Investigation and adjustment of damping of Balinese Gamelan with various resonators and damping layers

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Abstract: Gamelan is part of Balinese culture. As a musical instrument, it plays an important role in Balinese daily ritual and ceremony. Balinese Gamelan is very popular, famous and has been exported to many countries worldwide. However, despite its popularity, Balinese gamelan has a classical problem that is out of tune-pitches due to bronze bar crack and change in resonator characteristics. This problem gets worse for gamelans that have been exported abroad with extreme weather change. In this research, the potential of synthetic resonators has been investigated and a special treatment has been applied to obtain a similar damping to that of bamboo resonator. The objective of this research is to investigate the feasibility of synthetic resonators as alternative materials for Bamboo resonators currently used. As we know, bamboo is an organic material that is easily destroyed by wood or bamboo eating insects. In this research, two steps of investigations were carried out. First investigation: The sound of gamelan with original bamboo resonators were measured for each bar. Then bamboo resonators were replaced with PVC and Acrylic resonators and the resulted sounds were measured. The damping of sound for each bar for three different resonators was compared. In general, bamboo resonators have higher damping compared with that of synthetic resonators. Second Investigation: The low damping of synthetic resonator is then modified further by adding a small amount of damping layer inside the synthetic resonators. Damping materials used to increase the damping are: acoustics wool, Dacron and carpet. The results of this investigation showed the potential of synthetic resonator as an alternative material to replace bamboo resonator, and it is also observed that by adding a small amount of damping layer on the top-end of synthetic resonators will easily meet the damping value of bamboo resonators. This investigation also gave guidance how to apply damping layer effectively and efficiently in term of area ratio and location.
Keywords: *Balinese Gamelan, damping, bamboo resonator, synthetic resonator, damping layer*

1. Introduction

As one of Indonesian heritage, traditional music instrument i.e. gamelan has been recognized worldwide. Balinese gamelans spread and they are easily found in many countries since it has become a commercial product just like other modern musical instruments. However, despite its popularity, Balinese gamelan has a classical problem that is out of tune-pitches due to bronze bar crack and change in resonator characteristics. This problem gets worse for gamelans that have been exported abroad with extreme weather change. Some works have been addressed to overcome this problem, especially the problem related to the cracks of the bars [1,2,3]. Previously, an additional work also has been reported related to the unique standard of Balinese Gamelan [4]. In this research, the potential of synthetic resonators has been investigated and a special treatment has been applied to obtain a similar damping to that of bamboo resonator. The objective of this research is to investigate the feasibility of synthetic resonators as alternative materials for Bamboo resonators currently used. As we know, bamboo is an organic material that is easily destroyed by wood or bamboo eating insects and normally has a short time of service.

2. Research Methodology

In this research, two steps of investigations were carried out.

2.1. Damping Investigation

First, the sound damping of gamelan is measured for both original (bamboo) and synthetic resonators. Two types of materials for synthetic resonators were investigated which are PVC and Acrylic Resonator. The original and synthetic resonator used in this study is shown in Figure 1. In this investigation special care is needed when measuring and tuning the resonators fundamental frequency. The damping is calculated from the decay of the waveforms previously measured. The damping using two synthetic resonators are then compared relative to that of bamboo resonator.

Figure 1. Type of resonators

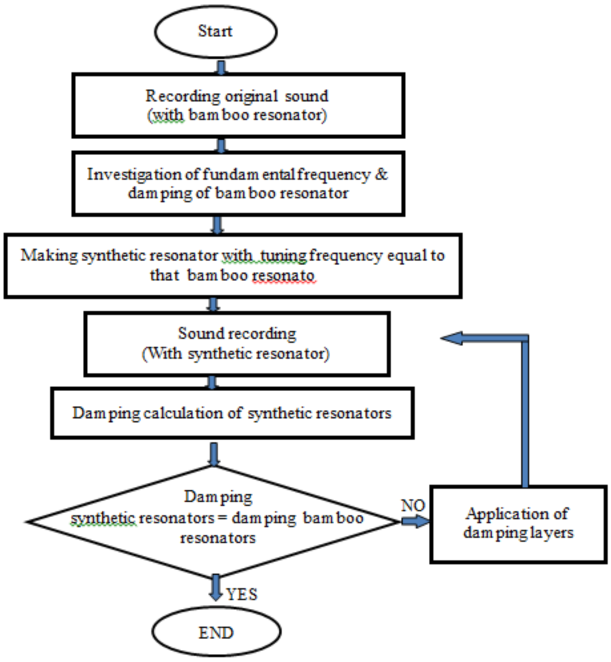

Figure 2. Investigation process

2.2. Damping Modification

Based on the damping value obtained in the previous step, modification is carried out by adding damping layer inside the synthetic resonators to achieve damping value which is close to that of original bamboo resonators. Three type of damping layers are applied: acoustics wool, Dacron and carpet with thickness of 1 cm. The application of these damping layers is carried out by trial and error basis. First trial was carried out by putting the damping layer on the top-end of the resonator, along the perimeter of the resonator. Then the position of damping layer is moved to the middle of the tube. The widths (area ratios) of damping layers are also varied. The complete process of investigation and the lay out of the experiments are depicted in Figure 2 and 3, respectively.

Notes:

1. Hammer
2. Sound recorder
3. Micropohone
4. Gamelan (bar and resonator)

Figure 3. Experimental set up

3. Results and discussions

In this research, out of 10 bars available, 2 bars were selected and investigated further which are bar #3 (small) and bar #10 (big). Table 1 below shows the original bar and bamboo resonators data, as references.

Table 1. Fundamental Frequencies (references)

Bars-Resonators	Fundamental Frequency [Hz]
Bar #3	820
Bar #10	294,5
Bamboo #3	786
Bamboo #10	295

Meanwhile, Figure 4 shows a typical sound waveforms with original bamboo resonator.

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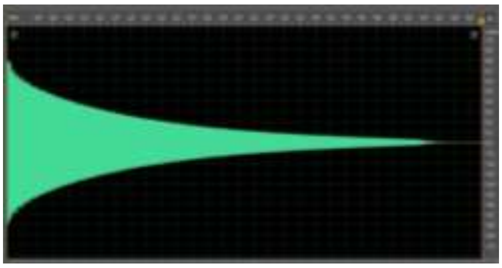

Figure 4. Waveform with bamboo resonator

Damping values for bamboo, PVC and Acrylic resonators for Bar #3 and Bar #10 are shown in Figure 5 and 6, respectively It can be clearly noticed that bamboo resonator give higher damping compared with PVC and Acrylic resonators. For Bar #10, damping of bamboo resonators is almost twice higher relative to the damping of the synthetic resonators.

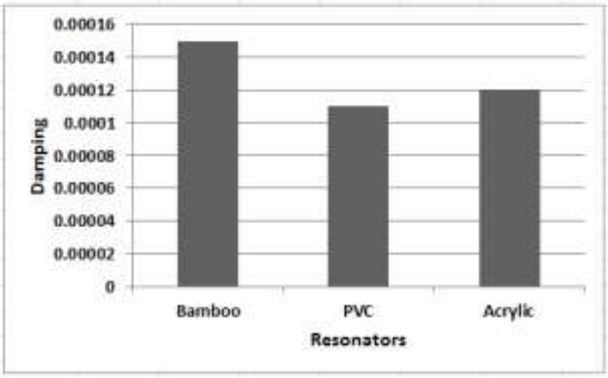

Figure 5. Damping for different resonators (bar #3)

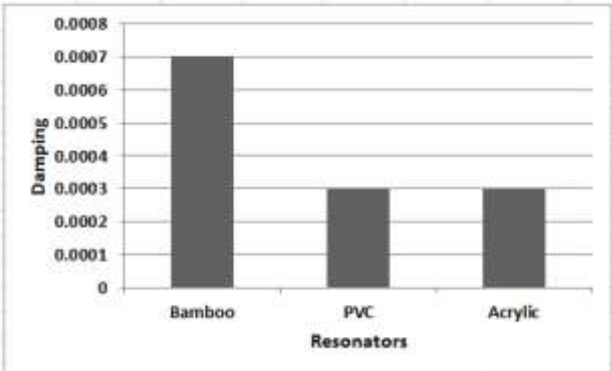

Figure 6. Damping for different resonators (bar #10)

Based on the fact of damping values in Figure 5 and 6, a trial and error process is carried out to modify damping of synthetic resonators by adding damping layer inside the resonator. Figure 7 shows the changes of damping values for acrylic resonator with acoustics wool damping layer as function of area ratio, for bar #3. The damping layer was applied on the top-end of the tube (resonator).

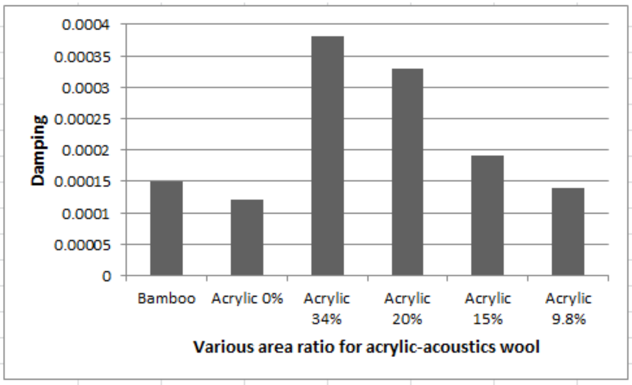

Figure 7. Damping improvement (bar #3)

It is observed that adding 9.8% of damping layer inside the acrylic resonator will approach the damping value of the original bamboo resonator. The same process was carried out for bar #10 and the result is depicted in Figure 8. For bar #10, adding 5% acoustics wool damping layer will improve the damping value close to bamboo resonator value.

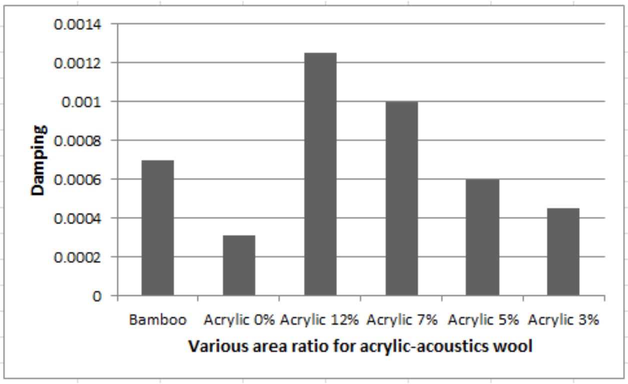

Figure 8. Damping improvement (bar #10)

The damping of acrylic resonator with acoustics wool damping layer (area ratio of 9.8%) as function of damping layer position is shown in Table 2. The results in Table 2 give guidance that the best position to apply damping layer is on the top-end of the tube.

Table 2. Damping as function of position (bar #3)

Area ratios	Position of Damping layer	Damping
9.8%	Along the top-end perimeter	0.00014 (close to that of bamboo resonator)
9.8%	At 1/3 height of resonator (from top), along perimeter	0,00011
9.8%	At 1/3 height of resonator (from bottom), along perimeter	0,0001

Tabel 3 lists the damping of Acrylic resonator and different damping layers for bar #3.

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Table 3. Damping comparisons for bar #3

Resonators	Condition, size and position of damping layers	Dampings
Bamboo3	*Original*	0.00015
Acrylic3	Without damping layer	0.00012
Acrylic3	Acoustics wool (width 1 cm) along the top-end perimeter of the resonator *	0.00014
Acrylic3	Dacron wool (width 1 cm) along the top-end perimeter of the resonator*	0,00014
Acrylic3	Carpet wool (width 1 cm) along the top-end perimeter of the resonator*	0,00011

*corresponds to area ratio of 9.8%

Meanwhile, Table 4 shows the damping for bar #10 using acrylic resonator and different damping layers.

Table 4. Damping comparisons for bar #10

Resonators	Condition, size and position of damping layers	Dampings
Bamboo10	*Original*	0,0007
Acrylic10	Without damping layer	0,00031
Acrylic10	Acoustics wool (width 1.5 cm) along the top-end perimeter of the resonator *	0,0006
Acrylic10	Dacron (width 1.5 cm) along the top-end perimeter of the resonator *	0,0006
Acrylic10	Carpet (width 1.5 cm) along the top-end perimeter of the resonator *	0,0006

* corresponds to area ratio of 5%

Both Tabel 4 and 5 inform that using either acoustics wool, Dacron or carpet will gave almost the same improvement on the value of damping. It seems that in this case, the resulted damping is not too sensitive to the material of damping layers.

4. Conclusions

The results of this investigation showed the potential of synthetic resonator as an alternative material to replace bamboo resonator, and it is also observed that by adding a small amount of damping layer, in this study 5 to 9.8% on the top-end of synthetic resonators will easily meet the damping value of bamboo resonators. This investigation also gave guidance that the best place to apply the damping layer is on the top-end of the resonators.

5. References

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