Configurations of an intermediate loop for SMART-C oil sands application

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1. Introduction

SMART (System-integrated Modular Advanced ReacTor), an integral light water-cooled small modular reactor, developed by Korea Atomic Energy Research Institute (KAERI) obtained Standard Design Approval (SDA) in 2012 for the first time in the world.

SMART100, an advanced version of SMART, was also completely developed. It greatly enhances economic feasibility and safety by increasing thermal output by 10% and upgrading the partially passive safety system to the fully passive safety system. It is expected to acquire another SDA by 2024.

Recently, KAERI has signed a series of memorandum of understanding respectively with Government of Alberta and Atomic Energy of Canada Limited (AECL) and is strengthening international cooperation to deploy SMART in Canada. The main target in Canada is the oil sands plant in Alberta. For Canadian application of SMART, a compact and slim design, **SMART-C** was proposed. In order to apply SMART-C to the oil sands industry, a new intermediate loop [1] shall be constructed between the reactor and the oil sands facility.

In this paper, the current issue of oil sands plants is briefly touched, and then how this is resolved by SMART-C will be highlighted. The necessity and basic configuration of the intermediate loop will be presented. The results of this study will be utilized to promote SMART business in Canada.

2. The design of SMART-C

A compact and slim design, SMART-C was proposed in order to simplify the system and further strengthen the transportability in Canada. Here, C means a compact design and also Canadian customization. This shows that KAERI has the world-leading design capability of small modular reactor that provides customized design in accordance with user's requirements. In this modification, the diameter and weight of the reactor vessel is greatly reduced. The steam generator and safety systems configurations are also optimized. The comparisons with SMART, SMART100 and SMART-C is are shown in Figure 1.

3. The necessity of SMART-C for oil sands

Steam assisted gravity drainage or SAGD is a method that is widely used to extract bitumen from underground oil sands deposits. This method involves forcing steam into sub-surface oil sands deposits to heat the bitumen locked in the sand, allowing it to flow well enough to be extracted. SAGD process requires a high-temperature

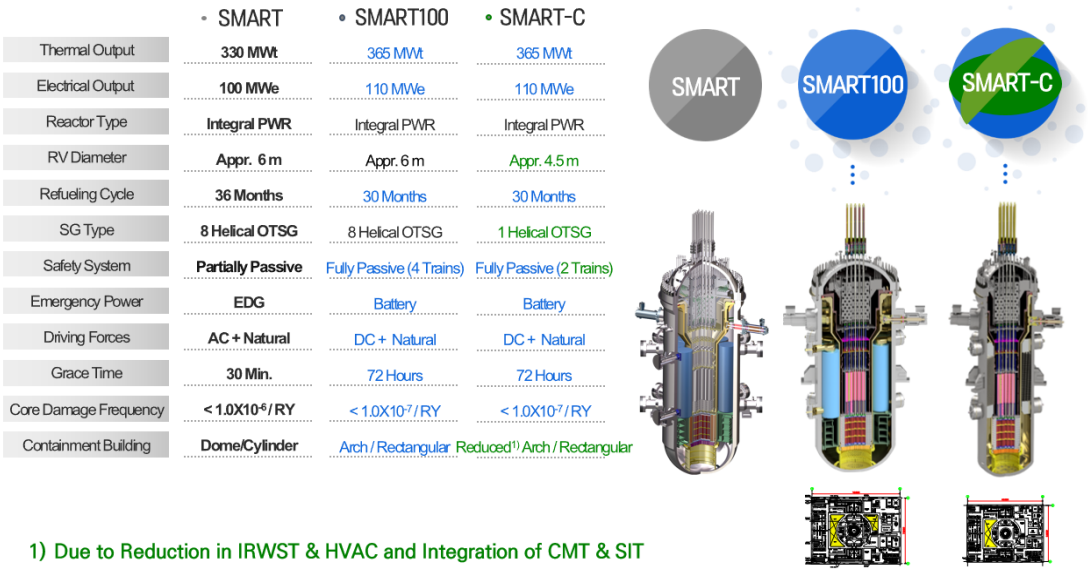

Fig. 1. The comparisons with SMART, SMART100 and SMART-C

and high-pressure steam supply, but currently, a gas boiler is used, causing a problem of emitting a huge amount of greenhouse gases (GHGs) [2]. Therefore, the Government of Alberta is seeking a method to reduce GHG in oil sands SAGD facilities. Figure 2 shows a typical SAGD process. If SMART is used to supply the necessary steam for oil sands SAGD process, it is expected that carbon emissions can be greatly reduced.

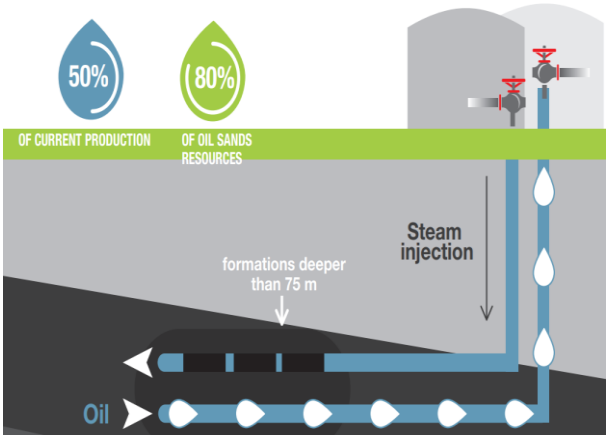

Fig. 2. The illustration of SAGD process in oil sands [3]

4. Configuration of an intermediate loop

According to HATCH [1], an intermediate loop is defined as a heat transport loop introduced between the SMR and the SAGD facility that is separate from the process steam (or heat transport fluid) being provided by the nuclear island. HATCH [1] mentioned that radiological protection is a greater concern in the production of SAGD steam compared to electricity generation because of the possibility that radioactive particles released into the injection steam could spread throughout a large area underground rather than just traverse an enclosed power generation loop. Figure 3 shows basic configuration of an intermediate loop for SMART-C application for SAGD facilities.

5. Conclusions

This study explained the design characteristics of SMART-C and why the introduction of an intermediate loop is necessary to apply SMART-C to oil sands plants, and suggested a basic configuration of an intermediate loop. In the future, when the oil sands end-user is determined and the applicable site of SMART-C is specified, a more detailed construction of an intermediate loop will be investigated. This study will be utilized in the future for the promotion of deployment of SMART-C in Canada.

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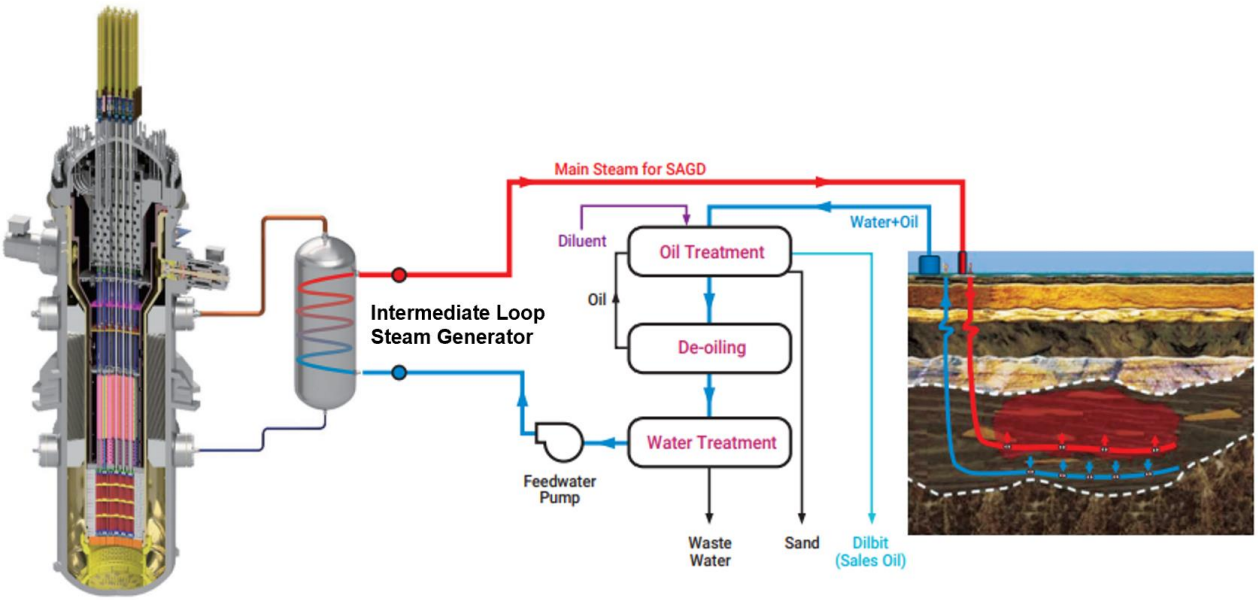

Fig. 3. Application of SMART-C with an intermediate loop