Safety issues related to hydrogen power generation technology

Hydrogen in power plants

The high thermal conductivity and lowest density properties of hydrogen make it an ideal cooling medium for high capacity turbine generators (TG). Due to the lowest gas density， it increases the efficiency of the turbine generator and reduces wind resistance losses compared to air-cooled turbine generators. Nearly 70% of the world's turbine generators above 60 MW are hydrogen cooled.

What are the challenges posed by hydrogen?

1. The physical properties of hydrogen

Hydrogen is a colorless， odorless， tasteless and highly flammable gas. Its presence can only be detected by gas sensors.

2. Flammability and explosive properties

Hydrogen is highly flammable and will automatically ignite when in contact with air at concentrations of 4% to 75%. Hydrogen that leaks into the air may spontaneously combust. Hydrogen fires are very hot and invisible and can therefore lead to serious accidental burns. Under optimal combustion conditions (hydrogen to air ratio of 29% by volume)， the energy required to start hydrogen combustion is much less than that required by other common fuels.

Hydrogen leaks into enclosed spaces and unventilated areas can quickly create a risk of explosion.

3. Typical causes of accidents

The causes of hydrogen-related accidents are similar to those of other combustible gas-related accidents. Human error， or neglecting to follow prescribed safe practices for gas handling operations， causes most accidents.

Hydrogen is a very small molecule with a low viscosity， which makes it easy to leak. Unless a dense form of metal is used， such as forged or killed steel， hydrogen gas， being the smallest molecule， can seep out of tanks and cylinders. Many metals become embrittle due to prolonged contact with hydrogen， leading to metal fatigue and failure. Therefore， inadequate consideration of equipment design can lead to failures and accidents.

How is hydrogen delivered to the TG?

1. Commercially sourced gas cylinders

This is by far one of the most common methods of hydrogen delivery to power plants，but it is fraught with challenges such as low hydrogen purity and the presence of moisture in the hydrogen， which in turn can lead to corrosion of the windings， thus reducing the life of the equipment. Another major challenge is cylinder availability， so power plants maintain a large inventory of hydrogen cylinders on site in case of any supply chain disruptions.

As reported on the U.S. Department of Energy's accident reporting website， many accidents related to accidental hydrogen releases have occurred due to improper filling connections or equipment failures (see attached photo of a hydrogen explosion at a U.S. power plant in 2008). The number of connections and disconnections of threaded joints increases the likelihood of hydrogen leaks and safety failures. According to international conventions， all fittings for flammable gases are reverse-threaded. Many hydrogen users were found to be using the wrong threaded cylinders， leading to catastrophic consequences.

2. On-site hydrogen generators

On-site hydrogen generation has continued to gain acceptance in power plants due to the challenges of obtaining hydrogen from outside suppliers. There are many technologies for on-site hydrogen generation， including hydrogen extraction from water and hydrogen extraction from hydrocarbons， such as methanol or natural gas.

Since the amount of hydrogen required for power plants is very small， water electrolysis hydrogen generators are preferred. Hydrogen production using electrolysis of water has become a preferred mode due to the relatively low cost of the equipment， its smaller size， and its relatively simple operation and maintenance.

Comparing the safety issues in various water electrolysis technologies

1. Monopole water electrolysis hydrogen generator