Transactions of the Korean Nuclear Society Autumn Meeting
Gyeongju, Korea, October 29-30, 2015

Preliminary Study for the Design of Mesh Region in Cold Trap

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1. Introduction

Sodium-cooled fast reactor (SFR) or liquid sodium test loop system need sodium purification system because it is essential to control the purity of liquid sodium for successful operation. Inadequate management on the sodium purity leads to problems such as plugging of pipes, corrosion of structural materials, insufficient cooling by sodium, etc. Cold trap is so far known as the most promising method to purify the liquid sodium in sodium test loop or SFR in case that most concerned impurities are oxygen and hydrogen, due to its simplicity in operation as well as efficient purification. The basic concept of the cold trap is to utilize the dependency of the solubility on temperature. Sodium oxide or sodium hydride can be crystallized inside the cold trap. It has been reported that mesh packed trap has higher efficiency than un-packed trap has. From this point of view, it is necessary to build up some strategies on the design of mesh region. It has been studies that trapping efficiency and capacity are dependent upon the configuration of mesh region. In this study, therefore, some parameters which affect characteristics of the wire mesh region are investigated.

2. Parameters

Fig. 1. shows a typical procedure of design of a cold trap. Once the total weight of the impurities is estimated, required volume of the wire mesh to trap the impurities can be calculated. Other than this, basic concept of mesh region design also can be considered because trapping efficiency or capacity largely depends on the design concept [1].

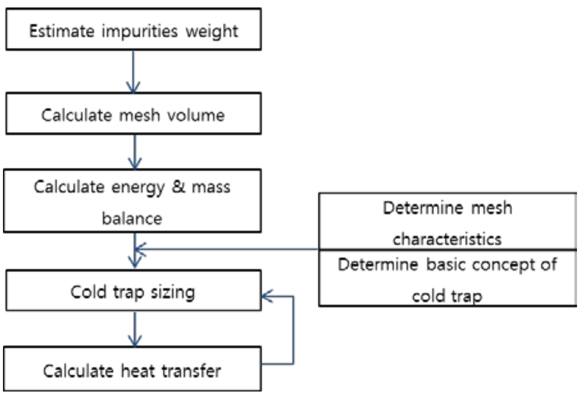

Fig. 1. Procedure of design of a cold trap.

2.1 Determination of required mesh volume

Total impurities which should be trapped throughout the repetitive cold trap operation are usually from raw sodium, structural materials of components, cover gas, maintenance, etc. Once total weight of the impurities is calculated, the required mesh volume can be determined. In case of oxygen and hydrogen, so-called 'capture rates', which are amount of the oxygen or hydrogen captured on the wire mesh per unit volume in forms of oxide(Na_2O) or hydride(NaH) have been reported to be 2.4~4.7 kg of H or 24~48kg of O, respectively [2].

2.2 Determination of mesh type and stacking method

There are several types of wire mesh as shown in Fig. 2. Parameters such as wire diameter, void fraction, pore diameter, and surface area to volume ratio differ from each type and they affect the trapping performance [3].

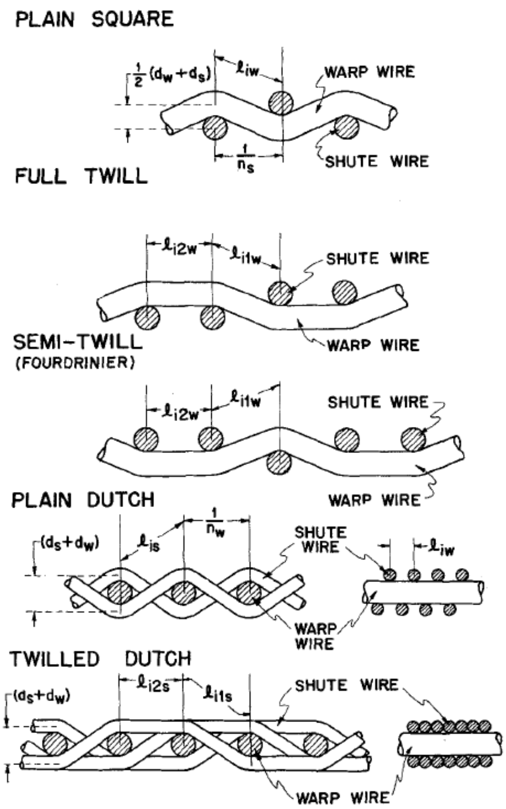

Fig. 2. Cross-sectional views of several types of wire mesh; plain weave and dutch weave types [4].

Besides the mesh type, stacking method of the wire mesh is important in terms of trapping performances. It has been studied that less than 400 kg/m^3 of the density of the wire mesh packing is recommended when 20 % trapping utilization is take into account[5].

2.3 Estimation of hydraulic characteristics

Pressure loss in wire mesh is based on the experimental results [4] :

$$\frac{dP}{dr} = \frac{b}{\sigma^2 d_h l_w}\left(\frac{8.61}{N_{Re}} + 0.52\right)\gamma V^2$$

P : pressure, Pa
r : radial length, m
b : wire mesh mean thickness, m
σ : mesh volume void fraction
d_h : mesh pore diameter, m
l_w : lattice length, m
N_{Re} : Reynolds number
γ : density of wire mesh packing, kg/m^3
V : velocity of sodium based on free volume, m/s

2.4 Investigation of microscopic phenomena: crystallization

As earlier mentioned, oxygen or hydrogen are trapped onto the wire mesh via crystallization in forms of sodium oxide or sodium hydride, respectively. Hence, the crystallization mechanisms also affect the wire mesh characteristics. It is reported that sodium oxide is mostly nucleated and grown onto the wire mesh, whereas sodium hydride is mostly deposited onto the cold wall. In case there is not enough wall space for the hydride to deposit, the deposition can occur onto the wire mesh instead. The difference comes from different crystallization kinetics for hydride and oxide each [6]. According to this different mechanism, the mesh allocation strategy be established.

3. Summary and Future Works

Trapping performance such as trapping efficiency and capacity can be highly dependent upon the configuration of mesh region. It is therefore important to understand phenomena inside the mesh region such as hydraulics and crystallization and to build up design strategy. This study categorizes the parameters which affect the trapping performances and will give insight to study mesh region characteristics, and eventually to design the mesh region for performance enhancement of cold trap.

Acknowledgment

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea Government (MSIP). (No. 2012M2A8A2025635)

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