Feasibility Study on Automatic Monitoring System of NaP Zeolite Defect for Increase of Radionuclide Removal Efficiency

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1. Introduction

Zeolite has been widely studied as absorbents to remove radioactive nuclides such as Cs, Sr, Ba, Pb, U and other heavy elements because of its large specific surface area and absorption ability. Zeolite that exists in Korea is usually the clinoptilolite mineral series. Clinoptilolite has great Cs removal efficiency [1]; however, the clinoptilolite also has poor divalent cation removal efficiency, such as Sr and Ni [2]. In this reason, natural zeolite is synthesized to the other composition such as NaP zeolite, which shows higher removal efficiency especially for Sr and Ni. During the synthesis process of NaP zeolite, defects are produced, and it is essential to remove these defective products for increasing the absorption efficiency of the radioactive nuclide. In this study, a preliminary study on the real-time monitoring system of the defects is performed using deep learning technique for the massive production of the NaP zeolite. After preparing the NaP zeolite dataset, the machine learning is conducted, and the accuracy of the artificial neural network is estimated for verifying the possibility of the automatic monitoring system.

2. Method and Result

Figure 1 shows the conceptual classification system of the NaP zeolite defects. The NaP zeolite products moves on the conveyor belt, and a camera of the system detect the defects, automatically. The shape, size and color of the NaP zeolites and the defects are not uniform. Therefore, it is quite difficult to classify them using conventional methods. In this study, the deep learning technique is proposed and tested for checking the possibility of the defect monitoring.

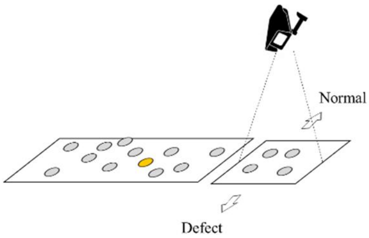

Figure 1. Conceptual Draw of Defect Classification System

2.1 Generation of Dataset

For testing the applicability of the deep learning technique, the NaP zeolites were produced. First, natural zeolites (10g) were hydrothermally treated with NaOH solutions (250mL, 3M) in HDPE (High density polyethylene) bottle. The bottle was sealed and put in the oven at 95°C for various reaction times. The modified zeolites were washed with deionized water until pH became neutral (~7), and then dried at 50°C for 12 hours.

After the synthesis of NaP zeolite, NaP zeolite dataset (images) was collected for both including and non-including the defects. The size of all zeolite particles has a wide distribution of 0.2 to 2cm. Sample images of NaP zeolite dataset are shown in **Figure 2**. The number of the normal and defected datasets are 550 and 550, respectively.

Figure 2. Sample Image of NaP Zeolite Dataset (Left: Defect Included, Right: Normal NaP Zeolite)

2.2 Machine Learning and Results

For classifying the defect images, the Inception-V3 structure [3] was used. Inception-V3 was developed by Google that the accuracy was ranked to top 3 in ILSVRC 2015. **Figure 3** shows the architecture of the Inception-V3 used in this study. The input image size was set to 256 x 256. The machine learning was conducted with the Adam optimizer, and the exponential decay (learning rate scheduler) was used with 0.005 initial learning rate and 0.9 learning rate decay factor. For the validation, training, validation and test datasets were set to 900, 100 and 100, respectively.

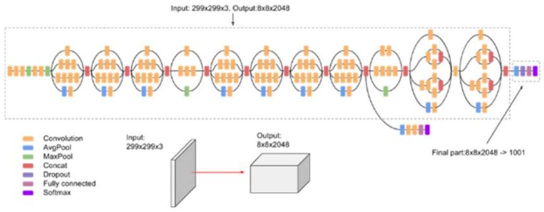

Figure 3. Overview of Inception-V3 Architecture

Figure 4 shows accuracy and loss of train data and validation data. The accuracy of train data reached at 1 only in 2 epoch, and accuracy of validation data was estimated to 0.98. Also, the losses of train data and validation data were gradually decreased. These results show that the deep learning can accurately classify the defects in NaP zeolite products.

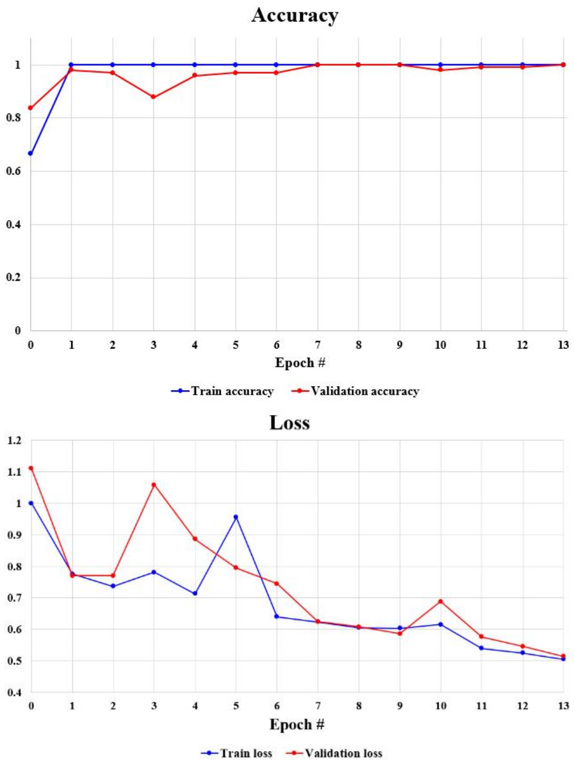

Figure 4. Accuracy and Loss of train data and validation data

3. Conclusion

In this study, the applicability of the deep learning technique into the defect monitoring system of NaP zeolite was tested. After collecting the dataset, Inspection-V3 was selected as the neural network architecture, and the machine learning was performed. The results of the accuracy with the test dataset, which were not used in the training, showed that the deep learning technique can be applied for the defect monitoring of the NaP zeolite with high accuracy.

ACKNOWLEDGEMENTS

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