Technical Article

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Achieving a breakthrough in wire EDM: No wire breakage, better control, improved processes

GF Machining Solutions' new Spark Track technology is a wire-cutting Electrical Discharge Machining (EDM) breakthrough in monitoring spark distribution along the wire. Spark Track technology, with its state-of-the-art Intelligent Spark Protection System (ISPS) module, makes the wire EDM process more secure, efficient and easy to execute.

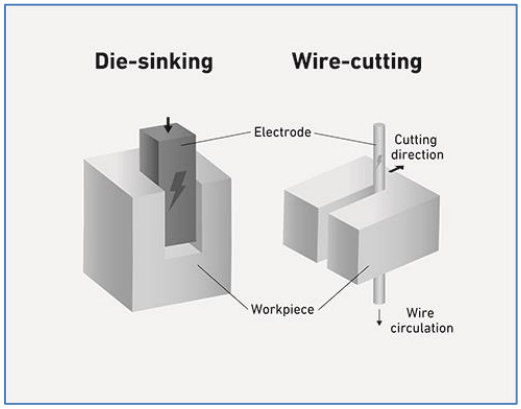
In wire EDM, the extremely thin wire electrode is exposed to discharge current peaks of up to 500 A. If the wire breaks during machining, production is interrupted and the surface of the workpiece may be damaged. Although modern machines automatically re-thread the wire, valuable time is lost, and to prevent wire breakage, the machine reduces the power (P) and thereby the processing speed. In addition, further generator parameters (ACO) are used to stabilize the process. Experienced operators can detect emerging difficulties in part processing at an early stage and react accordingly, but such a manual adjustment of the programming is time-consuming and leads to reduced machining time.

With the new ISPS module, sparks are analyzed and their concentration is defined. The parameters of the machine are adjusted accordingly to prevent wire breakage while maintaining an optimum cutting speed. The process is automatic and very effective, especially during difficult cutting conditions.

Wire EDM

Wire EDM is extremely accurate and used for a wide variety of applications. The electrical discharges are distributed along the engagement line of the wire and workpiece. The distribution of the discharges should be essentially uniform to get the best performance in terms of speed, accuracy and surface roughness. For various reasons, however, this is not always the case. Factors such as changes in material quantity to be removed (varying part height), debris, wire oscillation, flushing conditions, and the part material itself make wire EDM a stochastic process. In contrast to die-sinking EDM, during which the process conditions can be detected in real time in order to correct them accordingly, this is hardly possible in wire EDM due to the very short duration (less than 2 microseconds) of the electrical discharges.

Fig. 1: The principles of die-sinking and wire-cutting EDM



For this reason, it is of the highest importance to have real-time data about the spark distribution or localization of the sparks and their density at one's disposal in order to avoid machining defects and eventual wire breakage. The latter, obviously, leads to an interruption of the process, loss of time, and a possible negative impact on the machined surface. GF Machining Solution's recent innovation in the field of wire EDM led to the development of a sensor, which is able to precisely track and locate each spark position in real time. This Discharge Location Tracker (DLT) constitutes the core of the new Spark Track technology.

Spark Track technology

With the intelligent Spark Protection System (ISPS) module, which is part of GF Machining Solutions' Spark Track technology, the EDM process is made easier. The basis of the Spark Track technology lies in evolutions in modern electronics, which allow fast and accurate signal acquisition and the processing of the real time data coming from the current sensors. In parallel, high computing power is required for noise filtering and decision making. Moreover, the detecting characteristics depend on the workpiece material and the wire diameter and type; the detection accuracy depends on the generator pulse stability and discharge loop impedance.

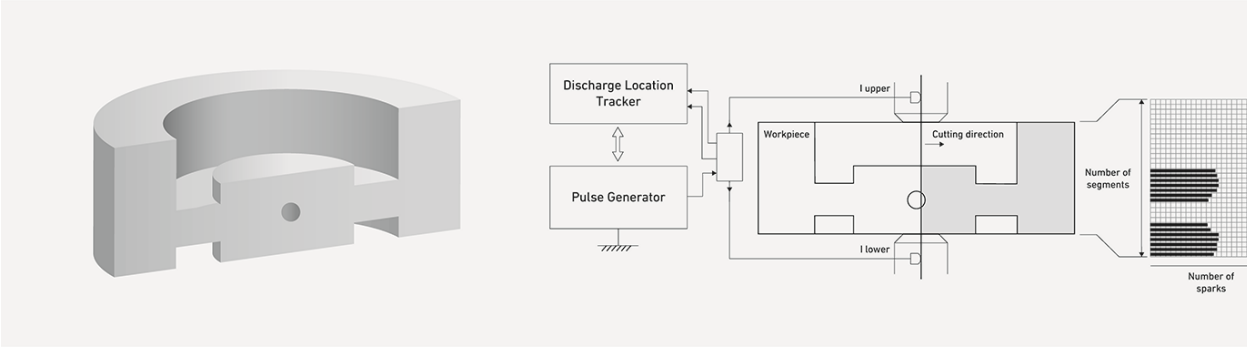
The current from the pulse generator (I_{tot}) is divided into a current for the upper feed path (I_{upper}), respectively the lower feed path (I_{lower}). Both currents are measured separately for each spark; their difference is associated with the corresponding discharge position according to the following formula:

$$Z_{li} = H_{wp}/2 + k*(I_{upper}-I_{lower}) \qquad (1)$$

Here, *k* is a calibration factor, H_{wp} is the workpiece height, and Z_{li} is the discharge position from workpiece bottom.

This results in the definition of the distance between the lower surface of the workpiece and the spark. By controlling all variables, the achievable precision of the spark localization is remarkable (less than 0.3 mm).

Fig. 2: Schematic showing the Discharge Location Tracker sensor principle



The workpiece height is divided into a number of distinct vertical segments in order to exploit the available information in a useable way. Each of these segments corresponds to a fast random access memory in the acquisition system. A discharge counter is allocated to each memory location, and thereby to each vertical segment.
For each discharge, the current sensor information is analyzed using the formula shown in ([1]). The discharge is then assigned to a vertical segment, that is, to the corresponding memory location, where the counter is incremented by one unit. As an example, in the case of a workpiece with a height of 50 mm and a memory or size of 50 locations, if there is a discharge at the 4th mm, the memory location corresponding to the 4th mm will be incremented by one unit.
Graphically, this shows the real distribution of the spark location and the quantity per vertical part segment.

Wire breakage protection
But how does the Spark Track technology improve the process performance?
It is known that the reasons for wire breakage are:

1. Discharge concentration
2. Thermal overload of the wire
3. Excessive wire wear, caused by the discharges
4. Vibrations and short circuits of the wire caused by gas bubbles, electromagnetic and mechanical forces

To prevent **discharge concentration,** Spark Track does the following:
A clear advantage of knowing the locations of the sparks and their number is that this ensures a fast, uninterrupted process by avoiding any risk of discharge overconcentration—which may lead to wire breakage—even when a considerable amount of energy is applied to the wire. To achieve this protection, one or more thresholds are set. The machining process is initially conducted with the machining parameters set according to the technology database (i.e., the pulse current, frequency, voltage etc.). Should the actual number of discharges exceed the threshold, the ISPS module proportionally reduces the spark energy delivered to the wire. This results in a machining process that is controlled in real time while considering the highest possible number of discharges, leading to a safe, smooth and efficient cutting process.

To prevent a **thermal overload of the wire**, a thermal model of the wire in real time is created. This allows the process control to be informed about the wire temperature and enables it to keep the EDM process within a safe operational setting.

A real-time model of the wire's shape and wear **prevents excessive wire wear.**

To prevent **vibrations and short circuits of the wire caused by gas bubbles, electromagnetic and mechanical forces**, not only the gap flushing, but also the wire mechanical tension and the electro-magnetic forces must be optimized. This is the task of additional algorithms, which are partly based upon the DLT.

Conclusion
With GF Machining Solutions' new ISPS module, the sparks can be measured and analyzed. The machine parameters are then adjusted in real time to prevent wire breakage while maintaining an optimum cutting speed. The process is automatic and highly effective, especially during difficult cutting conditions—and as a result, process interruptions or downtimes due to wire breakage and manual adjustments of the generator parameters are eliminated. The performance potential of the digital IPG generator is fully utilized, cycle times are reduced and productivity is maximized. A fast and reliable job execution is guaranteed.

More information:

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