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EXPIRED

IAPWS Certified Research Need - ICRN

Decomposition of Ion Exchange Resins

The IAPWS Working Group Power Cycle Chemistry has examined the published work in the area of decomposition of ion exchange resins. Such information becomes increasingly important, as there is a trend that new power cycles will operate at higher temperatures. Resin decomposition products can lead to serious corrosion damage in the steam / water cycle.

IAPWS recognizes that there is a requirement for work to be pursued in this field and has prepared this document to assist potential investigators obtain sponsorship. Specifically, the mechanism of resin decomposition, as well as its influence factors should be clarified in order to specify improved manufacturing techniques, resin selection, condensate polisher design and operating conditions.

Although encouraging this work, IAPWS is not able under its statutes to provide financial support. The IAPWS contact can provide any further development information and will act as a liaison between research groups.

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Decomposition of Ion Exchange Resins

Background

Condensate polishing is one of the most important tools for purity control of the water/steam cycle. Ion exchange is the exclusive technology for the chemical polishing of condensates. By means of this technology it is possible to remove dissolved ionic contaminants ensuring safe and reliable operation without risk of corrosion damage. However, this technology has its limitations. Thermal stability of the ion exchange resins is one of the most inconvenient problems.

The temperature of condensates depends on the access to the cooling medium. The temperature of condensate from water-cooled condensers is usually between 5 and 50 °C. Air-cooled condensers give higher condensate temperature (40 – 80 °C). A cogeneration plant, in which the steam is condensed by district heating circulation water, may have an even higher condensate temperature.

Producers of ion exchange resins specify the operational temperature range up to 130 °C and 60 °C for cation and anion exchange resins respectively (1, 2). Even within these specifications, decomposition of resins has been observed. Most units operate the condensate polishers up to 50 °C, but some are forced to operate at higher temperatures, even up to 85 °C (3).

Thermal stability of anion exchange resin is generally the limiting factor for operation temperature of a condensate polishing plant. High temperature enhances the decomposition of the strong basic quaternary ammonium groups (active sites of anion exchange) to the tertiary amine. Operation at high temperature results in decrease of the capacity of the anion exchange resin.

According to the specifications, the thermal stability of a cation exchange resin should not be a problem at the operation temperature of the condensate polishing plant, limited by the thermal stability of anion exchange resin. This is not quite so. The decrease of the capacity of the cation exchange resin due to the operation temperature is not a significant problem. However, the relatively modest decomposition gives enough decomposition products to cause significant problems elsewhere. The decomposition may happen as a decomposition of the bone polystyrene matrix, resulting in styrene sulphonic acid derivatives (4), or as a substitution of the sulphonic group (active site of cation exchange), giving sulphate (5). Further decomposition of styrene sulphonic acid derivatives will also result in sulphate as one of the end products. The amount of sulphate produced is sometimes so high, that significant amounts may be locally deposited at critical places in the water/steam cycle. Turbine, reheater and high-pressure heater in fossil plants are particularly exposed areas (6). Several off-load corrosion damages have been linked to sulphate deposits in these places.

Research needed

Published information on the stability of the ion exchange resins mainly deal with anion resins (9-14). The mechanism of the degradation of quaternary ammonium salts and tertiary anions is reasonably enlightened and even kinetic data are available (12). Only few publications treat the problems of decomposition of cation exchange resins (7, 10, 15). The modest interest in cation exchange resins is due to relaxed specifications from the manufacturers. However, even small traces of decomposition products from cation exchange resin degradation have caused serious corrosion damage. This problem seems to escalate due to changes in operating conditions in general.

Broad introduction of oxygenated treatment has changed the chemical conditions for condensate polishing plants. At the same time the requirements to the purity of the water/steam cycle are more stringent. Furthermore, condensate polishing plants are more and more often operating at elevated temperatures because of restrictions on cooling water access. In several places air-cooled condensers are introduced.

There is need to enlighten the mechanism of the cation resin decomposition, both by straight desulphonation and by backbone decomposition. The investigation should comprise both reducing and oxygenated environment at pH 7 to 9.6 and resin properties (cross-linking, porosity). Furthermore, the role of iron oxides (corrosion products) as catalyst of these reactions should be considered.

The information on resin stability properties will give possibilities for improvements on resin manufacture, choice of resins, quality control of resins, design and operation of condensate polishing plants. All these activities focus on how to ensure the purity of water/steam cycle even at stressed conditions for polishing plant.

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