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Multi Aspect Optimization of Milling Machines : Review

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ABSTRAK

Manufaktur modern menunjang kelancaran berbagai aspek kehidupan modern. Manufaktur modern pada era sekarang dititik beratkan kepada pengaplikasian kecerdasan buatan, percepatan hasil produksi, otomasi produksi, keberlanjutan serta perlindungan terhadap kelestarian lingkungan. Mesin milling merupakan piranti yang sangat dibutuhkan dalam rangkaian proses produksi. Keberadaannya menunjang proses produksi yang merupakan bagian dari sistem manufaktur modern. Dalam pengoperasian mesin milling, terdapat kendala maupun permasalahan yang sering terjadi, mulai dari operasional, kapasitas mesin, maupun prediksi penggunaan mesin atau tool. Studi ini mencoba merangkum dan mereview studi terdahulu dengan tujuan akhir menghimpun jenis – jenis optimasi mesin milling. Optimasi multi aspek yang didapat meliputi : optimasi dengan pendekatan prediksi umur tool, optimasi dengan pendekatan proses milling, optimasi dengan modifikasi atau retrofit, optimasi dengan pendekatan hasil produksi yang terakhir optimasi dengan waktu operasional. Dengan hasil yang didapat, diharapkan dapat berkontribusi pada optimasi mesin milling dalam dunia manufktur modern. Penelitian kedepan diharapkan dapat melakukan analisa yang medalam terhadap tiap – tiap aspek optimasi mesin milling yang telah disebutkan..

Keywords:

Optimazation; milling machine; age prediction; retrofit

ABSTRACT

Modern manufacturing supports various aspects of modern life. Modern manufacturing right now is focused on the application of artificial intelligence, acceleration of production, automation production, sustainability and environmental protection. A milling machine is a tool supports in a series of production processes. Its existence supports the production process which is part of the modern manufacturing system. In operating milling machines, several problems that occur, starting from operations, machine capacity, and predictions of machine or tool usage. This study summarizes and reviews previous studies in order to collecting types of milling machine optimization. Multi-aspect optimization obtained includes: optimization with a tool life prediction approach, optimization with a milling process approach, optimization with modification or retrofit, optimization with a production yield approach and finally optimization with operational time. With the results obtained, it is hoped that it can contribute to the optimization of milling machines in the modern manufacturing world. It is hoped that future research will be able to carry out in-depth analysis of each aspect of milling machine optimization has been mentioned.

1. INTRODUCTION

Modern manufacturing supports various aspects of modern life. Without modern manufacturing, the implementation of new technology would be impossible. Modern manufacturing began in 1760 – 1830 when the first steam engine was invented[1]. Modern manufacturing right now is focused on the application of artificial intelligence, acceleration of production, automation production, sustainability and environmental protection[2]. In America, 20% of Gross National Product is obtained from modern manufacturing activities[1]. This shows that modern manufacturing activities have a numerous impact on a nation's economic growth.[3]

Modern manufacturing converts raw materials, into semi-finished materials. Or semi-finished materials become finished products, which are then used for further processing by consumers[1]. Modern manufacturing is widely applied, some common examples include machining, welding, stamping, forging, casting and molding[4]. These activities cannot be separated from certain equipment with their respective working and operating principles.

A milling machine is a tool that is really needed in a series of production processes. Investment in milling machines in the period of about 20 years from 1978 to 1995 increased in several modern countries. Japan recorded 3 billion Euros as the largest investment value for metal machining activities[5]. Its existence supports the production process which is part of the modern manufacturing system. Milling and lathe are the activities of forming metal, non-metal, wood, ABS or other materials by means of a feeding process.

Milling machines are divided into manual milling machines with full operation by the operator and CNC milling machines that work fully automatically. There are various milling functions ranging from face milling, drilling, threading and so on[6]. Recurring problems occur with milling machines such as long operating times, unlike injection molding and casting, to form a certain shape, a milling machine takes a long time, this happens because the basic principle of a milling machine is through a feeding process[7]. Surface finishing also takes a long time, especially when done on parts with irregular shapes (free form surfaces) [8]. Accuracy is the next reliability value of a Milling machine, the object produced should comply with the planned design in terms of shape, dimensions and level of roughness. In previous research, many researchers discussed the accuracy of milling machines or CNC machines. This study is considered important in terms of many problems happened in the operation, maintenance and life prediction approaches for milling machines. In its output, the urgency of this research aims to increase the efficiency and effectiveness of milling machines as a means of production in modern manufacturing. Milling machine optimization is carried out using various approach methods. In this study, we will try to present some of the main focuses of findings regarding types of optimization on milling machines.

2. Research Methodology

This research is a review of previously published articles. Research using this kind of review method focuses on drawing conclusions from the methodology or approach used by previous research. This is similar to the systematic literature review (SLR) study method [9][10]. The literature review that will be involved is the results of research related to milling machines, both manual milling machines and CNC milling machines. The author raises the theme of focusing on multi-aspect optimization studies. We employ research methodology chart using a systematic literature review as the research flow chart in Figure 1 [11]

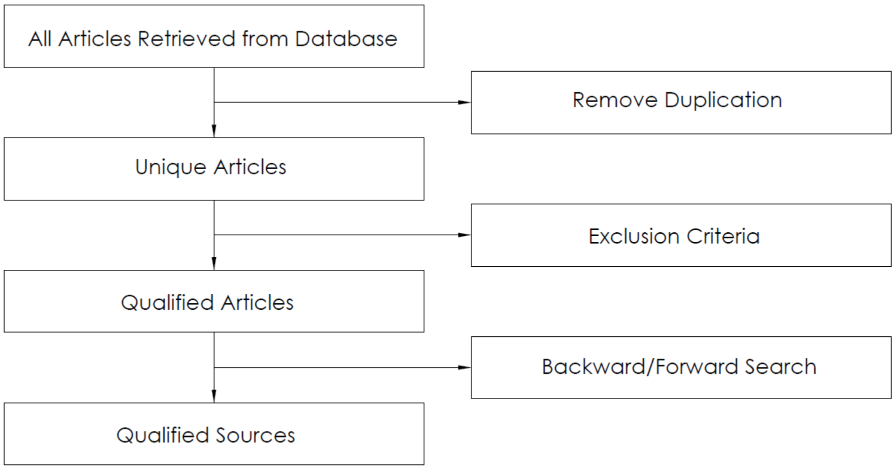

Figure 1. Flowchart of systematic literature review research.

3. RESULT AND DISCUSSION

The authors' manuscripts should be completed with title, abstract, keywords and the main text. Furthermore, the authors should present tables, figures, and equations in good order.

3.1 Services life prediction methods optimization

Predicting service time or technical life needs to be known, this is needed to provide decisions when we have to replace or maintain the system we use or that we build. This has the same concept as predictive maintenance. In the operation of the cutting edge, of course there will be a point where the cutting edge is no longer sharp and will produce an ugly and undesirable product. In previous research, it was reported that 3 cutting tools with a cutting diameter capacity of 1.8, 2.5 and 2.2 mm had a hardness of 300 HRC. These 3 tools were used to machine stainless steel SUS 420 with a hardness of 262 HRC. Theoretically, all three cutting tools can be used to machine the workpiece. In this research, it was concluded that the technical life was 920 usage cycles. So on the 921st production cycle, the three cutting edges had to be replaced[12]. What the researchers did seems to be very useful for the industrial world to implement so that defects can be avoided as much as possible. Industry should also be able to apply these findings into new manufacturing standards in its production activities.

Prediction of the service life of the cutting tool has also been carried out with cost reduction as the final output in a production process. Prediction of the service life of the cutting tool assisted by the Design of Experiment (DOE) method with Minitab software, in CNC milling machines DOE Minitab is used to analyze input in the form of feed rate and cutting depth to the output which is the service life of the cutting tool, the correct formulation between input and output bring through cost reduction in modern manufacturing[13].

3.2 Process approach methods optimization

The process approach is a study used to increase the performance or optimization of CNC machines on the basis of a series of processes. What is meant by a series of processes is starting from the design and analysis phases of product development. In a study, it was found that the critical factors that influence tool tip position errors on CNC milling machines are Dimensional and Geometry Tolerance, Machine Kinematics, Thermal Effects and existing loads. Tool tip errors will result in defect products. In optimizing with this process approach, in the future ways can be developed to avoid tool tip errors in the form of model improvements and CNC Milling machine software improvements.[14]

3.3 Modification methods optimization

Milling machine modified in order to increasing its performance. The upgrades carried out are of course aimed at increasing accuracy, speed, effectiveness and production efficiency. Previous studies have shown that retrofitting manual milling machines have been upgraded to CNC milling machines, showing the success of the retrofit concept offered. This development was carried out by adding Sanyo Denki 103H8223-5041 stepper motor control, Mivro Controller Chip Set hardware control and G/M Code programming code. As a result, the capability of the retrofit milling machine has clearly increased, especially for complex features such as milling with circular paths or curved paths which almost impossible for operators to do manually. In this research, the retrofit milling machine testing method used was the dry run method or no-load testing method, the spindle was not fitted with a cutting tool but instead a marker was attached which would later be passed onto the paper[15].

The other research find that retrofit of manual milling machine become CNC milling machine enabling error caused by irregular coulomb friction and backlash. To controlling this disturbance, self tuning adaptive control strategy is proposed. From the experimental result, satisfactory accuracy reached against irregular coulomb friction and backlash. This approach, improving the result of retrofit of manual milling machine become CNC milling machine [16].

In the other retrofitting milling research, modification proposed in the simple way, enabling operator do not need build even G or M code as a standard code in CNC language for inputting the command. A simple DXF, BMP, JPG files convert automatically to the G or M code. Simple architecture considering (i) user friendly instrument (ii) cost effectiveness (iii) using local technologies [17].

3.4 Quality product approach optimization

Feed rate is an important parameter in the final results that will be obtained. Feed rate is the feed speed of a milling process, feed rate is expressed in units of length compared to units of time, for example, seconds or minutes[18]. Feed rate become a finding in several studies, feed rate is reported to be the main factor in the roughness of milled products. It is reported that a feed speed of 100 mm/minute with a depth of 0.5 mm produces a roughness of 2.468 micrometres. As the feed speed increases to 300 mm per minute with a depth of 0.2 mm, the roughness value increases to 6.467 micrometres [19]. For precision parts, the roughness value is the absolute value of whether a part is finished good or rejected, generally the finer or smaller the roughness value, the part produced will be accepted. In other research, product quality is an approach to develop the most appropriate formula in terms of cutting speed, axial depth, radial depth, over hang length and flank circumference. The orthogonal arrays L36 and L9 approach was carried out to determine the grey relation. The result of this approach is an increase in side milling performance which has been carried out in confirmation tests[20].

3.5 Operational time approach optimization

We hope the cycle time of a product as quick as possible, but it is impossible without consideration. A CNC machine is a production machine that is known to take the longest operational process when compared to other machines or processes. In a study, it was reported that 3 parameters including feed rate, spindle speed and cutting depth influence the length of the production process using a CNC machine. The Taguchi orthogonal array method was used in this research. As a result, the feed rate has the highest influence on production. Followed by spindle speed and depth of cut, which is in third position which influences the operational process speed of CNC milling machines[21]. These findings can be taken into consideration by parties involved in using CNC in industry to determine parameters regarding the speed of the production process.

3.6 CNC Optimization as Model Major Dimensions.

Of the five aspects mentioned above, the optimization that has been carried out in previous research will be linked to industrial optimization in general. A model offered in research states that manufacturing optimization includes Triple Bottom Line (TBL) dimensions which include economic, social and environmental[22]. From these three dimensions, the author groups all the aspects optimized in this review paper into the first and third aspects which are directly applied, while the second aspect is the aspects which are indirectly applied. A study conducted a quantitative evaluation of production time and machining costs[23]. Optimization of the last aspect mentioned in this manuscript shows a process similar to that research. Meanwhile, a review of design and structure optimization in additive manufacturing (AM) states that the intrinsic side of AM utilizes fabrication, layout, design, performance, economics and digitalization [24]. This means that the CNC machine optimization review in this paper can be categorized on the extrinsic side, including multifunctionality and process parameters.

4. CONCLUSION

Milling process never completely free from product failures and defects, there will be defect products. However, milling process also allow for optimization. Optimization is carried out in order to minimize failures that may occur. In this study, a review of previous research has been carried out. Multi-aspect optimization is very possible on milling machines. Multi-aspect optimization in this study includes services life prediction methods optimization, process approach methods optimization, modification methods optimization, quality product approach optimization and operational time approach optimization. . It is hoped that the five results of this approach can serve as a resume for further research or applications in the industrial world to improve the performance, effectiveness and efficiency of manual milling machines or CNC milling machines.

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