Development of In-Process Tool Wear Detection System Based on Electrical Contact Resistance

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論 文 名　：Development of In-Process Tool Wear Detection System Based on Electrical Contact Resistance
（接触電気抵抗に基づく工具摩耗のインプロセス計測システムの開発）

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論　文　内　容　の　要　旨

The cutting tool life is one of the important economic consideration in metal cutting processes. Considerable efforts have been made over the years to develop in-process tool wear monitoring and also to develop and improve materials for better tool life. This thesis presents the research finding of development of an in-process tool wear detection system, which is able to operate under a different type of cutting tool with a different type of geometry and coating, such as face milling cutters, solid square end mills and indexable insert types under different applications. The performance has been evaluated experimentally. The developed tool wear detection system uses the electrical contact resistance between the tool and workpiece as a gauge to monitor the progression of tool wear. It has been demonstrated in the previous papers that electrical resistance decreases with an increase in contact area on the tool flank. Based on this result, various experiments have been conducted in order to evaluate and improve the presented tool wear detection system. In fact, high quality finished surface, optimization of tool life, and accuracy during the cutting process are essential for improving the performance of the manufactured products and components, thus to achieve this high quality criterions, different steps have been scheduled through the chapters to achieve those objectives.

Chapter 1 introduces the background of the cutting process and its applications, including one of the big issues that manufacturing filed is still facing until now, which is the tool wear. Problem statements are also listed to clarify the motivations of the research objectives. The methodology is presented to illustrate the direction of the presented research.

Chapter 2 introduces the fundamental knowledge and theories used in this dissertation, which highlight all the theoretical terms that built the methodology applied in the developed measurement system. This chapter is also dedicated to the exploration and analysis regarding the capability of the first-developed system in order to understand the methodology of the wear detection and the contact resistance measurement. The developed signal processing method for further tools were applied and evaluated. The tool wear detection system based on electrical contact resistance was effective as the in-process detection tool wear system in face milling process.

Chapter 3 evaluates the extension of the measurement range to find out the capability of measurement delivered by the previous measurement system. Based on this chart, various experiments have been accomplish using a different type of cutting tool with a variation in geometry in end milling processes without coating, such as indexable inserts with and without chip breaker. The system has the enough capability in detecting tool flank wear even for end mills with and without chip breaker as well as using indexable inserts.

Chapter 4 presents additional experiments that complete the objective of the previous chapter, which is the evaluation of the possibility in extending the measurement range under coated tools. Evaluation of the measurement under coated solid square end mills and coated indexable end mills were conducted. Both experiments have shown great results, which are clear correlations between the progression of electrical contact resistance and tool flank wear area. An additional important result is that there is no influence of variation of cutting speed on the measured contact resistance even with coated square end mills and with different coating thickness.

Chapter 5 gives an overview about the drawbacks that the first-developed system was facing, and introduces the new development system that solves all the issues related to the first-developed measurement system; the problem of the isolation located between the workpiece and the vice of the CNC machine, that is the major issue in this research, because it disables the system to operate under wet machining. The second issue is related to the resistivity of the circuit and the noise that affected the signal processing and the precision measurement. The third issue is the complexity of the system implementation. The results of the experiments were evaluated by comparing the output signals of the first-developed measurement system and the new developed one, which was based on relationship between tool flank wear area and tool-work contact resistance. Finally, this chapter concludes also the results of the experiment obtained by the new developed system indicates that the system is very efficient and could accomplished successfully all the objectives of this research. By comparing the raw signals, it is also confirmed that the new developed tool wear detection system based electrical contact resistance is more effective as an in-process tool wear detection system for a different type of tool owing to the fast reaction time in the signal processing. The excellent achievement is that the new system is able to operate under dry and wet machining conditions, which was impossible in the past.

In Chapter 6 summarized and highlighted the results of the study, and then proposed the future works involving the problem of the EMF noise relating to the signal processing, and suggested the solution to improve the system.