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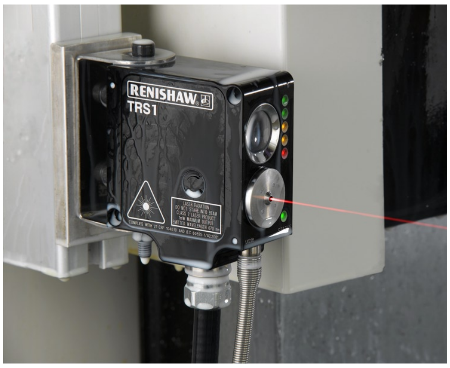
Unique ‘tool recognition system’ detects broken tools with ease

Abstract

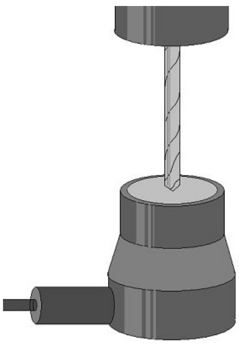


The swift and reliable detection of broken tools on many machining centres is essential. A broken tool can lead to scrap and rework, and can have costly implications on subsequent processes if left undetected. Conventional ‘contact’ broken tool detection systems have a number of weaknesses and are often unsuitable for smaller tools.

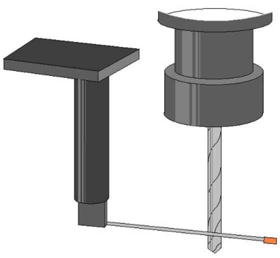
The emergence of laser systems in recent years has enabled non-contact broken tool detection, and the ability to measure increasingly small tools safely. However, using a ‘beam block’ system for broken tool detection also has its weaknesses, as it cannot distinguish between a tool and contaminants such as coolant and swarf – potentially leading to spurious results. Renishaw has addressed these limitations with an innovative new laser system, offering extremely fast and reliable broken tool detection.

Existing tool detection systems

Currently, ‘contact’ systems are the mostcommon method of broken tool detection. Generally these can be divided into two types – a ‘button’ system and a ‘rotating wire’ system. The button system involves bringing a tool into contact with the ‘button’, thus triggering the device and so confirming that the tool is present and not broken.

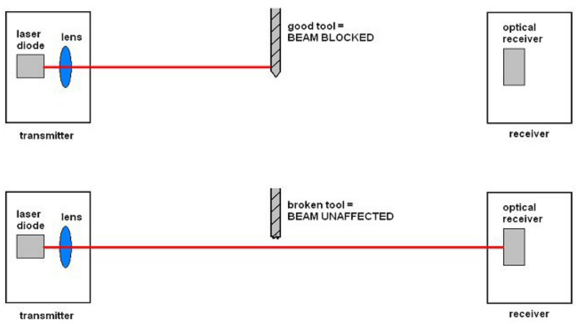


The rotating wire system consists of an actuator, which rotates a wand until it comes into contact with a tool. Failure to contact the tool therefore leads to the conclusion that it is broken.



Conventional non-contact tool setting systems use a beam of laser light passing between a transmitter and a receiver, located either on the table of the machine, or on each side of it so that the beam passes through the working volume.

The presence of a tool in the beam causes a reduction in light seen at the receiver, and a trigger signal is generated. If there is no reduction in the light received, it is assumed that the tool has failed to obstruct the beam as anticipated and is therefore broken.



The limitations of conventional systems

Both methods of contact-based broken tool detection are often less than satisfactory. Whilst they can be unreliable, a more common problem is that the contact with the tool can actually break or damage smaller tools.

Consequently, only tools over a certain diameter can be safely tested. Even so, larger tools or those with a delicate surface finish can be at risk due to their high surface speed. Furthermore, using contact methods for broken tool detection

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is a slow process and adds significantly to production cycle times, as the tool must contact slowly to avoid damage. Often, contact systems must also be mounted within the working environment, taking up valuable table space and creating a danger of collision. Those with actuators may jam, causing poor reliability.

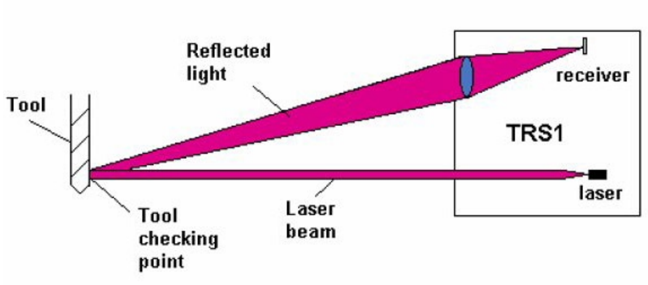
Using a conventional non-contact laser system for tool breakage detection can present a number of problems due to the system's inability to distinguish between a tool and a contaminant such as coolant or swarf. In particular, coolant streams in take a number of seconds to stop after the pump has been switched off. Consequently, there is a possibility that the system could inadvertently mistake contaminants, such as a coolant stream, for a tool and be fooled into thinking the tool is 'OK' when in actual fact it is broken.

The reliability of the process can be improved by increasing the time spent by the tool in the beam, giving the coolant more chance to disperse, hence giving greater confidence in the result. However, the possibility remains that a broken tool may pass through undetected, leading to costly scrapping or rework of parts.

In summary, the beam-blocked method of broken tool detection takes time and is potentially unreliable. It should also be noted that using an existing non-contact system only for broken tool detection, can be an expensive solution. Often, M-codes are required for broken tool detection. The system may require aligning to the machine axes, resulting in a lengthy installation procedure. Those with separate transmitters and receivers will also require costly brackets that must be aligned.

The Renishaw response: the TRS1

The TRS1 is Renishaw's innovative new device dedicated to broken tool detection and is truly the first product of its kind. The TRS1 uses a laser beam, but dispenses with the beam block method of tool detection. Instead, the TRS1 relies on the beam being reflected back to the receiver, which is contained in the same housing as the transmitter. The unique tool recognition system (TRS) electronics then establish whether a tool is present – and hence is good, or is not present.



How it works

The tool recognition system electronics used in the TRS1 represent a major step forward in reliable broken tool detection. The system is capable of quickly and definitively establishing whether or not a tool is present.

The TRS1 works by directing a laser beam towards a point where the tool detection is to be conducted. The tool is then positioned so that the laser beam shines onto the tip of the tool – typically 3 mm from the end of the tool. The tool is rotated at 1000 rpm, and the laser is reflected off the tool and back to the TRS1 receiver. Due to the tool's rotation, the reflected light level varies resulting in a repeating pattern. This repeating pattern is recognised by the micro controller within the TRS1 and the output relay is triggered, rapidly signifying a good tool and allowing the machining cycle to continue. As the repeating light pattern can only occur when a tool is present, the TRS1 cannot be fooled by contaminants such as swarf or coolant. If no tool is identified, at the end of a given period the application software issues a 'broken tool' alarm.

There are considerations in the design to ensure safe and reliable operation. The TRS1 relies on reflected light to identify the tool - the amount of light reflected depending on a number of factors, such as tool size, surface finish, tool shape, operating range and coolant. If the tool cannot be rapidly recognised, the user can vary the amount of time allowed before an alarm is generated. Typically, the TRS1 requires around 1 second to identify a good tool, but in cases where the reflected light level is low, or the repeating pattern is obscured, the detection cycle may last longer than this. This time is only then required for certain specific circumstances, not for every tool detection cycle.

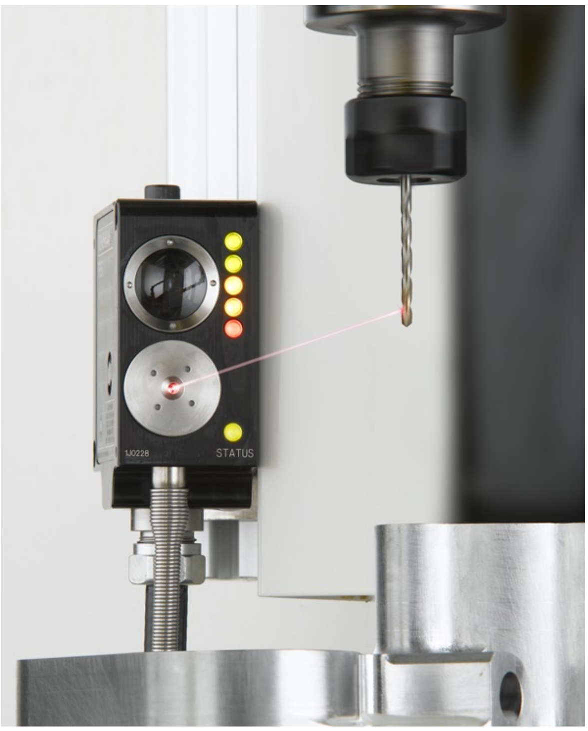
In a theoretical extreme case, if the tool is not recognised during the time limit set by the user, a broken tool alarm will result - a failsafe condition. It should be noted that a damaged tool would not be passed as good.

Longer cycle times are therefore rare and limited to particular conditions where steps can be made to reduce the effect.

Optimisation of the application of the TRS1 is advised to gain the maximum benefit in production. The TRS1 is easy and flexible to mount, and range-adjustable by the user, allowing the best parameters to be quickly determined to ensure tools can be recognised. Using the TRS1 at the shortest possible range will increase the reflected light level. Furthermore, by adjusting the position on the tool at which checking is done, detection accuracy can be improved further. For example, on small tools around 2 mm diameter, coolant tends to gather near the tip, so checking higher up the tool is likely to be beneficial. Spinning the tool at high speed or removing coolant with an air blast before checking, are also considerations.

The advantages of the TRS1

The innovative technology of the TRS1 brings with it numerous advantages over existing tool detection systems. The compact single unit is straightforward to install, requiring no M-codes or calibration routines. It can be fitted outside the working envelope of the machine, eliminating any possibility of a collision and saving machine table space. Similarly, installation time and space is saved in the machine's control cabinet, as there is no interface.



In terms of performance, the TRS1 can operate over a range of up to 2 m. The TRS1 does not contact the tool, therefore it can safely detect tools as small as 0.5 mm diameter, without damaging or breaking the tool. High feed rates can be used, resulting in short cycle times. Unlike existing non-contact methods of tool detection, the TRS1 cannot mistake coolant or swarf for the tool and so it becomes virtually impossible for a broken tool to pass undetected.

The simple design of the TRS1, with no moving parts, makes the device extremely robust, reliable and capable of enduring even the harshest of machining conditions. The crucial laser optics are well protected by an air stream, sealed to IPX8, originating from the same hole as the laser itself and preventing any contaminants entering into the device. The simplicity of the TRS1 makes the product a cost-effective solution to broken tool detection.