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Investigation of Visualization Techniques for Failure Factors of Die Casting Machines using Neural Network

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Precision die casting is a technique for carrying out a high-precision casting that involves filling a mold with molten aluminum under high pressure. It is utilized in the production of automotive parts. Widely used to reduce cavities by increasing the fluidity of the molten metal and enhancing product quality is the "vacuum die casting method," which involves high-speed filling after depleting the chamber. The fact that the degree of vacuum when emptying the chamber does not fall below a set value, or "abnormal degree of vacuum," is one of the defects of the die casting system. Finding the cause of the failure took time because there are many factors connected to the irregularity. Even a skilled individual who was familiar with the apparatus found it challenging to determine the failure mode from the waveform of the degree of vacuum fluctuations. So, in this study, we attempted to apply a neural network to estimate the cause of failure for the transition waveform of the degree of vacuum during exhausting. Visualizing whatever portion of the waveform influences the estimation results when estimating the components were taken into consideration to increase the results' reliability. This study looks into how vacuum degree data behaves when there are anomalies brought on by "clogging of foreign matter in the hose", "damage to cast parts", and "adhesion of aluminum to cast parts". The vacuum degree data's behavior when "foreign matter in the hose is clogged" is depicted in Fig. 1. Every casting cycle, the degree of vacuum is checked at a particular point in the degree of vacuum waveform (Point of measurement in Fig. 1), and maintenance is carried out when a predetermined threshold is reached (Preservation in Fig.1).The local outlier factor (LOF) method was used to determine the anomalous and normal periods for each of the three variables during the same period (shown by the red and blue areas in Fig. 1, respectively). Then, anomalous and normal are defined as appropriate terms for the vacuum degree waveforms that are covered in this section. A model that categorizes anomalous and normal waveforms is developed using a convolutional neural network (CNN) for each factor. Both of these characteristics in the test data contributed to the validity rate reaching over 94%. The properties of the anomalous waveform of each factor were also examined to visualize how the vacuum waveform influences classification. The slope of the input data of the binary cross entropy error at each time point was used as an index to determine the degree of effect, and the slope of the normal and abnormal waveforms at the time of input was separately shown. The visualization of "abnormality due to foreign materials in the hose clogging" is shown in Figure 2. Each row displays the normal, abnormal, and influence level from top to bottom. Calculated from the anomalous data, the degree of influence approaches the abnormal waveform when the degree of vacuum diminishes when the degree of influence > 0 (blue area in Fig. 2). As the degree of vacuum rises, the waveform begins to resemble an irregular waveform when the degree of influence < 0 (red region in Fig. 2). Figure 2 shows that the absolute value of the degree of influence is high throughout the entire region when the degree of vacuum is low, and the classification is influenced by the waveform shape throughout a vast portion. Because the "clogging of foreign matter in the hose" is thought to always impair the exhaust performance during the die casting process, the aforementioned propensity can be qualitatively described. At specific moments during exhausting, abnormalities brought on by "the damage to the cast components" and "the adherence of aluminum to the cast parts" had a higher impact, and tended to differ from those brought on by "the clogging of foreign items in the hose”. This study demonstrates how the information on the waveform component that affects the classification of abnormal/normal waveforms can be used to estimate a failure cause.

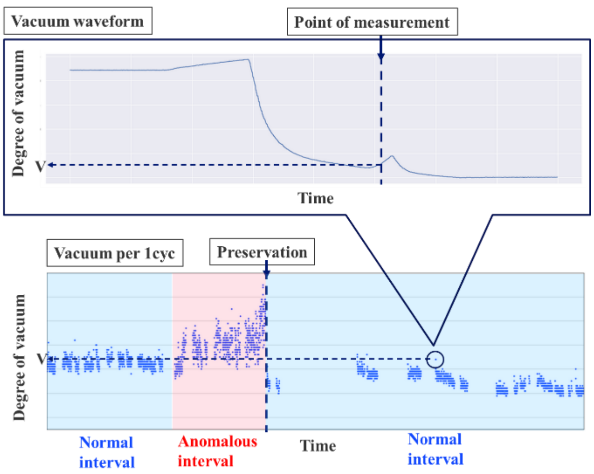

Fig.1 Relationship between degree of vacuum and vacuum waveform

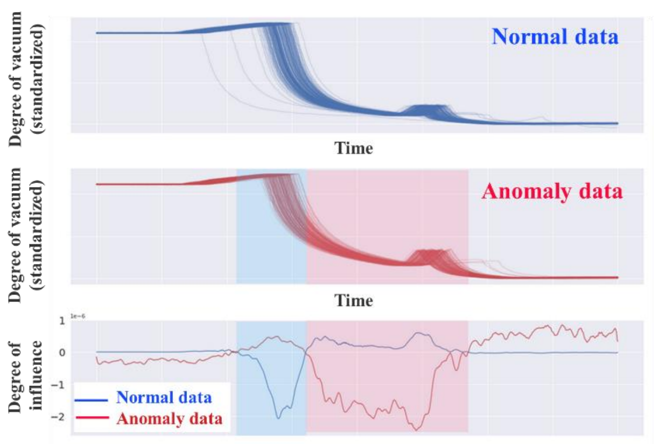

Fig.2 Degree of impact of hose clogging