The Inflatable Roof Stage Structure with Independent Photovoltaic Energy

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ABSTRACT

The Applied Research of inflatable roof stage structure using Tarpaulin PVC coated fabric. This facility can be built, dismantled and moved to other locations easily, safely, quickly and lightly with an independent energy source (photovoltaic solar energy system). The aim of the research is to develop a stage rooftop facility as a means of exhibiting SME products that meet the aesthetic, strength, speed, effectiveness, comfort and use of independent energy. The research method uses the Experimentation and Action Research Method, beginning with the design, manufacture and testing of the pneumatic inflatable Energy Self-contained stage roof, including: (1) speed test in the manufacture, transportation, assembly, installation, dismantling of the roof of pneumatic inflatable structures and solar energy modules , (2) material strength test (3) thermal comfort test under the inflatable structure roof stage, (4) effectiveness test of the use of solar photovoltaic energy to drive the blowers of the inflatable stage roof. Material testing conducted at the Textile Laboratory of the Islamic University of Indonesia (UII), University of Merdeka Malang Science Lab and Field Tests in the City and Regency of Malang, has proven to provide reliable and satisfying results, including: a) the speed of installation and dismantling installation (6 minute stage roof, solar panel installation 15 minutes), b) the air pressure needed is only 0.9 psi to erect an inflatable roof, c) the tensile strength of PVC tarpaulin material reaches 55,619 kg / cm, d) 4 solar panels each with a capacity of 100 wp with storage energy in the form of a 100 AH 12 V battery and 1000 WH converter in sunny conditions produces a minimum of 13.6 Amp, 18.8 V can meet the energy requirements to drive blowers and stage sound blowers, and f) comfort under the inflatable roof temperature a maximum of 35 degrees Celsius. The practical and quick-wake stage of the independent energy inflatable stage is expected to be a prototype stage facility for the SME Exhibition on a national scale.

Keywords: stage roof, inflatable, solar energy, exhibition.

1. INTRODUCTION

Small and Medium Enterprises (SMEs) have a very important role in national economic development. That is because in addition to having a role in the growth and absorption of labor, it also plays a role in the distribution of development results. Small companies can absorb 51% of the national workforce (Manurung, 2006). In terms of

marketing, the SME product exhibition is an effective marketing method for creative economy SMEs that needs to be supported by the role of Higher Education (Budiyanto, Hery & Rofieq, Mochammad. 2018). One of the most important parts of the UKM product exhibition is the entertainment stage which attracts visitors to come and be in the exhibition area. This research focuses on the design and manufacture of an inflatable roof stage structure with independent energy as a means of exhibiting SME products, using tarpaulin fabric coated with PVC so that it is lighter and more concise and quick to install and dismantle.

There are 4 main aspects that become a problem in this study, namely: 1) Design and manufacture of the inflatable roof stage structure with independent energy; 2) Speed and effectiveness in the process of transporting, assembling, installing and dismantling the inflatable roof stage structure with independent energy; 3) The level of thermal comfort under the inflatable roof stage structure; 4) The efficiency of solar photovoltaic energy in providing energy for the inflatable roof stage structure.

The research was carried out in the Material Laboratory and in the field. The testing of membrane material in the form of pararsit PVC tarpaulin fabric strength testing was carried out at the Textile Laboratory of the Islamic University of Indonesia Yogyakarta, while testing the use of the inflatable stage roof was carried out in several places, namely: 1) Handicraft Parade in Skodam Yard Malang City (July 2019); 2) The Stage of Closing Student Community Service Program and the Stage of Movement to Build a Village in Kampung Bunga Grangsil, Jambangan Village, Dampit, Malang Regency (August 2019); 3) Stage of Anti-Narcotics Movement at National Institute of Technology Malang City (September 2019)

Figure 1: Handicraft Parade, July 2019

Figure 2: Student Community Service Program, August 2019

Figure 3: Anti-Narcotics Movement at National Institute of Technology, September 2019

II. LITERATURE REVIEW

2.1. Inflatable Pneumatic Structure

Pneumatic membrane structure is a soft shell structure system, where the structure can stand due to the difference in air pressure inside the pneumatic structure with the air pressure outside the structure (Sukawi, 2011). The pneumatic structure is divided into 2 major groups namely air supported structure and air inflated structure (Schodek, 1980). a) air supported structure is called a single membrane structure because it only requires one layer of membrane and requires low air pressure (about 2-20 pounds per feet above atmospheric pressure). b) air inflated structure (figure 5) is also called a double membrane structure.

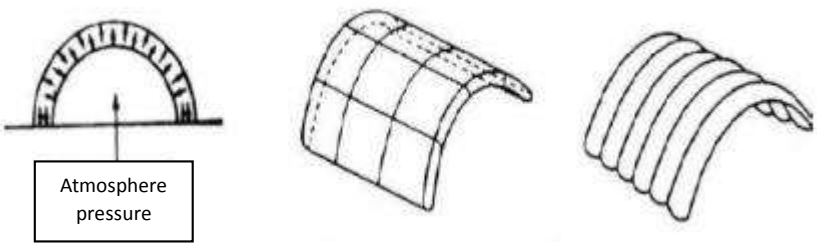

Figure 4: Air Inflated Pneumatic Structures

(Source: Schodek, 1980)

Air-inflated fabric structures are included in the category of tensioned structures and have unique advantages over their use compared to traditional structures. These advantages include a lightweight design, fast and easy to install, fast transport and small packing volume. Most of the research and development of inflated structures are carried out in aerospace, military, commercial, marine and recreational functions, for example: airship, weather balloon, inflatable antenna and radom, temporary shelter, inflatable boat, emergency bridge, and automotive airbags (Avallone, 2006).

2.2 Photovoltaic Solar Energy System

The main components of a Photovoltaic Solar Energy System are photovoltaic cells that convert solar radiation into direct conversion captured by Solar Array, which requires Balance of System (BOS) to include charge controllers and inverters, battery storage units and other supporting equipment (Widayana, 2012). This energy system will support the electricity needs of the blower as an air source on the pneumatic structure of the air inflated roof stage.

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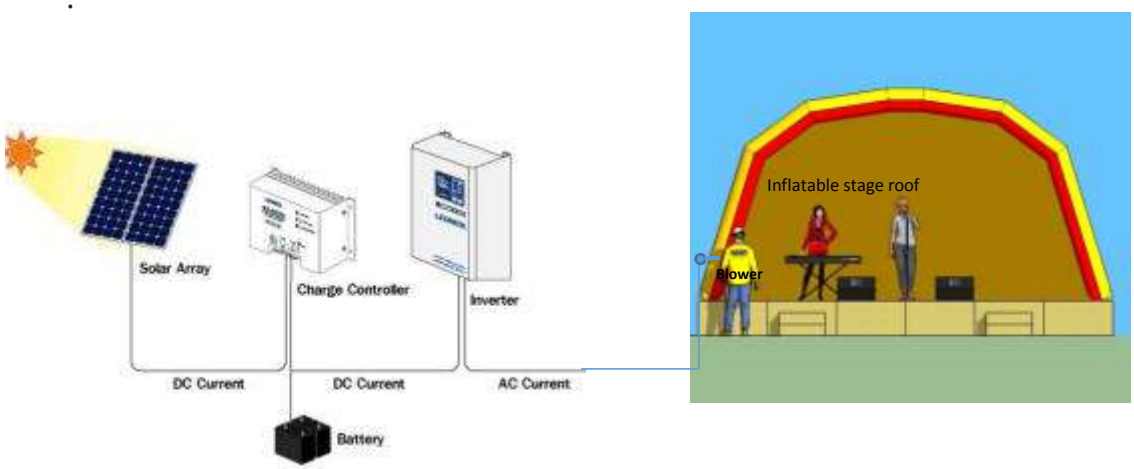

Figure 5: Schematic Design of Portable Stage Prototype and Inflatable Stage Roof

III. RESEARCH METHODS

This study uses experimental methods and action research in the form of making prototypes, conducting laboratory trials and field trials on various variables (Chassagnoux, Alain, et.al. 2002.). In this study various tests were carried out, namely: a) inflatable membrane material, c) pressure testing in inflatable membrane tubes, d) thermal comfort test under the roof of the inflatable stage, e). material testing and f) the effectiveness of solar photovoltaic power supply systems.

Variables in this study are: a) The speed of the process of making, assembling, installing, dismantling, b) Efficiency of Systems and Structural Components, c) Air pressure in the inflatable membrane tube, d) The thermal condition of the building, e) Strength of membrane material, f) Photovoltaic Solar Energy.

Tensile and stretch strength test and water permeability test are carried out in the Textiles Laboratory in Islamic University of Indonesia Yogyakarta use tenso laboratory tools. This tool can determine the maximum tensile strength of tarpaulin-PVC cloth and parasitic cloth. In addition, water permeability was tested.

Figure 6: Tensile Strength and Translucent Strength Test Equipment

IV. RESEARCH RESULT

1. Making a portable stage

The stage is made from 18 mm multiplex material, designed to be portable mounted. Consisting of 30 modules, each measuring 120x120x60 cm.

Figure 7: Making a Portable Stage (2 weeks)

2. Portable stage assembly

Figure 8: Portable stage assembly (50 minutes)

3. Manufacture and assembly of the inflatable stage roof

The order of manufacture is as follows: a) preparation of PVC tarpaulin fabric, b) cutting, c, dipping, d) inflatable tube assembly, e) roofing installation.

Figure 9: Making Inflatable Stage Roof Prototypes (2 weeks)

4. Installation of the inflatable stage roof

Figure 10: Installation of Inflatable Stage Roof Prototypes (6 minutes)

5. Installation of Portable Bracket and Photovoltaic Energy Solar Panels

Figure 11: Installation of Portable Bracket and Solar Photovoltaic Energy Panels (20 min)

6. Utilization of Portable Stage Prototypes and Inflatable Stage Roofs

Portable Stage and Inflatable Stage Roof have been designed and utilized in activities: Handicraft Parade (July 2019 - Figure 1); Closing of Student Service Community Service (August 2019 - Figure 2; Village Building Movement (August 2019 - Figure 3); ITN Anti-Narcotics Movement (September 2019 - Figure 3).

7. Test the air pressure in the inflatable membrane tube

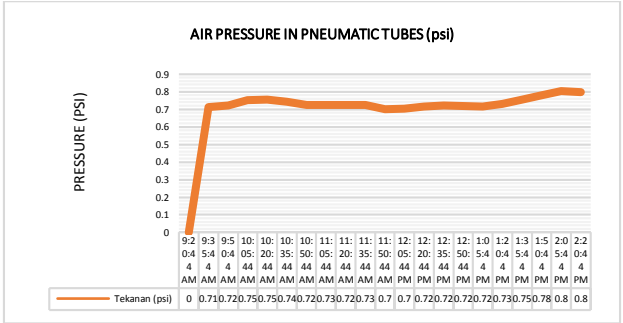

Figure 12: Pressure Graph in a Inflatable Stage Roof Membrane Tube

The minimum air pressure required for the erection of the inflatable membrane tube is 0.7 psi, this pressure is achieved within 6 minutes of the initial markup.

8. Thermal conditions inside and outside of the inflatable stage roof

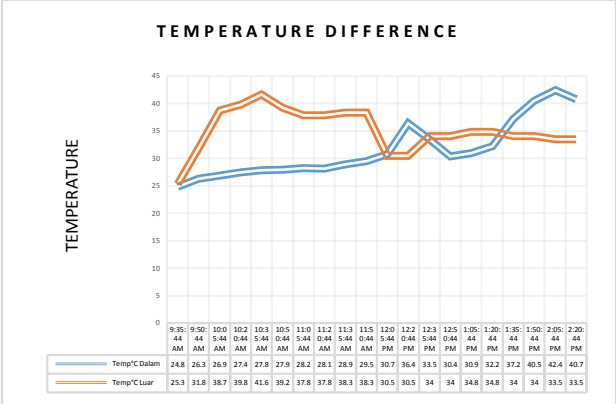

Figure 13: Graph of Thermal Conditions in and Outside of the Inflatable Stage Roof

In the morning of 09.05 am to 12.05 am the temperature of the air inside the stage is lower than outside the stage. There are differences in air temperature inside and outside the stage between -4.9ºC to 13.8ºC.

9. Strength and elongation of the inflatable tube roof membrane stage

Testing the strength of the inflatable membrane roofing stage is carried out in the Lab. Yogyakarta Indonesian Islamic University Textile with the following results:

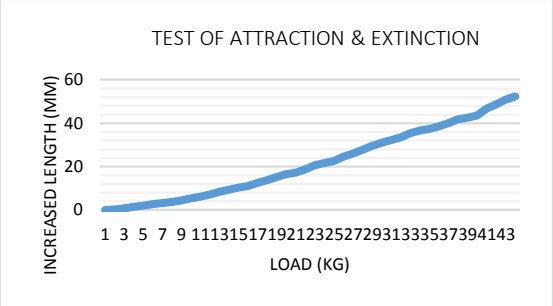

Figure 14: Load Test Graph of PVC Tarpaulin Fabric

Maximum strength of 0.5 mm thick PVC coated tarpaulin fabric membrane is achieved at a load of 55,619 kg, elongation value of 21,453% for a surface width of 1 cm.

10. Photovoltaic solar energy testing

The results of testing of each solar panel 100 wp are as follows:

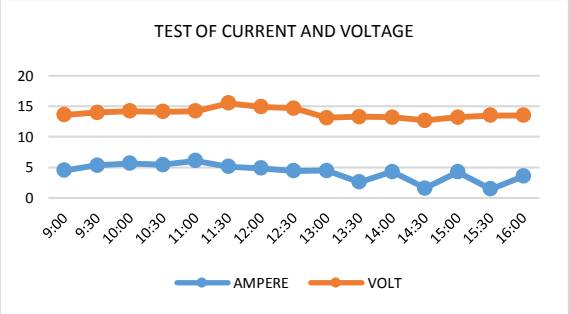

Figure 15: Solar Panel Current and Voltage Graph

In sunny weather, a 100 WP solar panel can produce an average of 4.2 Ampere 13.8 Volts, whereas when the weather is cloudy the current drops to 1.4 Amper 6.07 Volts. The electrical energy stored in the battery can already be used to drive a blower with a power of 550 Watt, 220 Volt voltage, this blower works to blow the roof of the inflatable stage for 6 minutes and clear the wind for 12 minutes.

V. CONCLUSIONS AND SUGGESTIONS

5.1. Conclusions

Portable stage and independent energy inflatable stage roof are very suitable for the needs of SME product marketing exhibitions, this is due to the speed, ease and comfort of the building structure. Proven in Laboratory Tests and Field Tests obtained reliable results include the tensile strength of the PVC tarpaulin stage roofing stage material able to withstand up to 55,619 kg / cm2, portable stage installation 50 minutes installation of the inflatable roof 6 minutes and dismantling 10 minutes and able to reduce the average temperature under the roof 2,2oC. Electrical energy requirements for blowers and portable sound systems can be met by 4 photovoltaic solar cell panels, in sunny weather it produces 13.2 Amperes of electricity, 19.2 Volts voltage, so it does not require electricity generators or electricity. This portable stage building and the rooftop of the independent energy stage can be a widespread prototype as a stage building that quickly builds independent energy. The use of tarpaulin and PVC is very flexible and strong so that it facilitates the process of transportation, installation and dismantling, in a simple and easy to use packaging.

5.2. Suggestions

a. Portable stage and inflatable stage roofs can be made on a large scale making it easier for SME creative product exhibitors to increase the frequency of exhibitions.

b. An automation system is needed in the regulation of air pressure on the inflatable roof of the stage on the air-fill blower. Also needed a sun tracker to adjust the angle of the solar panel automatically.

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