DOI: https://doi.org/10.46632/jame/1/4/7

REST Journal on Advances in Mechanical Engineering

Vol: 1(4), December 2022

REST Publisher; ISSN: 2583-4800

Website: http://restpublisher.com/journals/jame/

# Development of a machine tool selection system using the SPSS Method

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**Abstract:** Productivity, cost of equipment, and the ability to provide satisfactory service are important factors to consider when selecting machine tools. Machine tool selection is a crucial decision-making process for many manufacturing companies. Improperly selected machinery can reduce the efficiency of the production system as a whole, affecting the speed of production, quality, cost, and efficiency. Machine tools such as lathes, drilling machines, shaping machines, planning machines, and milling machines play a significant role in the manufacturing and processing of various equipment. They are often referred to as "work machines." Machine tools are essential in the development of various industries and depend on the specific type of machine tool. Therefore, they are often referred to as the "mother of machines." Machine tools are utilized in various sectors, including frictional materials technology, casting manufacturing, transmission, electrical equipment, and system integration. Moreover, they are widely used in the electronics, automobile industry, mechanical manufacturing, electrical equipment, railway locomotives, shipbuilding industry, defense industry, aerospace industry, and other occupations. A machine is a physical system that utilizes power and controlled movement to perform actions. This term usually refers to artificial devices, engines, motors, etc. However, the concept of machines can also be applied to natural biological macromolecules, such as molecular machines.

***Keywords:*** *lathes, drilling machines, Shaping machines, Planning machines and Slotting machines.*

## 1. INTRODUCTION

A machine tool is used for manipulating or machining metal or other hard materials, typically through cutting, boring, grinding, shearing, or other formative deformations. Machine tools utilize various types of cutting or formatting tools, all of which are mechanically controlled within the work area. Some machine tools have guided movement of their parts, providing precise relative movement between the cutting tool and the work material to achieve the necessary size and shape changes. The movement can be controlled by machinery or by a person (offhand or freehand) to some extent. A machine tool, often referred to as a toolpath, is a powered metal cutting machine that helps manage the relative movement between the cutting tool and the work material. The precise definition of machine tools can vary among users, but the discussion below covers the general understanding. It's important to note that although mechanical tools assist people in manufacturing, not all factory machinery qualifies as machine tools. Mechanical tools today are typically powered by electricity, hydraulics, or line shafts and are used as components to create various fabricated parts from metal or other materials. The purpose of a machine tool is to make the job easier for humans, acting as an instrument or invention that creates a mechanical advantage. It multiplies the effect of human effort and serves as a tool for designing and manufacturing parts.

## 2. MACHINE TOOL SELECTION

Machine tool selection has strategic implications for manufacturing companies, as it is closely linked to the overall manufacturing strategy. In order to understand these links and make informed decisions, it is important to identify and model the relationships between machine tool replacement and manufacturing strategy. However, studies specifically focusing on the strategic implications of machine tool selection decisions are currently not available in the literature, to the best knowledge of the author. This paper aims to address this gap by introducing a strategic justification tool for evaluating investments in machine tools and measuring strategic considerations. The paper emphasizes the strategic impacts and benefits of individual machine tools and creates a scalable model [1]. Traditional models of justification in advanced production methods have often been criticized for their defects, such as the inability to quantify unquantifiable factors and the presence of incomplete and partially known information. To address these limitations, the paper proposes the application of fuzzy set theory to incorporate additional information into the decision model. The proposed approach utilizes the Analytic Hierarchy Process (AHP) for evaluating advanced manufacturing systems and handling the ambiguity inherent in multi-attribute decision systems. An example of machine tool selection is provided to explain and demonstrate the proposed approach [2]. Machine tool selection is a critical process for companies, as an improper selection can negatively impact productivity, accuracy, flexibility, and the overall capabilities of a responsive manufacturing system. This thesis proposes a hybrid approach that integrates AHP with simulation techniques to determine the most suitable machine tool among the possible alternatives in the market, meeting the company's needs and expectations. AHP is a widely used decision-making method for multiple criteria, which helps eliminate inferior options by assigning scores or weights based on predefined values. It is also employed to reduce the number of tool replacements by considering all possible machines available in the market [3]. For organizations that add significant value to the machining process and product, machining operations quality and flexibility, machine tool selection is very important. The timing used in the production of products varies, leading to variations in machining as the primary manufacturing process. Unutilized remaining production can have consequences and is essential for manufacturing tools such as molds. Therefore, poor results in quality, flexibility, and productivity can cause significant problems. This study focuses on a systematic, accurate, fast, and practical decision-making process for machine tool selection [4]. Selecting the perfect machine tool becomes an important issue for manufacturing companies. Incorrectly selected machinery can inhibit the performance of a production system. To a large extent, the machine tools used determine outputs such as quality and cost. Choosing a new machine tool is a challenging process that requires experience, time, and analysis of large-scale data. Many factors and possible alternatives must be considered by the decision-maker [5]. Evaluating and comparing the positive and negative characteristics of different alternatives is a difficult task. The process of selecting appropriate mechanics and tools should start with a critical appraisal considering quantity, quality, and economics. Therefore, the decision-maker, whether an engineer, manager, or machine tool manufacturer or seller, should analyze large amounts of data for effective evaluation [6]. In manufacturing, machine tools are considered raw materials that are transformed into physically finished goods and consume a significant amount of energy. As a strategy for improvement, reducing energy consumption in machine tool systems has been identified to enhance production stability. The environmental impact during the use phase of a machine tool, which is mainly a mechanical rather than cyclical condition, depends on the amount of energy consumed. Approximately 83% of the total impact is attributed to the total life of machine tools, making it a crucial consideration for environmental impact [7]. Each component of a machine tool is responsible for at least 80% of the total environmental impact. Various elements such as the bed, feed, coolers, and power consumption are investigated to assess their impact and potential for improvement. Evaluating the potential of machine tools should consider their capacity during the procurement stage, accounting for the diversity of tasks and uncertainties in programs and parameters [8]. Procedures and methods for machine tool selection have been developed, primarily focusing on multi-criteria decision making. In the literature, fuzzy MCDM models have been proposed to address the inherent ambiguity and imprecision in the machine tool selection problem. However, although various studies have created ambiguous models, they do not propose an approach to scale the benefit created by linking these models. This article aims to fill the gap by introducing a fuzzy MCDM model that calculates the interval of benefit, thus addressing the ambiguity in selection models [9]. Global economic competition and market demands have stimulated the manufacturing sector to invest in equipment upgrades to meet modern needs. Among the various challenges, machine tool selection stands out as the most crucial problem. In a production environment, it plays a primary role in the development of productivity and flexibility. However, this decision-making process often involves imprecise, vague, and uncertain information. To handle such information, fuzzy ANP (Analytic Network Process) is utilized, which considers expert judgments and determines weights between attributes based on communication, feedback relationships, and model interdependencies containing uncertain information. Therefore, selecting the right machine tool means making an important decision and investing in amenities during production and upgrades, which is vital for the growth and survival of production systems [10]. To purchase a new machine tool, companies must evaluate several alternatives under conflicting factors such as table size, spindle speed, power, axial travel, positioning accuracy, repeat probability, workpiece material and dimensions, and cutting tool requirements. Numerous studies have proposed Decision Models and Analytical Hierarchy Process to solve the machine tool selection problem, constructing a structured approach [11]. Following this technique, companies facing challenges often need to choose a more suitable machine tool based on the characteristics of the product in question and their organizational requirements. This paper presents a decision support system for tool selection, specifically for high-speed grinding machines. It is based on mechanical tests, performance tests, and profile analysis. The system is designed to evaluate factors such as product dimensional accuracy, CNC feed rate, interpolation scheme, process parameters, machine accuracy, and cost of mechanical properties. Ultimately, it aids in making informed decisions regarding the selection of a suitable machine tool [12]. Machine tool selection is a crucial issue in the field of manufacturing as improper selection of machine tools can have a negative impact on a company's productivity, accuracy, flexibility, and overall responsiveness. The current approach to machine tool selection, known as Multi-Criteria Decision Making (MCDM), largely relies on subjective perspectives. However, it is essential to consider both subjective and objective assessments to accurately represent the actual performance of the machinery when selecting a machining tool. Therefore, this study proposes a novel hybrid MCDM model that integrates both subjective and objective perspectives for machine tool selection [13]. In the context of Flexible Manufacturing Systems (FMS), where machining cost, material handling cost, and setup cost need to be maintained within specified limits, determining the optimal combination of machine tools becomes crucial. The Machine Tool Functional Allocation approach allocates available functionality for various categories and assigns them to machines while considering restrictions such as limited tool press capability, tool life, and machining efficiency. To address this problem, an integer programming model, specifically a 0-1 integer programming assignment model, has been attempted for machine-tool allocation and operation [14]. Machine tool selection is a significant decision for manufacturing companies as it directly impacts overall performance, including speed, quality, and cost of production, depending on the type of machine tool used. Consequently, choosing the most suitable machine tool becomes increasingly challenging given the numerous available options. One of the notable developments in factory automation is the implementation of flexible manufacturing systems (FMS) [15]. Multi-axis control and multi-function machines can machine target parts with increments. However, selecting suitable machine tools, including the types of tools, can be challenging due to the diversity of machining processes. The aim of automating machine tool selection is to analyze and compare the mechanical and functional descriptions of tools and create a step-by-step system on the computer. Firstly, the alleged machine tool structures with their shape-shaping movements are discussed. Then, workplace CAD models and machining features are recognized using patterns [16]. These operations are related to drilling and are performed in various manufacturing environments using specific machining operations in machine tools. This research addresses the machine tool selection problem in the face of changes in product demand and examines the effect of optimum process parameters and SPM configuration. Previous studies have shown that the feasibility of machine tool selection has received limited attention from researchers [17]. The strategic implications of selecting strong machine tools lie in the optimization of manufacturing company policies during the analysis phase. Inappropriate machine tooling often leads to reduced productivity, flexibility, accuracy, and poor response. Generally, machine tools offer inherent accuracy and the capability for multitasking with precision. Additionally, for specific shape features in the material, special-purpose machine tools such as gear hobbing machines can be used [18]. An integrated machine tool selection and hierarchical model is proposed for all types of areas. This model determines machine arrival sequences, reducing the total production time and balancing the workload on machine tools. The model is designed as an integer programming problem using the 0-1 approach. To solve the model, a genetic algorithm approach based on sequence technique topology is developed. Several numerical experiments are carried out to demonstrate the performance of the proposed GA approach for different levels of problems [19]. Machine tools and material handling systems play a crucial role in operations management in Flexible Manufacturing Systems (FMS). However, the conventional methods of production, exchange line, or job-shop production systems face more complex decision-making challenges. The resolution of these problems depends on various factors, primarily due to the versatility of machines, their quick tool changes, and their capability to perform large-scale manufacturing operations with broad instructional changes [20].

### *2.1. Lathe:*

Lathes are commonly used in various industries and crafts, including: Woodworking: Lathes are extensively used in woodworking to turn cylindrical or symmetrical wooden objects such as table legs, spindles, bowls, and decorative items. Woodturning lathes are specifically designed for this purpose. Metalworking: Lathes are widely used in metalworking to shape and cut metal components. They can perform operations like turning, facing, drilling, boring, threading, and knurling. Metal spinning: Lathes are employed in metal spinning processes, which involve shaping metal sheets or tubes into symmetrical shapes like bowls, cups, or decorative items. The workpiece is clamped to the lathe and formed by the application of force with specialized tools. Thermal spraying: Lathes can be used in thermal spraying processes, where a coating material is sprayed onto a surface using heat. The lathe rotates the workpiece while a thermal spray gun applies the coating, resulting in a uniform and precise coating. Part restoration and mirror making: Lathes are used in the restoration of old or damaged parts by removing imperfections or recreating missing sections. They are also utilized in mirror making to shape and polish glass or metal substrates. Ceramics: Lathes can be adapted for shaping ceramics as well. A potter's wheel is a type of lathe used in ceramic work to shape clay into various forms such as pots, vases, and sculptures.

### *2.2. Drilling machines:*

A drilling machine, also known as a drill or drill press, is a powerful tool used to create round holes in various materials such as metal, wood, plastic, and even concrete. It is commonly used in construction, manufacturing, and DIY tasks. Here are some key points about drilling machines: Hole creation: The primary purpose of a drilling machine is to create holes in materials. It uses a rotating cutting tool called a drill bit to remove material and form a hole. The drill bit is selected based on the material being drilled, and different types of drill bits are available for specific applications. Versatile applications: Drilling machines can be used on a wide range of materials, including metals, plastics, woods, and even hard surfaces like rocks or concrete. They are versatile tools that can create holes of various sizes and depths.

***2.3. Shaping machines:***

Design for machined surfaces: The machine is commonly used for cutting out various shapes, including curves and angles. It is popular in workshops due to its simplicity of operation. However, different machines may have distinct methods of operation and capabilities. Forming machines are available in various sizes, with a common size being smaller. For women, shapewear is a commonly used garment that provides general elasticity. It supports and shapes the body, particularly the lower back and hips, helping to alleviate pain in those areas. Furthermore, it significantly improves your posture when walking or sitting.

***2.4. Planning machines:***

A planing engine is a linear mechanical tool used for planing the surface of a plane, groove, or workpiece. It utilizes a planer for this purpose. A planar machine is a type of metalworking machine that enables the workpiece and the work area to have linear relative motion. It achieves this through reciprocal movement. Single-point cutting is employed to cut using the tool. Although General Bentham discovered that its design bears a resemblance to others, there are a few fundamental differences.

***2.5. Slotting machines:***

Sometimes called slotting Designing is of the machine table A piece of work is placed on it is the machining process, then it is a Progressing along the path of mutual RAM, A single-point cut on it the instrument is installed. Slotting is A warehouse and its inventory Arrange to increase efficiency is the process. It is a company Analyze inventory or SKUs Includes doing and understanding, in which Amount of material, often together Products purchased are seasonal Includes forecasts.

***2.6. Milling Machines:***

Milling is the process of removing material from a workpiece using rotary cutters. A milling machine utilizes a cutter that rotates and moves into the work area to remove material from the object being machined. Grinding machines, whether vertical or horizontal, are typically used to machine flat and irregularly shaped surfaces. They can also be used for cutting, as well as for tasks such as machining gears, creating threads, and making slots.

# 3. RESULT AND DISCUSSION

**TABLE 1.** Reliability Statistics

| **Reliability Statistics** | | |
|---|---|---|
| Cronbach's Alpha[a] | Cronbach's Alpha Based on Standardized Items | N of Items |
| .288 | .288 | 6 |

Table 1 shows the Cronbach's Alpha Reliability result. The overall Cronbach's Alpha value for the model is. 288 which indicates 28% reliability. From the literature review, the above 28% Cronbach's Alpha value model can be considered for analysis.

**TABLE 2.** Descriptive Statistics

| | **N** | **Range** | **Minimum** | **Maximum** | **Sum** | **Mean** | **Std. Deviation** | **Variance** | **Skewness** | |
|---|---|---|---|---|---|---|---|---|---|---|
| lathes | 10 | 4 | 1 | 5 | 34 | 3.40 | 1.430 | 2.044 | -.319 | .687 |
| Drilling machines | 10 | 4 | 1 | 5 | 34 | 3.40 | 1.265 | 1.600 | -.544 | .687 |
| Shaping machines | 10 | 4 | 1 | 5 | 34 | 3.40 | 1.265 | 1.600 | -.544 | .687 |
| Planning machines | 10 | 4 | 1 | 5 | 27 | 2.70 | 1.337 | 1.789 | .334 | .687 |
| Slotting machines | 10 | 3 | 2 | 5 | 30 | 3.00 | 1.054 | 1.111 | .712 | .687 |
| Milling Machines | 10 | 4 | 1 | 5 | 32 | 3.20 | 1.476 | 2.178 | -.425 | .687 |
| Valid N (listwise) | 10 | | | | | | | | | |

Table 2 shows the descriptive statistics values for analysis N, range, minimum, maximum, mean, standard deviation, Variance, Skewness, Kurtosis. Lathes, Drilling machines, Shaping machines, Planning machines, Slotting machines, Milling Machines this also using.

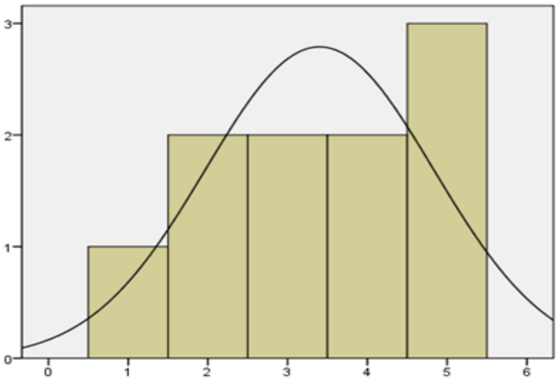
**TABLE 3.** Frequencies Statistics

| | | lathes | **Drilling machines** | **Shaping machines** | **Planning machines** | **Slotting machines** | **Milling Machines** |
|---|---|---|---|---|---|---|---|
| N | Valid | 10 | 10 | 10 | 10 | 10 | 10 |
| | Missing | 0 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Median | | 3.5 | 3.5 | 3.5 | 2.5 | 3 | 3.5 |
| Mode | | 5 | 3a | 3a | 2 | 2 | 4 |
| Percentiles | 25 | 2 | 2.75 | 2.75 | 1.75 | 2 | 1.75 |
| | 50 | 3.5 | 3.5 | 3.5 | 2.5 | 3 | 3.5 |
| | 75 | 5 | 4.25 | 4.25 | 4 | 4 | 4.25 |
| a. Multiple modes exist. The smallest value is shown | | | | | | | |

Table 3 Show the Frequency Statistics in Lathes, Drilling machines, Shaping machines, planning machines, Slotting machines, Milling Machines curve values are given.

Figure 1 shows the histogram plot for Lathes from the figure it is clearly seen that the data are slightly Right skewed due to more respondent chosen 5 for Lathes except the 3 value all other values are under the normal curve shows model is significantly following normal distribution.



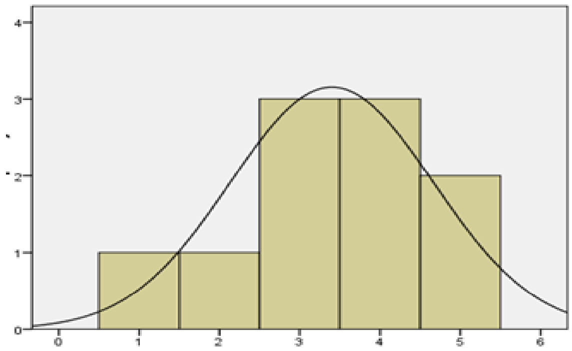
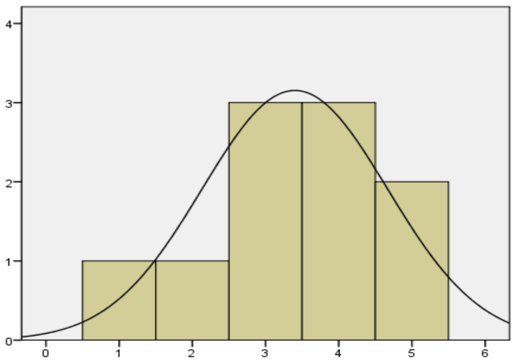


**FIGURE 1**. Lathes **FIGURE 2**. Drilling machines

Figure 2 shows the histogram plot for Drilling machines from the figure it is clearly seen that the data are slightly Right skewed due to more respondent chosen 3,4 for Drilling machines except the 3 value all other values are under the normal curve shows model is significantly following normal distribution.



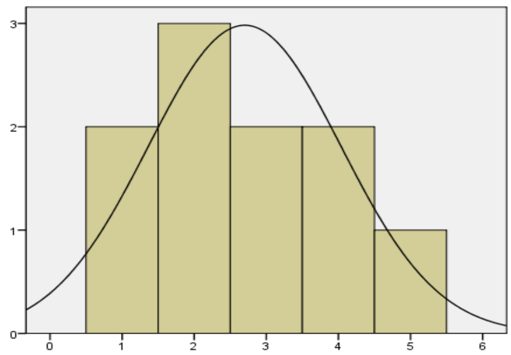
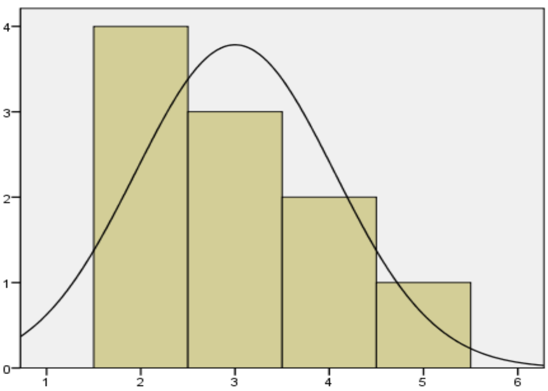


**FIGURE 3.** Shaping machines **FIGURE 4.** Planning machines

Figure 3 shows the histogram plot for Shaping machines from the figure it is clearly seen that the data are slightly Right skewed due to more respondent chosen 3,4 for Shaping machines except the 3 value all other values are under the normal curve shows model is significantly following normal distribution. Figure 4 shows the histogram plot for Planning machines from the figure it is clearly seen that the data are slightly Left skewed due to more respondent chosen 2 for Planning machines except the 2 value all other values are under the normal curve shows model is significantly following normal distribution.



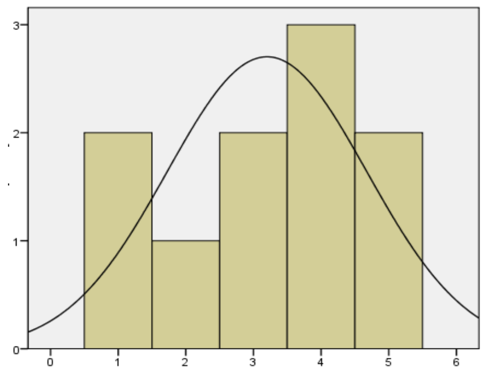


**FIGURE 5.** Slotting machines, **FIGURE 6.** Milling Machines

Figure 5 shows the histogram plot for Slotting machines from the figure it is clearly seen that the data are slightly Left skewed due to more respondent chosen 2 for Slotting machines except the 2 value all other values are under the normal curve shows model is significantly following normal distribution. Figure 6 shows the histogram plot for Milling Machines from the figure it is clearly seen that the data are slightly Right skewed due to more respondent chosen 4 for Milling Machines except the 3 value all other values are under the normal curve shows model is significantly following normal distribution.

**TABLE 4.** Correlations

| Correlations | | | | | | |
|---|---|---|---|---|---|---|
| | **lathes** | **Drilling machines** | **Shaping machines** | **Planning machines** | **Slotting machines** | **Milling Machines** |
| lathes | 1 | 0.024574 | 0.024574 | 0.06972 | -0.07372 | 0.116 |
| Drilling machines | 0.024574 | 1 | -0.45833 | -0.31524 | -0.5 | -0.524 |
| Shaping machines | 0.024574 | -0.45833 | 1 | -0.24957 | 0.166667 | 0.012 |
| Planning machines | 0.06972 | -0.31524 | -0.24957 | 1 | 0.551677 | 0.146 |
| Slotting machines | -0.07372 | -0.5 | 0.166667 | 0.551677 | 1 | 0.429 |
| Milling Machines | 0.115847 | -0.52381 | 0.011905 | 0.146363 | 0.428571 | 1 |

Table 4 shows the correlation between motivation parameters for lathes for Milling Machines is having highest correlation with Slotting machines and having lowest correlation. Next the correlation between motivation parameters for Drilling machines for lathes is having highest correlation with Milling Machines and having lowest correlation. Next the correlation between motivation parameters for Shaping machines for Slotting machines is having highest correlation with Drilling machines and having lowest correlation. Next the correlation between motivation parameters for Planning machines for Slotting machines is having highest correlation with Drilling machines and having lowest correlation. Next the correlation between motivation parameters for Slotting machines for Planning machines is having highest correlation with lathes and having lowest correlation. Next the correlation between motivation parameters for Milling Machines for Slotting machines is having highest correlation with Drilling machines and having lowest correlation.

## 4. CONCLUSION

Machine tools are used for designing and creating fixed and powered engines, as well as cutting materials like wood. The development of machine tools accelerated in the 18th century with the invention of the steam engine, and by the 19th century, various types of machine tools were commonly designed and used. Today, there are numerous types of machine tools used in both home and industrial settings. These tools enable precise and efficient manufacturing processes, allowing for the production of complex parts and components. They contribute to advancements in technology, manufacturing, and other sectors. As for your mention of Cronbach's Alpha Reliability, it appears to be unrelated to the topic of machine tools. Cronbach's Alpha is a statistical measure used to assess the internal consistency or reliability of a scale or questionnaire. It is commonly employed in the field of psychometrics to evaluate the reliability of measures. The overall Cronbach's Alpha value for the model is.

288 which indicates 28% reliability. From the literature review, the above 28% Cronbach's Alpha value model can be considered for analysis.

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