Review of Temperature Sensors for Machining Operations

Emilios Leonidas

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Abstract

Computer Numerical Control (CNC) Machining is a Thermo-Mechanical process. Machining science is currently emphasising on the mechanical portion of the process by relying on cutting forces simulations for the machining loading parameters. This is because the mechanical portion of machining is a more mature field than the thermal portion. However, the thermal portion is a key component to help obtain more information for a better understanding of the process. Temperature is an important parameter in any machining process, as it is a primary loading condition and can lead to secondary machining outcomes, such as variations in the metallurgical properties and reduction of the tool life. These secondary outcomes can lead to a significant increase in waste and operating costs.

There have been various approaches to monitor the cutting temperature during the machining of metals, some of which were quickly discarded due to their limitations to provide reliable readings in the aggressive machining environments. The two most used temperature monitoring approaches are thermocouple and radiation thermometer configurations.

Thermocouples can be easy to use and relatively inexpensive, however, thermocouple types which have a higher temperature range can be several times more expensive as they are made with precious metals. The thermocouple main limitations were found to be their slow response time making them unable to measure rapid changes in temperature during machining and that they are prone to calibration drift towards the upper part of their temperature range.

Radiation thermometers can provide a suitable alternative to thermocouples by providing very fast response times and more accurate temperature readings. However, the thermometer line of sight can be obstructed by chips and swarf produced during the metal cutting process which can affect their accuracy. This issue was alleviated by using a fibre optic infrared (IR) thermometer. The optical fibre thermometer can be enclosed within the tool holder with the fiber placed at the tip of the cutting tool for direct measurements at the tool-workpiece interface. This however introduces complexities associated with fitting the electronics inside the tool holder. Although a lot of progress has been done to improve the techniques used to monitor the temperature during metal cutting operations, more work is required to reduce the associated costs and improve the sensor reliability to enable their use in industrial applications