Weld Purging World

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THE LATEST NEWS FROM OUR UK HQ

TECHNICAL ARTICLE: CLARIFICATION OVER TUNGSTEN ELECTRODES FOR TIG/GTAW WELDING

WELD PURGING PRODUCTS INNOVATORS MANUFACTURERS AND INTERNATIONALLY RENOWNED SPECIALISTS
Dear Reader,

Welcome to issue five of Weld Purging World for 2022.

This month features our article ‘Advanced Freezing Technology reduces Maintenance Costs’, which discusses the use of both carbon dioxide and liquid nitrogen freezing techniques.

If you have any information that you would like to be featured in future issues of this publication, please contact me.

As always, we hope you enjoy the issue.

Best wishes,
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CALENDAR: EVENTS IN THE INDUSTRY

**Tube 2022**
20 - 24 Jun 2022
Düsseldorf

**TechniShow**
30 Aug - 2 Sep 2022
Holland

**ADipec**
31 Oct - 3 Nov 2022
Abu Dhabi

**Fabtech**
8 - 10 Nov 2022
Atlanta, USA
Transmission of fluids in pipework play a crucial role throughout the manufacturing industry, meaning any interruptions can be expensive. They can lead to lost production if sections of pipe need to be restored or if control gear such as valves and monitoring equipment have to be replaced. Often these requirements involve closing the entire pipe system and draining off and safely disposing of fluids.

The concept of freezing the fluid either side of a section of pipe for repairs or replacement of control gear is in widespread use in domestic and commercial plumbing but this is limited to 50 mm (2”) diameter tubes.

More recently techniques involving the use of liquid carbon dioxide or nitrogen have now extended the potential to pipes up to 300 mm (12”) diameter and beyond.

CARBON DIOXIDE FREEZING

Pipes between up to 200mm (8”) diameter are commonly used for transport of liquids in virtually every processing industry. Petrochemical manufacturing plants in particular employs highly complex pipework, valves, pumps and monitoring equipment to control product manufacture. Lubrication and fuel systems on aircraft, marine vessels and power generating plants are also extensive users of this range of pipework diameters. This is also essential during liquid beverage and dairy product processing.

Fig 1. Liquid carbon dioxide (CO2) being used to freeze pipe contents either side of a valve prior to valve removal and replacement.

A liquid CO2 technique now commonly used across the world is the Qwik-Freezer™ System. A specially designed insulating jacket is wrapped around the pipe at the point where the freeze is required. When liquid CO2 is injected into the space between jacket and pipe at a temperature of -78°C (-108°F) the pipe contents freeze and a secure “ice plug” is formed which seals the pipe.

The plug forms only in a section of pipe covered by the jacket so the resulting rise in pressure is very small and there is no damage to the pipe.
LIQUID NITROGEN (LN$_2$) FREEZING

Liquids in pipes up to 300mm (12”) diameter can be frozen using liquid nitrogen. Of the various products available the Accu-Freeze™ System is an example of a world leading system.

Copper tubing can be coiled around the pipe upstream and downstream of the location requiring attention and liquid nitrogen is passed through it. Alternatively, lightweight metal jackets known as ‘Cryo Shells’ can be fitted around the area to be frozen.

Advanced temperature-monitoring units are available to control the surface wall temperature of the pipe to accurately and safely create an ice plug.

The Accu-Freeze™ System is automatic and can be remotely operated. This makes it attractive for use in locations where engineer access is restricted.

Fig 2. Example of liquid nitrogen freezing being used to isolate a pipe section with restricted access prior to replacement of corroded pipework.

CONCLUSIONS

Pipe freezing technology allows fluids to be frozen below using liquid carbon dioxide or nitrogen.

Specially designed insulation and feeder hoses are used to deliver coolants. Continuous temperature control during the freeze operation can be incorporated.

The use of freeze technology affords the opportunity to isolate sections of pipework for maintenance, repair and replacement of valves and instrumentation.
LARGE DIAMETER PIPE PURGING

Care is necessary when welding large diameter pipework in stainless, duplex, chrome steels, nickel alloys and zirconium. When welding such reactive materials, they need to be purged of oxygen before, during and after welding, which can cause a huge expense when they are of a large diameter.

Weld Purging Experts Huntingdon Fusion Techniques HFT®’s innovative QuickPurge® Systems, which are manufactured up to 88” (2,235mm), dramatically reduces the space that needs to be purged, thereby reducing purging time dramatically, making huge savings in both time and gas costs.

Luke Keane, Technical Sales Manager for HFT® said: “Using QuickPurge® means there is no longer a need to fill complete pipes with an inert gas. The systems are so efficient they pay for themselves in the first couple of welds in gas savings alone, whatever the pipe size. QuickPurge® is simply inserted into a tube or pipe, inflated within the pipe, restricting the area that is to be welded, reducing the oxygen level down to 100 ppm (parts per million) within minutes.”

QuickPurge® has an additional gas input line, which means extra purge gas can be introduced for applications such as this, thereby achieving a much faster purge, down to the lowest oxygen levels, which is perfect for larger diameter pipes where quality welds are required.

High speed pipe purging system QuickPurge® is leading the way in the field of purging tube, pipe and pipeline joints over 6” diameter, where oxygen levels are required to be as low as 100 parts per million (ppm) or less.

Huntingdon Fusion Techniques HFT®’s innovative design of the QuickPurge® System means that zero colour welds will be achieved and there will be no loss of corrosion resistance or loss of mechanical strength caused due to the presence of oxygen, nitrogen or hydrogen gas.

Using IntaCal® combined with the integrated PurgeGate® device makes it possible to safely inflate the dams with argon gas, for purging the space between the dams where the weld joint is located. With PurgeGate®, burst dams are prevented in the event of undue pressure increase or accidental flow increase of the purging gas.

All systems are manufactured as standard with a hose for connecting a Weld Purge Monitor® to, which can read oxygen levels down to as low as 10 ppm depending on the model.

For pre-heated chrome steel and high strength stainless steel pipe joints, HFT® design and manufactures the HotPurge® range for a higher and longer temperature exposure.
Resistant to very high temperatures so fully compliant with GTAW, GMAW and PAW processes
CLARIFICATION OVER TUNGSTEN ELECTRODES FOR TIG/GTAW WELDING

The tungsten arc welding concept, originally introduced as a practical tool in 1950, is now established as the most versatile technique for producing fusion welds to the highest quality standards.

A temperature of around 4,000ºC is generated in the arc during welding and the role played by the electrode is therefore crucial. It must have a high melting point and it must be non-consumable: tungsten quickly established itself as the most suitable material.

As the knowledge of arc characteristics increased however it became clear that the use of pure tungsten presented some limitations on process development, particularly arc starting, stability and electrode wear.

Early research showed that the addition of thoria resulted in overall improvements in performance and from this work a range of tungsten electrodes containing oxide additions or ‘dopants’ were introduced progressively.

Flawed Background

Despite the clear significance of electrode composition the last 60 years has witnessed the publication of few scientific papers of practical use. Some of these advocate the widespread use of dopants on the basis of improved welding performance, some highlight the hazards associated with them.

Evidence supporting results of these trials is flawed however and cannot be used as a basis on which to make generalised conclusions. Here we present an objective review of what has become an emotive issue – the use of dopants in tungsten electrodes.

The issues under examination fall generally into two categories; those associated with technical and commercial advantages, and those relating to health hazards.

The principal dopants

A major advantage of tungsten as a welding electrode material is its low work function – the energy needed to remove an electron. This is an essential requirement for efficient arc generation. Dopants reduce the work function and thus enhance electron emission. As a consequence, this increases the usable life of the electrode and can also promote arc starting and stability.

The most commonly used additives are oxides such as thoria (ThO2), zirconia (ZrO2), lanthana (LaO2), yttria (Y2O3) and ceria (CeO2) and some of these are classified in Table 1 along with their respective work functions. Some electrodes (1) contain complex mixtures of rare earth oxides, referred to as multivariate electrodes, and these are known to lower the work function further.
Arc Starting

Although the electrode material has a considerable influence on the ease with which an arc can be initiated, there exist several other controlling factors. Among these are arc gap, tip geometry, open circuit voltage, welding current, shielding gas, and the characteristics of the welding power source.

With so many interacting variables, experimentation is time-consuming. The relative arc starting performance of any one electrode varies with other parameters; the most difficult starting conditions prevail with low open circuit voltage (i.e., < 35 V), low current (i.e., < 20 A), and long arc gap.

Castner (2) reported that a 2% ceria electrode offered the best performance but Matsuda (3) found that at low open circuit voltages ceria was inferior to lanthana, yttria, and thoria.

Specific work on multi-dopant electrodes concluded that some offered marked improvements in overall performance (4 and 5), with MultiStrike® electrodes achieving 10 times longer life than a thoriated tungsten under the same conditions.

Review Summary. There is little to choose between the effect of various doped electrodes on arc starting but none of them is any worse overall than pure tungsten. Under certain defined conditions, lanthana and ceria offer significant advantages, while the multivariates offer considerable arc striking advantages.

Arc Stability

A stable arc is a prerequisite for producing welds of consistently high quality. Stability is inversely related to the electrode material work function so that although tungsten is good, additions of dopants with their lower work functions increase arc stability.

There is evidence (2) that some dopant materials are lost from the electrode surface however and may or may not be adequately replenished by diffusion from the body of the electrode. This would have the net effect of progressively reducing arc stability during use.

Some multivariate electrodes provide a higher percentage of dopant to counter this effect.

Electrode Erosion

As with arc starting, erosion is influenced by many related variables; even sophisticated research must therefore lead to conclusions based on limited combinations of circumstances.
A major contributory factor is contamination through touch starting and contact with the weld pool. Other factors are electrode tip geometry, welding current, open circuit voltage, shielding gas, parent material and welding power source.

Winson & Turk (6) reported that thoria-doped electrodes exhibited longer life than pure tungsten in most applications. Matsuda (3) found that dopant additions offered significant advantages at higher welding currents.

**Weld quality considerations**

The welding electrode plays a major part in ensuring consistency of operation since it influences stability of the arc. Whilst low cost tungsten and oxide-doped tungsten electrodes are available commercially they are usually of low quality: in particular the operational consistency is poor. A traceable tungsten electrode will go some way to ensuring the critical user of consistency and reliability (1).

**Health Hazards**

Health warnings are issued (7 to 9) by many legislative and advisory bodies in connection with the use of welding electrodes which contain refractory oxides and in particular thoria (Fig 1).

The warnings refer to the potential toxicity and in particular to the risk of inhalation of dust particles from thoria-containing electrodes generated during grinding. Whilst the use of thoria doped electrodes has not yet been banned there is a duty of care responsibility on the suppliers and users of these products to take precautions during storage and use.

![Fig 1. Comparison of radiation output from thoriated (left) and multivariate (right) electrodes. Whilst the thoriated output is below the recommended threshold (Ref 10) any radiation should be considered harmful and avoidance is the best solution. This reinforces the generally held belief that thoriated electrodes should be banned.](image)

**Storage**

In all cases a dedicated storage arrangement is advised. With low-volume users this could be a simple metal cabinet, but for large scale users a separate room may be more suitable. In either case the cabinet/room walls will probably be adequate to provide effective shielding against harmful effects (7).
Preparation/Grinding

Electrode grinding creates a major health hazard by virtue of the dust generated. In the case of thoriated products any dust released may be ingested and give rise to toxic poisoning.

There are a number of reasons why using a dedicated grinding machine to prepare tungsten electrodes offers attractive benefits. It may be because of the control that can be exercised over point geometry and consistency. It may be due to the fact that it eliminates cross-contamination from a grinding wheel, which has been used for other purposes. Or it may be since radio-toxic hazards associated with carcinogenic dust can be eliminated.

Grindstones with local dust extraction in combination with a simple filter mask should be used unless the number of electrodes involved is very small (less than about 20 per year). If the grinding wheel is not fitted with a protective viewing screen, eye protection should be worn. The air extract from the grindstone should be arranged so that the particles are deposited into a substantial disposable bag.

In addition to these precautions a safe method of collecting and handling the dust from the collection unit is preferable to minimise release to the atmosphere (simple sealing in a paper/plastic bag is adequate.)

The area around the grinding wheels should be cleaned daily with a vacuum cleaner to remove dust particles. If a high efficiency vacuum cleaner is not available, then the material should be damped down to minimise dust.

Commercially available grinding equipment designed specifically for welding electrode preparation are available such as that shown in Fig 2.
Conclusion

With respect to arc starting, all oxide-doped electrodes perform better than pure tungsten electrodes. Under certain defined conditions lanthana and ceria offer significant advantages.

Addition of any refractory oxide dopant to tungsten electrodes improves arc stability but ceria or ceria-containing multi doped tungsten is most effective. Dopant additions of all types reduce electrode erosion under some circumstances but no single dopant is superior to the others under all welding conditions.

Electrode quality and traceability can be an important consideration. Traceable tungstens should be used by companies with critical welds and operating to ISO standards or similar.

The use of thoria-doped electrodes constitutes a health risk and alternative oxide doped electrodes should be employed. The uncontested evidence on radioactivity and the consequent radio-toxic hazards strongly suggests that thoria-containing electrodes should be banned.

References

MultiStrike® tungsten is a specialist electrode developed by Huntingdon Fusion Techniques Limited. www.huntingdonfusion.com
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Manual Welding Trials with MultiStrike® Tungstens on Aluminium Site Trials May 1999
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The Health and Safety Executive HSE 564/6 (Rev) Storage and use of thoriated tungsten electrodes
The Health and Safety Executive: Guidance note EH53 Respiratory protective equipment for use against airborne radioactivity
The Ionising Radiations Regulations 2017

Further Reading

2. Tungsten electrodes for inert gas shielded arc welding and for plasma cutting and welding
3. ISO 6848-1984: Tungsten electrodes for inert gas shielded arc welding and for plasma cutting and welding
7. IIS/IW VIII 1702-93 Health Aspects in the Use of Thoriated Tungsten Electrodes.
9. IS/IW-VIII 1582-91 Estimated Radiation Doses from Thorium and Daughters Contained in Thoriated Welding Electrodes
10. IS/IW VIII 1702-93 Health Aspects in the Use of Thoriated Tungsten Electrodes. 2017 No. 1075 SCHEDULE 3
11. Radioactivity : Internal Exposure
12. Manifestations of Toxic Effects - PMEP - Cornell University: Toxicology Information Briefs
13. IIS/IW VIII 1702-93 Health Aspects in the Use of Thoriated Tungsten Electrode

Huntingdon Fusion Techniques Ltd has produced a wide range of supporting documentation on tungsten electrodes and grinding, much of which has been published internationally by independent journals. These are available on request from the company. (www.huntingdonfusion.com).
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