Recommendations

RC29

for spark erosion machining

InFiReS

LOSS PREVENTION RECOMMENDATIONS

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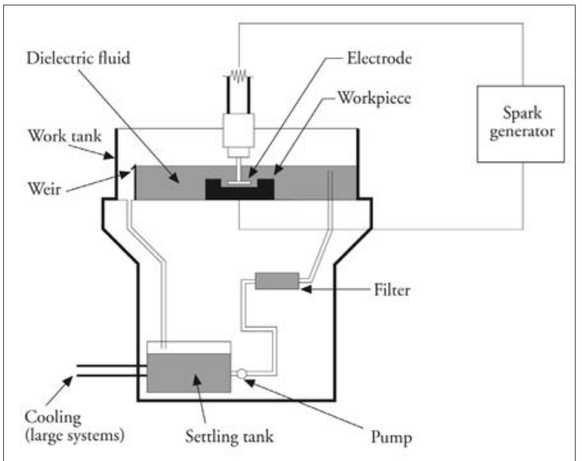

Spark Erosion Machine - General Arrangement

SCOPE

These recommendations concern electrical discharge machining (EDM), sometimes known as spark erosion machining, which is a known source of serious fires in engineering premises. The document aims to reduce the incidence of such fires and minimise the hazards to life, property and the continuity of the business should a fire occur, by ensuring that the design, installation and operation of such equipment is of a suitably high standard.

These recommendations are applicable to die sinking machining. They also extend to the following allied operations:

- abrasive electric discharge grinding
- rotary spark emission grinding
- electrical discharge milling (also known as rotary EDM or EDM grinding) is used for sharpening carbide and diamond-tipped cutting tools, thus reducing the high cost of using diamond grinding wheels
- ultrasonic aided EDM, with the electrode vibrating at ultrasonic frequency to drill small or micro-holes
- abrasive electrical discharge grinding, which is the combined process of electrical discharge erosion and mechanical grinding for machining extremely hard materials
- micro-wire EDM, using a small diameter tungsten wire electrode for machining extremely small parts
- micro-electrical discharge machining, using a small machine of the sinker type
- mole EDM, which can machine a curved route through the workpiece using ultrasonic waves
- double rotating electrodes EDM to erode a rotating workpiece
- electrical discharge dressing using a pulsed elecrtric voltage to dress grinding wheels.

The guidance presented in this document does not, however, extend to wire erosion machining, where the dielectric used is de-ionised water. This is usually a computer controlled operation, making this a particularly expensive item of plant.

INTRODUCT ION

Spark erosion machines are commonly utilised in engineering facilities to form dies and moulds with complex geometries. The process involves the generation of sparks beneath the surface of a dielectric fluid, which is generally flammable. The process is therefore inherently hazardous although effective protective measures can serve to mitigate the risk.

An associated process, known as wire eroding, uses a thin brass or copper wire to cut complex, two-dimensional components, such as gear wheels, from metals and alloys that are difficult to machine by conventional processes. Wire erosion machining uses water as a dielectric and thus the fire risk associated with this process is significantly lower.

In common with many modern technological processes, the equipment involved is complex and costly and thus must be idle for as short a time as possible. Spark erosion machining is a slow process and machines may often be left to operate with minimum supervision, or completely unattended for prolonged periods of time, sometimes overnight.

DEFINITIONS

Dielectric fluid: the medium in which the tool and workpiece are submerged in order for the spark erosion process to be controlled more effectively.

Die sinking: this is the conventional spark erosion process whereby a die shaped as a negative of the desired final product is sunk into the workpiece by the removal of small pieces of metal by application of a prolonged series of electrical arcs between the die and the workpiece. (Die-sinking machines are also known as ram-type, plunge, sinker and vertical electro discharge machines.)

EDM: electrical discharge machining, an alternative name to spark erosion machining.

Tool: the die that is formed as a three-dimensional mirror image of the component to be manufactured. The tool is the upper electrode in the process.

Wire electro-discharge machining: A two-dimensional cutting process utilising electrical sparks between a wire and the workpiece to cut an accurate shape in the latter.

Workpiece: the piece of metal which is to be formed into the finished product, this is the lower electrode.

THE PROCESS

A spark erosion machine shapes soft and hard metals, and some conducting ceramics, without distortion or otherwise affecting their structure, although tempering or other surface treatments may be needed following the process. The process is one of the most accurate manufacturing methods for creating complex or simple geometries; the process can be economical and have an acceptable production time.

As is often the case with technology, the spark erosion process is a simple concept but in practice requires complex control measures. An electrically conducting tool and workpiece are placed close together but not in contact. A voltage is then applied between these two items which causes a spark to jump across the gap. The spark may be up to 1mm in length with a temperature of 8,000°C-12,000°C and will thus melt and vaporise a small area of the workpiece. If the process is repeated in a carefully controlled manner over a long period of time the workpiece can be formed into a very accurate mirror image of the tool.

The upper electrode, or tool, is carefully crafted from materials such as copper, graphite, tungsten, tellurium or brass and is a mirror image of the shape to be created in the workpiece. The workpiece is clamped securely to a metal table and, together with the tool assembly, is lowered beneath the surface of a tank of dielectric fluid.

The purpose of the fluid is to increase the intensity of the spark, to cool the workpiece and to flush away the traces of metal that are removed with each successive spark. The dielectric fluid also allows the spark gap to be reduced to increase the quality of the finished product.

To remove heat and debris from the process, the fluid is cooled and filtered, and pumped back to the work tank. Variations in this process may involve weirs, suction or pressure flushing. The filtration process involves passing the fluid through a cartridge, a process similar to filtering the oil in a car engine.

The quantity of dielectric fluid present may vary from a few litres in small machines to several hundred litres in large machines. In some instances several machines may be linked to a single dielectric system. The fluid must be an electrical insulator, must de-ionise as quickly as possible to allow a minimum time lapse between successive discharges and must have a high specific heat. Although in theory any electrical insulator could be employed as a dielectric, in practice hydrocarbons tend to be the fluid of choice. These tend to be derived from white spirit and have a flashpoint from 80°C upwards.

Dielectric fluids should be inert with respect to the materials on which work is being carried out and have minimum toxicity and dermatological effects. They should also be compatible with components of the equipment such as seals and filters.

There are complex electrical systems controlling the voltage and timing of the pulses required to carry out the work. Economics require the pulses to be as frequent as possible while allowing adequate time for cooling and de-ionising of the dielectric and flushing away the condensed metal particles which form the by-product of the process.

The voltage applied between the tool and the workpiece can vary widely, although it tends to be between 60V and 120V with the current ranging between 200mA and 100A. Several thousand pulses may be applied each second, leading to a rapid wearing away of the workpiece and correspondingly widening the gap between the two items. The process is therefore computer controlled in two or more axes to allow the optimum spark gap to be maintained.

Access to the workpiece is provided by either ‘rise and fall’ or ‘swing door’ mechanisms, the latter requiring the tank to be drained before the front wall is hinged open.

This brief introduction to the spark erosion process indicates the complexity of the controls required to keep the system functioning effectively; controls that must be robust and accurate if the equipment is to operate safely with minimal operator attendance.

RECOMMENDATIONS

The greatest hazard in spark erosion machines is the use of a flammable dielectric fluid. A fire can occur in the tank if the fluid in the vicinity of the spark reaches its flashpoint and there is an adequate supply of air to bring the concentration of the vapour to within its flammable limits.

1. General recommendations

1.1 Operation of spark erosion machines should be an important element of the fire risk assessment for the workplace carried out in compliance with fire safety legislation. Where a machine may be left operating with minimum supervision, or be left working completely unattended out of normal working hours, this should be considered as a key part of the fire risk assessment for the equipment.

1.2 If, following the fire risk assessment, machines are to be left unattended for prolonged periods of time, insurers should be informed and additional fire detection or suppression systems will normally need to be provided.

1.3 The fire risk assessment should identify the combustible materials in the workplace as well as the potential sources of ignition and identify how these hazards are managed. Where practicable, combustible construction materials (including insulated panels with combustible cores) should be physically separated from the spark erosion machine to a suitable degree. Where this is not possible, existing combustible construction materials in the immediate vicinity should be protected so as to provide at least 60 minutes fire resistance.

1.4 Before operating the machine, staff should receive appropriate instruction, including:

1.4.1 The correct method of using the machines in accordance with the manufacturer's instructions.

1.4.2 The importance of routine maintenance and the procedures for undertaking and recording this.

1.4.3 The safety features that are incorporated and the correct tolerances that must be maintained for these (in particular for the float switch).

1.4.4 The maximum period for which the machine may be left between checks.

1.4.5 The operation of the fire detection and suppression systems that may be installed.

1.4.6 Shutting down the equipment safely in an emergency.

1.4.7 Emergency procedures in the event of a fire.

1.5 Spark erosion machines should be installed, used and maintained in accordance with the manufacturer's instructions. In this respect particular attention should be paid to ensuring that float switches, thermostats and other safety devices are maintained so as to function correctly. The periodic maintenance regimes should be carefully followed even if the machines are only used occasionally.

1.6 In addition to the main power supply control located remotely from the machine, the safety devices incorporated into the design should include a switch to isolate automatically the high voltage supply to the equipment in the event of the work tank being opened during operation.

1.7 The interlock installed between the fire detection/extinguishing system and the equipment controlling the machine should be tested periodically and suitable records should be kept.

2. The dielectric fluid

2.1 Wherever possible, non-combustible dielectric fluids should be selected for use. Details of the properties of the dielectric fluids should be available in case of emergency.

2.2 The dielectric fluid should be selected so that the flashpoint is as high as possible, always bearing in mind the necessity to ensure that the working temperature of the fluid is at least 30 deg C lower than the autoignition temperature of the fluid.

2.3 The level of fluid above the workpiece is critical and the instructions issued by the manufacturers of the equipment should always be followed. These normally dictate that a minimum cover of approximately 40mm be maintained.

2.4 To ensure an adequate level of dielectric fluid above the workpiece a low level shut-off device should be incorporated in the equipment. A float switch, or similar device, should therefore be designed to switch the machine off automatically while there is still a safe level of fluid above the electrode. The electrode should always be submerged to a suitable degree and never be allowed to become exposed to the atmosphere. For additional safety many machines are fitted with duplicate low level monitors.

2.5 A thermostat should be incorporated to close down the process should the temperature of the dielectric fluid rise above a predetermined level. This safe level should be at least 10 deg C below the flashpoint of the fluid. For additional safety, duplicate thermostats should be incorporated, both operating at the same temperature.

2.6 Bulk supplies of dielectric fluid should not be stored in the machine shop but be kept in a purpose-built store or enclosure (ref. 1).

2.7 Any small quantity of dielectric fluid required in the workplace for topping up purposes should be stored in a proprietary fire cabinet.

3. Spark control

3.1 The spark erosion process involves high voltage electricity; operators should thus receive suitable training before using the equipment and should remain constantly aware of the machine and its surroundings. Contact with any part of the fluid or the electrode can cause severe injury or even death.

3.2 The equipment should incorporate suitable pulse monitoring as an early aid to the prevention of fires.

3.3 Equipment with pulse monitoring and correction facilities may be allowed to operate automatically with minimum supervision whereas machines without this level of protection should be constantly manned.

3.5 Spark erosion machines are designed to control the spark gap by moving the tool (the upper electrode). In the event of a build-up of waste material between the tool and the workpiece, the tool will rise to maintain the required gap. It is therefore necessary that a back-off switch be incorporated to ensure that the tool does not rise above a preset distance (often about 8mm) above the workpiece and thus does not reach the surface of the dielectric fluid.

3.6 Should an electrode break, or there be a build-up of waste material sufficient to bridge the gap between the tool and the workpiece, a continuous arc would occur, resulting in a fire hazard in the form of a sharp rise in the temperature of the dielectric fluid. An anti-arc control device should therefore be incorporated into the electronic controls. By measuring the spark frequency and the gap voltage the upper electrode can be controlled so that it automatically backs away from the workpiece when predetermined criteria are reached to allow the fluid to flush away the material causing the problem.

3.7 Anti-arc controls should be designed to permit a small number of attempts to allow waste materials to be flushed away. If these are not successful, the machine should safely close down automatically.

3.8 An associated control is the fixed start point monitor. As work progresses, the tool descends into the tank as material is removed from the workpiece. If the anti-arc controls cause the upper electrode to be raised above the fixed start point then the machine should automatically shut down safely. The fixed start point monitor should operate independently of the back-off switch.

4. Fire protection

4.1 Wherever possible, the spark erosion process should be carried out in a separate fire compartment in the building providing at least 60 minutes fire resistance (integrity and insulation).

4.2 The installation of an automatic fixed fire extinguishing system is strongly recommended and is essential if the equipment is to run unattended. Such an installation should be specified for all new equipment; retro-fitting of systems to existing machines is normally feasible but the manufacturers should be consulted where this is being considered.

4.3 The fire suppression system should operate automatically at the first signs of fire. Detection may be by means of passive infra-red or heat detectors. The latter may take the form of break-glass bulbs, fusible links or other suitable mechanisms. A polymer tube containing pressurised gas may also be used as a means of detecting fire. Such devices may be positioned around the head of the machine but should also be installed so as to be located away from sharp edges and hot surfaces.

4.4 The most effective extinguishing agent for a particular application should be selected, taking into consideration such matters as the effectiveness, toxicity, asphyxiation potential, ecological and contamination issues.

4.5 The principal alternatives are dry powder, which can cause contamination of electrical control systems, or carbon dioxide, which should not be released in large volumes in a small confined space.

4.6 Any fixed firefighting installation should comply with the appropriate British Standard (see refs 2, 3, 4, 5 and 6).

4.7 On operation of the fire suppression system, the spark erosion process should automatically switch off and remote signalling be activated.

4.8 The extinguishing agent should be directed efficiently into the tank.

4.9 The application may be regarded as a Class B (deep liquid) as defined in BS 5306: Part 8 (ref. 7). In this case the quantity of extinguishing agent provided should be related to the surface area of the dielectric fluid as indicated in Table 1 in BS 5306: Part 8, part of which is reproduced below.

Extinguisher rating Class B fire risk	Maximum area for one extinguisher (m^2)
21B	0.14
34B	0.23
55B	0.37
70B	0.47
89B	0.59
113B	0.75
144B	0.96
183B	1.22
233B	1.55

4.10 The design of open fluid tanks may also be suitable for the application of a heavier than air extinguishing gas such as carbon dioxide.

4.11 Fixed fire suppression systems should be designed, installed, commissioned and maintained by a company having the approval of an independent third-party certification body as complying with the requirements of LPS 1204 (ref. 8) (or BAFE SP202 (ref. 9)).

4.12 Suppression systems should be tested and maintained according to the requirements of the relevant British Standard and the manufacturers' recommendations. Suitable records should be kept.

4.13 Arrangements should be in place for the prompt recommissioning of an automatic fire suppression system. Back-up supplies of extinguishing agents should therefore be kept or arrangements made for their immediate replacement.

4.14 A spark erosion machine should not be reused following even a minor fire until it has been inspected and found to be serviceable by a competent person and the automatic fire suppression system has been recharged.

4.15 In addition to the automatic extinguishing systems fitted to spark erosion machines, a suitable number of appropriate portable fire extinguishers should be available in the area in which the equipment is installed. Such portable extinguishers should be approved and certified by an independent, third-party certification body and be installed in accordance with BS 5306: Part 8 (ref. 7) and inspected and maintained in accordance with BS 5306: Part 3 (ref. 10).

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8. *Requirements for firms engaged in the design, installation and commissioning of firefighting systems,* Loss Prevention Standard (LPS) 1204: Issue 2, BRE Certification, 1994.

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Protecting people, property, business and the environment

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