MAZURCZAK THERMOPROZESSE

Safe heating – fire protection in wet chemical manufacturing facilities

Technical solutions – between illusion and manageable risk

by Klaus Frischmann, Schwabach

Electric heating systems, especially when not purpose designed or of inferior quality, constitute a significant source of fire hazards especially in metal finishing plants. Fires caused by such heating systems can result in severe damage and financial losses while the plant is out of action. Such events can be avoided by installation of safety switches to control the heating system, suitable level and temperature sensors using modern control technology. However by the use of indirect heating systems, the danger of fire can be virtually eliminated.

In wet-chemical production, the temperature of the fluids often plays an important role for the effectiveness of the processes. For this, the fluids generally have to be heated to and held at temperatures between well above room temperature and near the boiling temperature of the fluid. In surface engineering, the aqueous solutions with pH values over the full range from strongly acid to strongly alkaline that are predominantly used in open tanks have to be heated by means of heating systems. Furthermore, in many processes high currents in the kA range with voltages up to approx. 15 V have to be transmitted between the current sources and the anodes and cathodes of the electrolysis systems. Both heaters and systems with electric current represent possible sources of fires if not properly operated or in the event of defects.

1 Fire risks

1.1 Damage statistics

In recent years, the number of fires in surface engineering plants in Germany, particularly in the field of electroplating, has increased to between 70 and 80 incidents per year. These included 10 to 15 major incidents each involving damage totalling more than EUR 500,000. As a rule, such fires cause such extensive damage that production is at a standstill for prolonged periods, and in some cases companies had to close completely. In these cases, the cost of the downtime is higher than the cost of the actual fire damage. Should the observed increase in the number of fires in electroplating companies develop into a stable trend, significant increases in insurance premiums for electroplating companies must be expected (indicated already by closer observation of the industry by the insurance companies). In the worst case, the industrial insurance companies will in future no longer cover the risks of electroplating companies, or only on far stricter terms, so that there is an urgent need for action on the part of electroplating companies and of the manufacturers of equipment and plants for the production.
In this context, the following were identified as the main causes of fires:

- Electrical malfunctions
- Missing or faulty safety equipment for temperature and filling level
- Corrosion of contacts (switch cabinet, plug sockets)
- Incorrect installation of equipment (i.a. electric heaters)
- Frequency of damage during non-operating times with few or no personnel present

Schlachthofstraße 3, D-91126 Schwabach, Tel: 09122/9855-0, Fax: 09122/9855-99, Internet: **rotkappe.de**, eMail: kontakt@mazurczak.de

1.2 System and plant-specific hazards

Different potential hazards for the occurrence of fires can be identified in the various areas of the plants. For electric heaters these include:

- Automatic starting of electric heaters not covered by fluid
- Dry running of electric heaters during operation, e.g. due to missing or non-functioning level monitoring systems
- Insufficient distance between heater elements and inflammable tank walls or installations
- Missing of non-functioning overheating protection systems

A further area with potential for the occurrence of fires is the power supply to the electrolyte systems used. Starting points for a fire here can be:

- Overheating of the DC power supply or its contacts
- Corrosion of contacts with resulting high transition resistance and consequent overheating

Furthermore, the mixtures of hydrogen and air or (during electrolytic degreasing) oxygen and hydrogen (oxyhydrogen) occurring during the electroplating process represent potentially explosive mixtures. In the event of a spark caused, for example, by poor electrical contacts, these can ignite and lead to a fire. The same applies to spontaneously inflammable chemicals.

In addition, the spreading of a fire due to fume extraction systems poses a particular hazard. The spreading of a fire, also to other fire sections, can also occur via cable channels or cable ducts and is dramatically increased by the high fire load there in the forms of plastics such as PP, PE or PVC that are installed in the systems. Measures to avoid any form of fire source are therefore absolutely imperative.

1.3 Standards and regulations

Measures to ensure the safety of electroheating installations and electrical equipment are defined in standards such as DIN EN 60335-1 (VDE0700-1):2012-10 [1] or DIN EN 60519-2 (VDE 0721-2) [2]. DIN EN 60519-1:2014-03 [3], for example, deals with protection against temperature influences in section 13 as follows:

- *The electrical heating appliance must be installed and operated in such a way that the temperature of the electrical heating appliance cannot pose a danger to the operator(s) or the surrounding area even if the appliance is unsupervised and is switched on inadvertently" (section 13.6).*
- *If hazards can arise in the event of malfunctions, for example due to the failure of the temperature control system, safety facilities must be provided to limit the temperature. These must be functionally and electrically independent (section 13.7).*

Furthermore, work has been continuing on a European standard for plating and anodizing lines (DIN EN 17059:2016-12 [5]) that has now reached the draft stage and will probably come into force during the course of this year.

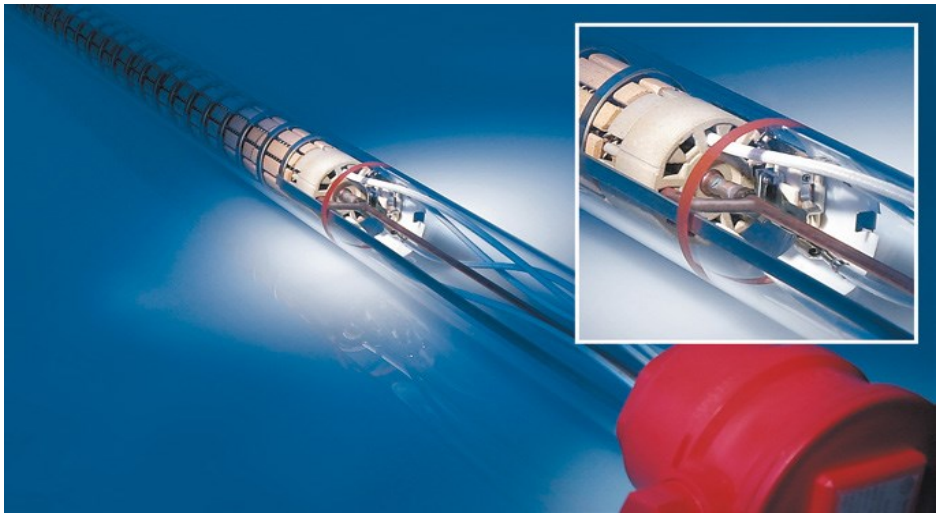
Guidelines and directives of the Central Association for Surface Technology (ZVO) [5] and of the Schadenverhütung GmbH (VdS) [6] also deal with fire protection. These regulations which apply in principle to new companies recommend the implementation of the guidelines also in existing companies by adapting the fire protection measures.
It is urgently recommend that the insurance company be consulted as early as possible on new installations and modifications, and that the relevant safety regulations for production facilities are observed in good time [7-11]. As a result, the fire risk should be reduced and the fire damage and consequential damage (plant downtime!) should be minimised.

1.4 Risk management

Risk management forms part i.a. of the current standard ISO 9001:2015 [12] according to which risks have to be identified, evaluated and, where possible, mitigated. As explicit requirements in this context, process engineering and organisational protective measures are to be satisfied.

The process engineering protective measures include:

- Use of indirect heating systems such as heat exchangers, as far as possible
- Use of electric heating systems only with the corresponding safety equipment and their installation according to the manufacturers' instructions



Organisational protective measures are:

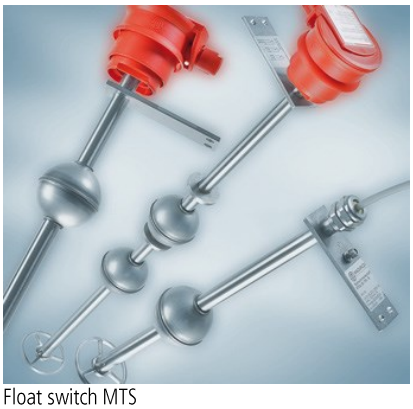
- Establishment/maintaining of protective measures for which the board of management is responsible (personal liability of managing directors of limited liability companies in the event of organisational faults!)
- Implementation and documentation of maintenance programmes for installations and equipment
- Appointment of company fire protection officers

2 Solutions for reliable process temperature control

Modern systems and installations offer different approaches to ensuring the necessary safety for the heating of wet chemical processes.
High-quality electrically powered heaters have integrated safety systems for avoiding fires, such as the anti-burn-system of the ROTKAPPE® safety immersion heater. The temperature limiter installed in the immersion tube switches off the heater permanently if dangerously high immersion tube temperatures are reached (e.g. in the event of overheating due to running dry or extreme encrustation). After remedying the cause of overheating, the heater can be switched on again by a manual reset of the temperature limiter.
Fixed wiring of the electric heater prevents the occurrence of poor electrical contacts and any resulting overheating. Further preconditions are the installation and operation of electric heaters according to the manufacturer's instructions in the operating manual.

In order to avoid the occurrence of fires, it is also necessary to use suitable level sensors, paying attention to the following points:

- Selection of the sensor systems with the requisite chemical and thermal resistance in the respective process liquid
- The function of the sensor system must be tailored to the influencing factors of the process liquids
- Use of float switches for electrically non-conductive liquids (e.g. water in rinsing stages)
- Avoidance of electromechanical sensors such as float switches in the case of liquids that cause encrustation (e.g. electrolytes with high salt content)



Float switch MTS

- Monitor electrically conductive liquids (e.g. electrolytes) with conductive measuring systems, such as rod-type level probes. The use of precisely adjustable electronic devices for conductive filling level monitoring permits good adaptation of the response sensitivity to the electrical conductivity of the respective process liquid.

Rod-type level probe NS

In addition to level sensors for monitoring levels, the use of suitable temperature sensors for temperature control is also to be recommended. Here again, attention must be paid to the chemical and thermal resistance in the respective process liquid during selection. The industrial standard for measuring temperatures in process liquids (temperature range 0°C to 120°C) is the Pt 100 sensor.

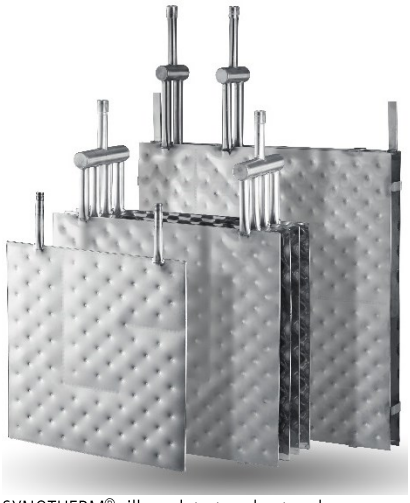
The following points must be observed when using thermal cut-outs:

- If a risk analysis demands the use of a temperature limiter, this **must** be installed
- It must be electrically and functionally independent of the temperature controller
- Use only safety temperature limiters to DIN EN 14597 [13]

Temperature sensor TF

Measuring systems through to redundant power contactors are recommended as important principles for fire protection. This approach is backed up by a documented maintenance concept also for heaters, sensors, connection technology and contacts.

The risks from the electric currents and voltages of electric heaters can be completely avoided by the use of indirect heating systems or heat exchangers. Here, however, an alternative economical heating source must be available. Possibilities here are heat-transfer media such as water, steam or glycol and heat sources such as heat pumps or cogeneration units. Furthermore, attention has to be paid to preventing carryover or contamination with chemicals and the avoidance of leaks in such systems and their pipework.



SYNOTHERM® pillow plate-type heat exchangers

SYNOTHERM® plate-type heat exchangers, for example, are used for indirect heating. These are characterised by:

- Indirect heating and cooling for use in tanks
- No fire hazard
- Simple maintenance (easy cleaning)
- Efficient energy utilisation
- Compact size and good chemical resistance (stainless steels and titanium)

3 Choice of suitable methods

Particularly in electroplating and surface engineering, a wide range of liquids and chemicals are used for the surface treatment of part in the process plants. The process parameters in the tanks and containers have a crucial influence on the quality of the product surface; these include not only parameters for the process solutions (e.g. metal content or pH value), but naturally also the exact temperature control of the electrolyte.

Crucial for homogeneous temperature control is the way in which the heat energy is transmitted to the liquid, e.g. using heat exchangers or immersion heaters ("surface load"). In this context, the heat development that may be caused by the Joule heating must also be taken into consideration. A wide range of electrical heating systems have proved effective here, but these have to satisfy certain demands on operational safety.

If the temperature of the process liquid is to be controlled indirectly using heat exchangers, then water and glycol or steam have proved to be the most reliable and at the same time safe heating and cooling media.
In practice, consideration also has to be given to the following points when selecting suitable processes for temperature control:

- Operational safety and availability (heating and energy)
- Risk potential (e.g. due to pressure or leaks!)
- Flexibility and efficiency
- Preconditions for installation
- Thermal, chemical and mechanical resistance
- Ease of maintenance and cleaning possibilities

4 Summary

Safe heating in wet chemical manufacturing processes is possible if the regulations, such as on fire protection, are applied correctly. The number of fires has nevertheless increased in recent years, so that industrial insurance companies are considering a tightening of the existing regulations. The present article presents an overview of the main hazard areas and outlines the contents of the corresponding standards and guidelines. The state-of-the-art for avoiding fire damage caused by heating systems is also considered.

Literature

[1] DIN EN 60335-1:2012-10; VDE 0700-1:2012-10, Household and similar electrical appliances - Safety - Part 1: General requirements (IEC 60335-1:2010, modified)
[2] DIN EN 60519-2:2007-05; VDE 0721-2:2007-05, Safety in electroheat installations - Part 2: Particular requirements for resistance heating equipment (IEC 60519-2:2006)
[3] DIN EN 60519-1:2014-03; VDE 0721-1:2014-03 – Draft, Safety in installations for electroheating and electromagnetic processing – Part 1: General requirements (IEC 27/889/CD:2012)
[4] www.beuth.de/de/norm-entwurf/din-en-17059/262477519
[5] DIN EN 17059:2016-12 – Draft, Plating and anodizing lines - Safety requirements (prEN 17059:2016)
[6] www.vds-industrial.de/service/vds-richtlinen/brandschutz
[7] Standards and regulations of the employers' accident liability insurance associations in the BGVR Library; www.arbeitssicherheit.de
[8] GUV-V A3 Accident prevention regulation "Electrical systems and equipment; http://publikationen.dguv.de/dguv/udt_dguv_main.aspx?MMRSV=1 www.dguv.de/medien/inhalt/praevention/fachbereiche/fb-etem/documents/dguv_num.pdf
[9] DGUV Information 203-049 Testing of mobile electrical equipment; www.arbeitssicherheit.de/de/html/library/document/5015052.1
[10] VDE rules and regulations; www.vde-verlag.de
[11] VDE Institute – Search for VDE-tested products; www2.vde.com/de/Institut/Online-Service/VDE-gepruefteProdukte/Seiten/Online-Suche.aspx
[12] DIN EN ISO 9001:2015-11, Quality management systems – Requirements (ISO 9001:2015)
[13] DIN EN 14597:2015-02, Temperature control devices and temperature limiters for heat generating systems (EN 14597:2012)

MAZURCZAK THERMOPROZESSE

Schlachthofstraße 3, D-91126 Schwabach, Tel: 09122/9855-0, Fax: 09122/9855-99, Internet: rotkappe.de, eMail: kontakt@mazurczak.de