TRIZ APPROACH IN DESIGNING AN INTEGRATED ROTATING DYNAMOMETER FOR MILLING PROCESS

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ABSTRACT
This study will utilize the TRIZ approach for designing an innovative integrated rotating dynamometer (IRD). This innovative IRD is designed, constructed and fabricated for fulfillment the need of measuring the cutting force in a wireless environment system. A complete data conditioning system was incorporated into a modified tool holder in order to collect and transmit the cutting force signal to the data acquisition system. The rotating dynamometer has been subjected to a series of tests to determine its static and dynamic characteristics. The results show that the integrated rotating dynamometer and tool holder can reliably measure the cutting force in milling and drilling processes.

Keywords: TRIZ, integrated rotating dynamometer, milling process, drilling process.

INTRODUCTION
Nowadays, flexibility and reconfigurability are the most significant challenges for the machining process. In this regard, the application of the sensors system must have a sufficiently broad operating range to allow for various cutting tool sizes and workpiece configurations. Therefore, there has been interest in developing a rotating force-sensing system built into the machine tool structure in order to allow for efficient reconfigurability. A spindle-integrated force sensor using a piezoelectric ring has been proposed for milling and drilling processes by Park et al. (2004) and Byrne and O’Donnell (2007).

However, commercial table dynamometers based on piezoelectric are commonly used for fundamentals study since they provide highly accurate measurement of cutting forces. However, they have a limited use in laboratory settings due to limited workpiece geometry and dimensions. They are also not suitable instruments for industrial use due to their lack of overload protection and their high costs (Byrne et al, 2007). There are several uses of a strain gauge on a rotating spindle, such as reported by Suprock (2009).

TRIZ approach is utilized to study the existing dynamometer limitation, technical and physical contradictions for finding an alternative solution. Alternatively, forces can be estimated from the elastic deformation that can be measured by a strain gauge. This is a sensor which produces an output voltage proportional to the elastic deformation and is also small in size and mass, low in cost, easily attached, and highly sensitive to strain.
RESULTS AND CONCLUSIONS

In order to design the structure of the integrated rotating dynamometer and rotating tool holder, important factors of geometry, size, stiffness, stability and accuracy of measurement were considered to ensure their adaptability with the wireless system. Fig. 1 illustrates the geometrical design of the force sensing element. The force sensing element of the rotating dynamometer is designed in the form of a cross beam type. It consists of a central shaft that provides a connection to the tool holder, cross and compliant beams as the sensing element and the bottom ring as a distributor of forces to the sensing elements. The cross beam has four symmetric horizontal beams, as well as the compliant beam. The whole body of the force sensing element has dimensions of 50 mm in height (H) and 82 mm in diameter (D). The height of the compliant beams (h) is 16 mm and the horizontal length of the cross beams (l) is 12 mm. The sectional dimensions of the beams are 8 mm in thickness (t) and 8 mm in width (b). The results from the tensile tests are shown in Fig. 1.

This dynamometer was designed to measure cutting forces up to 3000 N and rotation at 5000 rpm. However, in order to operate safely, a safety factor of 2 was used to measure the cutting force, so it can in practice measure a 1500 N maximum cutting force and rotation at 2500 rpm. Static and dynamic calibrations were done in order to evaluate the performance of the rotating dynamometer developed. The results show that the relationship has high linearity and sensitivity of approximately about 0.75 - 0.92 mV/N.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the funding by Ministry of Science, Malaysia, and UKM under grants SF and GUP.

REFERENCES