Enclosure design of train of eating and generator on production PT. INKA Madiun using computational fluid dynamics

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Abstract. Trains are a means of transportation much in demand by the community because it is considered effective and efficient. The railway has several sections, one of which is the carriage and the power plant. In this study, train carriage and power plant with the loading of one railway carriage, designed to be quieter, with reference not exceeding the standard limit based on Kepmen LH Number 48 of 1996. Design used by altering the enclosure insulation in the generator chamber. In the existing condition, the train carriage has not met the standard at station noise. This study obtained the noise insulation results from enclosure design on railway carriages and generators made with various variations, so obtained enclosure with 25% grill ratio and ventilation on the floor, that is with the value of sound pressure level at a distance of 6 meters of 65.77 and 65.56 dBA.

1. Introduction
Trains generally consisted of locomotives and several carriages to transport passengers and goods in bulk either between cities, provinces and interstate. This means of transportation was much in demand by society because it was considered effective and efficient. However, in addition to having a positive impact, the railway also gave a negative impact that causes noise to the environment, both internal and external environment of the train. Some sources of rail noise include noise from wheel and rail area, generator system on railway carriage, other than noise from inverter, compressor and noise from AC system (air conditioner) [1].

The railway has several parts, one of them on the carriage section of the carriage. The generator train was part of a series of trains that had the function of supplying electrical energy into the circuit, in which there was a generator to supply electricity during travel, usually placed at the end of the circuit. The carriage included a noise source inside the railway circuit. According to Regulation of the Minister of Transportation No. 15 of 2011, that the generator train must have a maximum noise test result of 85 dBA on 6 meters [2]. Noise caused by generating machinery would affect the hearing health of both passengers and operators on duty on the carriage. One of the most effective and widely used forms of noise reduction today is the passive noise control which can be achieved with the use of an acoustic barrier, such as an enclosure [3].

From the previous research, an optimal acoustic enclosure was developed for portable generators using passive noise control techniques. In an effort to develop a commercially attractive enclosure to reduce the noise was emitted from the generator, this investigation would determine the correct design method intended to optimize the enclosure performance for the generator [4]. Based on information about the generator train which was the largest noise source in the railway circuit, therefore it was necessary to conduct research on the design of the power plant with the enclosure at PT. INKA Madiun which was then analyzed using CFD (Computational Fluid Dynamic) whose goal was to reduce the noise level generated by the carriage, so it does not negatively affect the health of passengers and operators.
2. Methods
This paper described an objective measurement and a computer simulation method using acoustics diffusion equation. Acoustics data of the existing room was needing to ensure the validity of the simulation model.

2.1. Measurement
2.2. The acoustical condition of train of eating and generator in PT. INKA was measured. The train had dimension with a length of 20 m, width of 2.9 m and height of 3.63 m. Noise object was a generator train with loading of one railway carriage, had dimension with a length 3.6 m, width 1.6 m and height 2.1 m. The first thing to do was to collect the generator data, to know the characteristics of the noise source with the measuring point of the noise. Data was 1 meter away from the generator and it was at 2 points (Fig. 1). Two sensors of SLM DEKKO Model: SL-130, were used to get a noise value.

![Figure 1. Point of Measurement Noise Generator](image1)

Method of measurement refers to the method described in ISO 3381-2005 Railway Applications – Acoustics – Measurement of Noise Inside Railbound Vehicles, which in principles of the source and microphones. Microphone were positioned inside train, in the dining room there are 10 points of measurement with the height of the sensor at each point of 1.2 (sitting position, point 1) and 1.6 meters (standing position, point 2) (Fig. 2).

The second method of noise measurement were described in Ministry of Transport Regulation No. 15 of 2011, noise data measurements were measured on the outside of the carriages within 6 meters of the carriage.

![Figure 2. Point of Measurement Inside Railbound Vehicles](image2)

Next experiment, method of measurement refers to the method described in ASTM:E1332(10), "Determination of Outdoor-Indoor Transmission Class" to know ability of insulation of generator chamber. Microphone are positioned at 8 position (Fig. 3), inside and outside generator chamber, and outside train.
2.3. Simulation Design
There were several simulation steps by using CFD analysis, drawing geometry, determining the boundary, determining the material, determining the variation on the enclosure, determining the boundary condition, meshing, then plotting the simulation result used in analyzing the simulation (see Figure 4). When the simulation results were similar to the data retrieval results, it was redesigned at the enclosure to reduce the pressure level. Firstly, we drew the geometry to representation shape of train simulation. On the drawing geometry, obtained 2 variation on the simulation. First simulation was figured enclosure (generator chamber, shown in Fig. 5) with a 75% grill horizontal and second simulation was figured enclosure with a 25% grill and ventilation under the floor. Meaning of 75% and 25% grill was comparison between grill and outside of wall generator chamber (Fig. 6). The constituent material on partition C was used in arranging the walls, roof and floor in the enclosure, while the B partition was still used to arrange the B partitions in the enclosure.

### Table 1. The Partition of The Generator Chamber

| Partition   | Material and Size                  |
|-------------|------------------------------------|
| Partition B | *Aluminium perforated 2mm*        |
|             | Rockwool 50 mm                     |
|             | Air Space 50 mm                    |
|             | Rockwool 50 mm                     |
|             | SS400 3 2mm                        |
| Partition C | *Aluminium perforated 2mm*        |
|             | Rockwool 50 mm                     |
|             | Air Space 50 mm                    |
|             | Rockwool 50 mm                     |
|             | SS400 3 2mm                        |
3. Result

3.1. Result of Measurement
The measurement results obtained the characteristic of noise generator, the noise characteristic in the train interior and the transmission loss of enclosure.

3.1.1. The characteristic of noise generator. The measurement at the generator site at two measurement points obtained a spectrum of noise at the generator. As shown in Fig. 7, the higher spectrum amplitude occurs from 630 - 8000 Hz, therefore it consequently most of the noise are high frequency. This may also imply that the noise is in high frequency range. Hence, acoustical insulation was necessary.

3.1.2. Result measurement of noise inside train. Based on ISO 3381-2005 Railway Applications – Acoustics – Measurement of Noise Inside Railbound Vehicles, the sound contour map is shown in Fig. 8 by placing the microphone 1.2m above the floor to simulate the height of normal passenger sitting whilst the Fig. 9 shows the sound contour of people standing 1.6m. These two figures suggest that the sound pressure level at the far end from the generator was lower about 10 dB than that of close to the Generator. However, the loudness level was more acceptable to the passengers at the far end.
Ministry of Transport Regulation No. 15 of 2011, data on the measurement of noise at a distance of 6 meters was obtained TTB (all) value of 74.9 dBA with loading of one railway carriage.

3.1.3. Result measurement transmission loss of enclosure. In the first data acquisition area obtained average transmission loss value of 8.2 dBA. While on the second area of data acquisition obtained average transmission loss value of 12.1 dBA. While on the third area data retrieval obtained the average transmission loss of 18.6 dBA.

3.2. Result of Simulation
On the result of simulation, obtained simulation with CFD analysis. After designed existing condition of train (Fig. 4), obtained result of simulation body train and enclosure with a grill 75% horizontal (Fig. 10 and 11), and with a 25% grill and ventilation under the floor (Fig. 12 and 13).
In Figure 10 and 11, we obtained the sound pressure level at a distance of 6 meters was 71.81 dBA, whilst in Figure 12 and 13, the sound pressure level at 6 meters was 65.88 dBA, respectively. The loudness level predictions were close to the measurement.

4. Conclusion
Simulation of several enclosure variations in a body train has been conducted. When compared between result of measurement and simulation that show variation of enclosure, simulation can lower sound pressure level value by 4.2% – 12.2%. the biggest noise reduction occurs on enclosure with 25% grill and ventilation under the floor, because it can reduce noise from the source due to the noise into the environment only through 25% of the hole from the wall enclosure and ventilation on the floor.

References
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