trying to achieve high quality, dimensional accuracy, surface finish, high production rate and cost saving along with reduced environmental impact.Machining can be defined as the process of removing excess material from an initial workpiece to produce the desired final geometry[1].It can be manufactured many metal products, and also used for materials such as wood, plastic, ceramic, and composites.

Turning is one of the extensively used machining processes in industrial applications[1]. It consists of removing material from an external or internal, cylindrical or conical surface.Turning process can be conducted either on conventional lathe or on computer numerically controlled (CNC) lathe. Nowadays, the CNC lathe is widely used where machining operations are controlled by a program of instructions based on alphanumeric code.Surface roughness remains the main indicator of the machined workpiece quality and its dimensional precision[2]. In fact, a low surface roughness improves several features of the machined product such as tribological properties, fatigue strength, corrosion resistance, and esthetical appeal. Consequently, the most important tasks in turning process are measurement and characterization of surface properties[3]. There are different parameters to characterize the surface roughness.In a turning operation, a considerable amount of the generated energy is largely converted into heat, which increases the temperature in the cutting area[4]. So, cutting fluids are used for maintaining the temperature of the operating material.

Figure 1. CNC Lathe machine

Surface roughness is a vital parameter in assessing the desirable quality of the finished product especially when dealing with issues related to friction, lubrication and tool wear[1]. The quality of surface is an important parameter to evaluate the productivity of machine tools as well as machined components. The surface roughness is used as the critical quality indicator for the machined surface. The quality of the work piece (either roughness or dimension) are greatly influenced by the tool material, tool geometry, cutting conditions, machining process, work piece material, chip formation, tool wear and vibration during cutting. The three main turning parameters considered in the previous studies were cutting speed, feed rate, and depth of cut.

By reducing the machining time with high speed machining, machining efficiency will be improved.The use of coating materials in machining processfor producing good products with minimum surface roughness is very useful in manufacturing industries. Coated hard metals havebrought tremendous increase in productivity since their introduction in 1969 and had an immediate impact on the metal cutting industries[5]. Due to their significantly higher hardness, carbide-cutting tools are widely used in the manufacturing industries today than high-speed steels[6]. The best alternative for most turning operations is coated and uncoated carbides and these are widely used in the metal working industry[7]. In very hot applications, cemented carbides are used and the process of PVD and CVD can be used to deposit coatings due to their heat resistance. It is necessary for tool materials to possess high temperature strength. The purpose of product or process development is to improve the performance characteristics of the product or process relative to customer needs and expectations. Advances in coating technology have resulted in a new generation of high performance coated carbide tools exhibits improved properties based on quality[8].

2. MACHINING CONDITIONS

The machining parameters involved in the turning operation are,

- Speed
- Feed
- Depth of cut

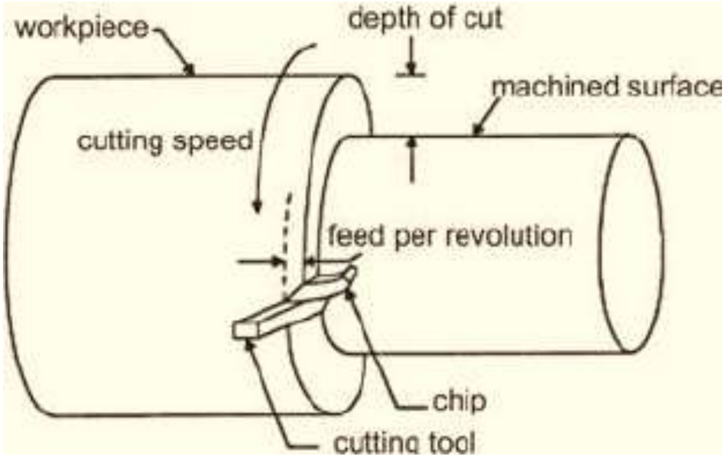

Figure 2. Turning operation and adjustable parameters

The variation of surface roughness with respect to the machining parameters indicates that the surface roughness fluctuated for various spindle speed, feed rate, and depth of cut[7].In case of high spindle speed, low feed rate, and low depth of cut, surface roughness will be better. Feed rate is found to be the most significant effect to produce the minimum value of arithmetic average surface roughness[9]. A feed rate has more dominant influence on than cutting speed and depth of cut due to the influence of mechanism of chip formation. At high cutting speed, the velocity of chip is faster and low feed rate that lead a shorter time for the chip to be in contact with the new machined surface and the probability of the chip to left over the new formed surface is small[10]. The average surface roughness (Ra) is selected for characterization of surface finish during turning operations, which is the most widely used surface finish parameter in industry[12].From various literatures review surveys that minimum surface roughness can be achieved by machining with correct proportion of cutting parameters for machining processes[11].

For the prediction of surface roughness various methodologies are being employed, such as, classical experimental design, machining theory, the Taguchi method and artificial intelligence[11].Surface roughness plays a significant role on machining cost where it is related to the dimensions precision so contributes in reducing assembly time and avoiding the need for secondary operation, therefore cost will be reduced. Machining parameters, material of cutting tool and its geometry parameters, work piece material and its mechanical properties, generated temperature, machine vibrations and cutting conditions (wet or dry cutting) were depended by the value of surface roughness[13]. Even small changes in any of the mentioned factors may have a significant influence on the machined surface.

Some problems will be created during the machining operation due to rapid machining process[17].The generated heat in the cutting zonewhere about 97% of the work that goes into cutting dissipated in the form of heat is one of the main problems in machining process[14]. The generated heat impacts on mechanical properties of the workpiece and wear rate of the cutting tool and consequently on surface roughness. Cooling Lubricating Fluids (CLFs) were used to moderate the damaging effect of heat in machining processes[15]. Economic and environmental troubles accompanied using conventional cutting fluids.The choice of CNC machine is based on the high precision of the parts produced by it and as consequence, it reduces cost of machining and improves productivity[16].Optimization of machining parameters means where the minimum surface roughness will be obtained by optimizing the different parameters based on the Taguchi approach.

3. EXPERIMENTAL CONCEPT

In modern industries, the main goal is to manufacture at low cost, great quality and less manufacturing time. Automated and flexible manufacturing systems that uses its extensive knowledge by combining Numerical Control (NC) and Computerized Numerical Control (CNC) respectively. Turning is the most familiar cutting method and mainly for finishing operations in machined parts. Cutting parameters are reflected on surface roughness, texture and dimensional variations of the machined product which is used to determine and to evaluate quality and attributes of the finished goods.

Surface roughness is the measure of quality and cost that required to manufacturing the product. It gives a new layout of machined surfaces combined with surface textures. It is a very complicated and process dependent. For selecting cutting parameters various parenthesis as to be considered based on the statistical regression obtained from Neural Network techniques to establish the relation between the cutting performances and cutting parameters. Based on the various analysis and study and detailed descriptions Taguchi method is involved to determine the desired cutting parameters more efficiently.

Taguchi has developed a methodology for the application of designed experiments, including a practitioner's handbook. This methodology is very useful to optimize the machining parameters using coated insert in ANN.Taguchi introduces his approach, using experimental design for,

-designing products/processes so as to be robust to environmental conditions;

- designing and developing products/processes so as to be robust to component variation;

- minimizing variation around a target value.

The philosophy of Taguchi is broadly applicable. System design, parameter design, and tolerance design are the three step approach proposed by Taguchi and these steps are carried out by the engineering optimization of process or product.The optimal process parameter values were to be obtained by trained and tested values in various software designs like ANN. Taguchi method is used to achieving high quality without increasing the cost by the key of parameter design. Taguchi design procedure is as follows,

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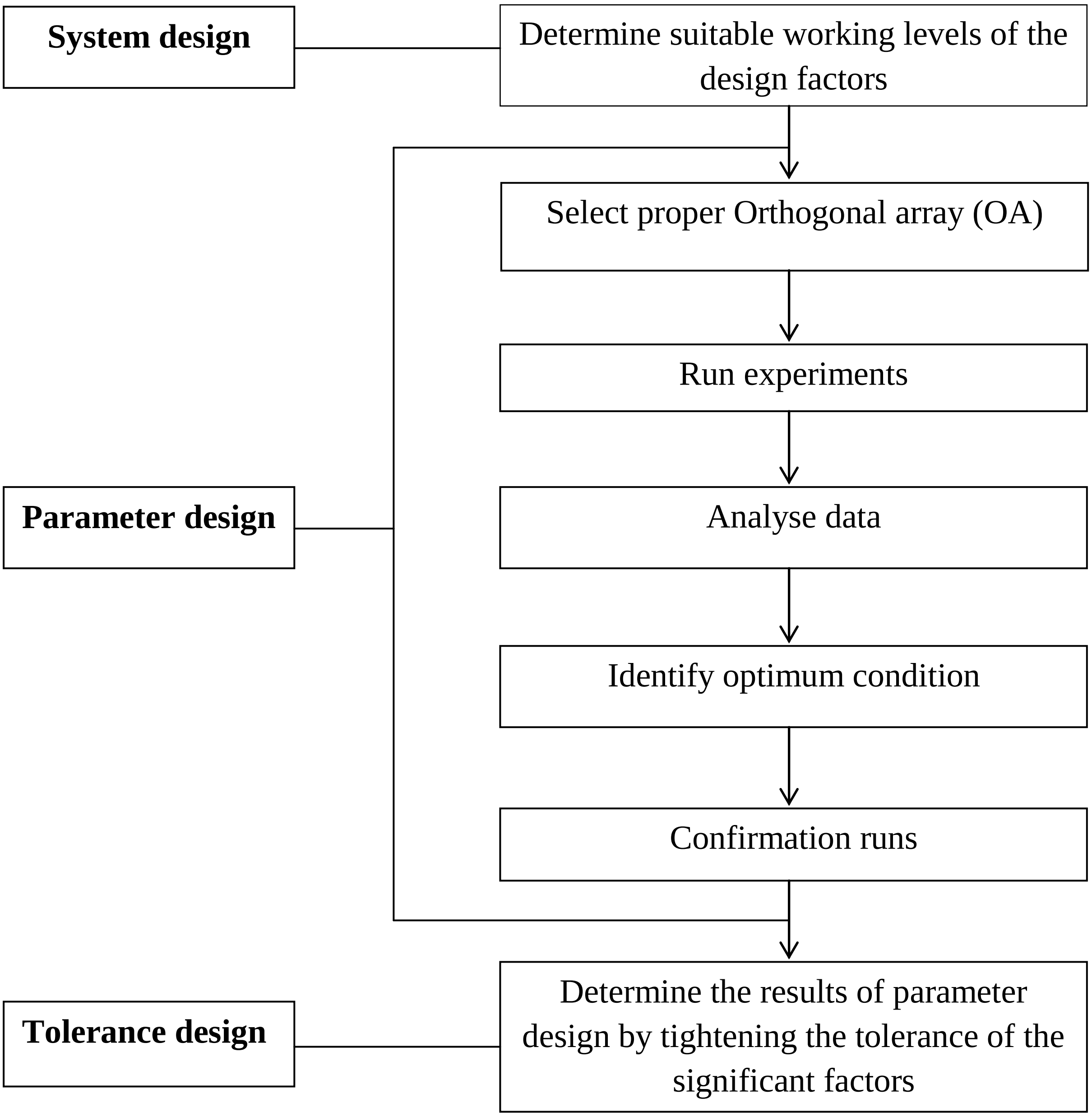

Fig. 1: Taguchi design procedure

A special design of orthogonal array was to be studied by the Taguchi's approach of work. A loss function is then defined to calculate the deviation between the experimental value and the desired value. A loss function is to measure the performance characteristic deviating from the desired value recommended by Taguchi. The value of the loss function is further transformed into a signal to noise (S/N)ratio(η).In the analysis of the S/N ratio,that is, the lower the better, the higher-the-better, and the nominal the better are the three categories of performance characteristics.The use of the parameter design of the Taguchi method to optimize a process with multiple performance characteristics includes the following steps:

- Identify the performance characteristics and select process parameters to be evaluated.
- The process parameters and possible interactions between the process parameters were determined with the number of levels.
- Conduct the experiments based on the arrangement of the orthogonal array.
- Calculate the total loss function and the S/N ratio.
- Analyse the experimental results using the S/N ratio and ANOVA.
- Select the optimal levels of process parameters.
- Optimal process parameters should be verified through the experiment which is confirmed.

The table of ANOVA is used to investigate which of the process parameters significantly affect the performance characteristics. It is used to determine the significant parameters influencing surface roughness during turning operation and the observed value of surface roughness (R_a, mm) is used for determining the influential factors during the machining process.

4.ARTIFICIAL NEURAL NETWORK

Artificial neural networks have focused in several papers on machining processes for surface roughness modelling in the recent years. Even in such a specific niche of engineering literature, the papers differ considerably in terms of how they define network architectures and validate results, as well as in their training algorithms, error measures, and the like. Engineers involved with modelling of surface roughness have at their disposal a number of options. For a variety of reasons, one particular option has been largely investigated in the literature the use of artificial neural networks (ANNs).

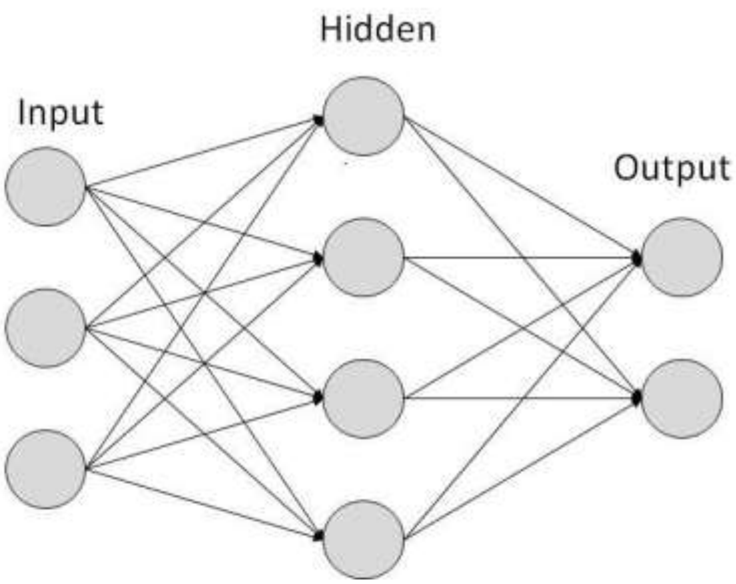

Figure 3. Artificial Neural Network

ANNs have their roots in the initial forays into artificialintelligence. In addition to that, neural networks have been successfully applied to solve a wide range of practical and complex problems in several distinct fields. These include pattern recognition, signal processing, chemical and biomedicalindustrial processes, and in manufacturing operations likewelding, moulding, machining, and many others.ANN has three types of layers namely the input, output, and the hidden layers. Each neuron on the input layer is assigned to an attribute in data and produces an output which is equal to the scaled value of the corresponding attribute.The hidden layers, usually numbering one or two, are intermediate between the input and output layers.

4.1 Input layer

It is a set of input units which take in information about the example to be propagated through the network. By propagation, we mean that the information from the input will be passed through the work and an output produced. The set of input units forms what is known as the input layer.

4.2 Hidden layer

A set of hidden units which take input form the input layer. The hidden units collectively form hidden layer. For simplicity, we assume that each unit in the input layer is connected to each unit of the hidden layer, but this is not necessarily the case. The set of input units forms the input to every hidden unit to a weighted sum of the output. Note that the number of hidden units is usually smaller than the number of input units.

4.3 Output layer

In neural network, the output layer collects and transmits the information according in way it has been designed to give. The pattern presented by the output layer can be directly traced back to the input layer. The neural network was performing by the direct relation of number of neurons in output layer. To determine the number of neurons in the output layer, first consider the intended use of the neural network.

The use of ANNs as a modelling tool for the estimation or classification of surface roughness prediction in machining is the problem in question for various reviewed papers. Process parameters are typically used as independent variables. The usual expectation is to obtain models presenting smaller errors in prediction than from other methods. By this, the optimized cutting parameters were to be observed which is better in performance.The construction of good ANN models is a complex and demanding task when compared to other modelling techniques. This is the trade-off for the superior computing capability of an artificial neural network. The present analysis suggests that great improvement could be made on works produced on the subject, if basic requirements in neuro computing were observed, and possibilities offered by the technique were better explored. It shows that in many works, inadequatetreatment is given to model validation. Moreover, confidencein the use ofANN models could be substantially improved where data and information required to reproduce results and networks are provided by the papers.

5.CONCLUSION

The following conclusions were drawn:

- The ANN approach developed can be very useful in fixing the cutting parameters to achieve good surface finish and to maintain the surface finish during machining.
- Taguchi's parameter design is a simple, reliable, and more efficient tool for optimization of the cutting parameters. The effect of various cutting parameter such as cutting speed, feed rate, and depth of cut has been studied through machining.
- Minimum surface roughness can be achieved through the optimization of cutting parameters using coated insert in Artificial Neural Network.

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