Analysis of Air Distribution at Molecular Sieve Vessel In RDE System Based On Fan Flow Rate Variation Using Aerosol Density Testing Facility

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Abstract. The Experimental Power Reactor uses the type of pebble bed fuel and helium gas as its primary coolant. Therefore, to maintain and maintain the quality of helium as a coolant in accordance with predetermined requirements helium purification system is designed. One part of the main component of this helium purification system facility that serves to absorb CO2 and CH4 is molecular sieve vessel. FASKERA is a test facility used to measure the density level of aerosols in a space in real time. To optimize the FASKERA’s performance, the characterize of its airflow rate distribution is needed. The purpose of this study is to know the airflow rate homogenous distribution in the FASKERA using fluent 6.3. The fan flow rate varied with speed 20 m/s and 25 m/s. Based on the simulation result of CFD that has been done, it can be concluded that the profile the airflow distribution within FASKERA by using a fan air flow rate of 20 m/s resulted in a more homogeneous air flow rate distribution compared to a fan air flow rate of 25 m/s, this is because the resulting drag force area is fewer and the spatial distribution area of the two airflows is evenly distributed in the chamber.

1. Introduction

Experimental Power Reactors use pebble bed reactor technology with very safe consideration, function for cogeneration, fuel flexibility, tested, competitive price, multipurpose, can be developed in all parts of Indonesia as needed, and to meet the needs of electricity supply. Based on the conceptual design that has been made, helium gas is used as a primary coolant and water is used as a secondary coolant. The primary coolant heat is transferred to the secondary cooling through the steam generator. The purity of helium in the primary cooler should always be kept to a certain extent so that the impact to the system, structure and components is minimal. To fulfill the desired helium purity requirement on a primary cooler, a helium refining system is required. This system should be designed to purify helium from solid and gas impurities. The buildup of graphite dust impurities will impact on the reduction of the heat recovery process. Gaseous impurities when carried in a coolant stream will trigger the carburization and decarburization of the material. Carburizing process will make the material more fragile [1] while decarburization process will decrease the carbon concentration in the material and prevent the formation of oxide layer on the surface so easy to corrosion process.
The main components used in the helium experimental refinery purification system are filters, CuO oxidation vessels, condensers, molecular sieve vessels and very low temperature activated carbon vessels. Based on the experience of operating the HTGR reactor in China (HTR-10) and Japan (HTTR) the principle of clearance of CO2, CH4 and H2O gas impurities is using molecular sieve [2]. Some research on cleaning of gas impurities using molecular sieve has been done by some researchers such as Myrilla et.al doing research to study the molecular dynamic behavior of Zeolite 4A to reduce CO2 impurities in natural gas at high pressure using Aspen Adsim software simulation [3]. Xiaojing et.al Performed experiments for molecular sieve characterization of several sizes to absorb hydrogen at pressures of 100 Pa, 200 Pa, and 0.2 MPa. The results show that molecular sieve 5A-2 can effectively absorb hydrogen rapidly [4].

Research on the measurement of aerosol density in the nuclear field is mostly done by previous researchers. Knebel et al. conducting aerosol characterization resulting from a simulated severe nuclear reactor accident at TMI-2 using an electron microscope [5]. F.G. Di Lemma et al. has conducted research to study the behavior of fission products in aerosols, a simulated aerosol released from nuclear fuel accidents is made with heated vapors using a laser. The results of aerosol characterization were then compared with evaporation process studies by Knudsen Effusion Mass Spectrometry and thermochemical equilibrium calculations [6]. Fenglei Niu et al. has simulated using fluent software to study aerosol filters MEMS (Micro Electro Mechanical Systems) that can filter and collect 1 to 3 micron aerosol particles without filter paper. The simulation results showed a significant reduction in flow resistance in filtering micron-sized aerosol particles [7]. Hannson et al. has undertaken the aerosol characteristics for risk assessment in the manufacture of nuclear fuel in nuclear industrial plants, methods performed using scanning electron microscopy and X-ray spectroscopy, aerosol sampling in the nuclear operator's respiratory zone is carried out at a nuclear fuel fabrication plant [8]. Alipchenkov et al. has developed a code model for predicting deposition and aerosol coagulation rates and knowing the behavior of aerosol fission products on the nuclear reactor core during severe accidents [9]. From the literature study, research on the method of measuring aerosol density in reactor containment at the time of nuclear accidents has been done but the monitoring process is not real time.

FASKERA is a test facility used to measure the rate of aerosol speed in a space in real time. To optimize the FASKERA’s performance, the characterize of its airflow rate distribution is needed. The purpose of this study is to know the airflow rate homogenous distribution in the FASKERA using fluent 6.3, Flow rate of fan in variation 20 m/s and 25 m/s.

2.Methodology
The FASKERA design is shown in Figure 1, the walls are made of acrylic with 8 ml thick, with a geometry of 30 cm long, 30 cm wide and 140 cm high. There are 2 fans mounted at the bottom and top of each flow rate can be set using regulator voltage. The height distance between the upper and lower wall cover with the fan is 20 cm. At the center mounted hose connector to insert the aerosol into the test facility, and on the wall FASKERA installed 48 LDR sensors connected with analog input pin arduino mega-2560.
In this simulation all exterior walls are designed to be closed and defined as wall, while the upper and lower fans are defined as velocity inlet. Process meshing model there are 2 stages of the meshing on the fan and the volume chamber. For meshing on the fan section use Elements = Quad, Type = Map and interval count with spacing 15. The total number of cells formed for each of the top and bottom fans is 225 cells elements as in Figure 2.
In the mesh the volume chamber space is divided into 3 spaces each of the lower, middle and upper parts. The method used in meshing space using Element = Hex / Wedge, Type = Cooper and interval size with spacing = 1. The total number of cells formed in the space below = 18000 cells, the center space = 22500 cells and the upper space = 18000 cells, as shown in Figure 3.

3. Results and Discussion
The type of aerosol to be used in a space density measurement experiment is starch flour, since the starch flour has a small density so that its distribution of distribution will follow the pattern of airflow. From the simulation results, we can see the distribution of air flow rate in the FASKERA test facility as shown in Figure 4. and Figure 5.

![Figure 4. Contour vector velocity with fan flow rate 25 m/s](image1)

![Figure 5. Contour vector velocity with fan flow rate 20 m/s](image2)
Figure 4 illustrates the incoming air distribution of the two lower and upper fans with the same flow rate of 25 m/s, on the walls of the test facility seen a lot of the phenomenon of drag force. Drag force is the force of the fluid that pushes an object in the direction of the fluid flow. Due to the emergence of drag force on some parts of the test facility wall, causing flow separation. Flow separation is a phenomenon when the fluid flow separates from the surface of the object after the flow following the surface contour of the object. The airflow velocity increases because of the encounter between the two airflows from the two fans. When the airflow hit the wall causing the flow of urgency in the enclosure of two airflow. In this area the airflow velocity increases due to the reduced effective flow area. Because of the many areas that experience drag force, causing the distribution of air velocity inside FASKERA to become non homogeneous, and the use of fan flow rate of 25 m/s less than optimal.

The profile of airflow distribution at a flow rate variation of 20 m/s is shown in Figure 5. From Figure 5 it can be seen that using a fan flow rate of 20 m/s, causing drag force to occur only in one area, so the area of flow separation caused by drag force is also small. The collision area of two airflows is seen occupying a lot of space, so the resulting air velocity distribution is more homogeneous than using a fan flow rate of 25 m/s.

4. Conclusion
Based on the simulation result of CFD that has been done, it can be concluded that the profile the airflow distribution within FASKERA by using a fan air flow rate of 20 m/s resulted in a more homogeneous air flow rate distribution compared to a fan air flow rate of 25 m/s, this is because the resulting drag force area is fewer and the spatial distribution area of the two airflows is evenly distributed in the chamber.

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