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Investigation the Effect of Mold Compression Time and Glue Flow Volume during the Bamboo Fiber Planting Pot Manufacturing Process

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Abstract: Plastic manufactured from non-renewable petroleum sources are rapidly being used in agriculture which causing serious environmental risk. In horticultural operations, manage to create a large volume of plastic waste from transplanting pots that are rarely recycled. Therefore, the aim of the project is to design and analysis on effectiveness of design upon producing bamboo planting pot with the end product of bamboo planting pot mold maker. Compression molding processes chosen to form the bamboo planting pot. The usage of specific types of bamboo fiber named Bambusa Vulgaris known 'Buluh Minyak' act as material that to be shape up into planting pot. This project showed the preparation for the material needed to fabricate the mold and involvement of machining process to indicate the steps on making up the mold. This project also examined the effectiveness upon flow of glue towards bamboo fiber with a set up volume of glue injector and the evaluation made upon mold compression performance according to its set up time towards bamboo fiber. The data observed with the set up volume of glue injector by one-third, half, and full of taking care of injection gun capacity while mold compression performance analyzed depend on its time of compression which is sixty (60), one hundred eighty (180), and three hundred (300) seconds. Based on the data and result recorded, the adaptable volume of glue injection which one-third is enough to stick and harden up the planting pot with diameter of 120 mm and long on 70 mm. One hundred eighty (180) seconds of time upon compression taken into consideration in producing bamboo planting pot.

Keywords: Compression Molding, Bamboo Fiber, Planting Pot

1. Introduction

The development of polymer composites in pot manufacture from recycle polymers is actively practices because the threats of unpredictable petroleum supply soon and environmental concern. The large production of plastics has led to a tremendous quantity of garbage globally, where over 320 million tons of polymers were generated around the globe in 2015. There have used fewer than 10 percent of

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production plastics are properly recycling, and a substantial volume is gathered in landfills or thrown away into the environment as trash [1]. Particularly, modern agriculture provides a larger number of plastics material, such as direct coverings, greenhouse covering films, silage films, shade, and protective nets and post-harvesting activities, irrigation and drainage pipes, strings and ropes, pots, packing containers, and bag [2].

As a consequences, fiber-based material is proposed in the pot making to substitute polymer composites with several advantages such as biodegradability, recyclability, and a high degree of flexibility. Planting pots manufactured from industrial and agricultural solid waste, such as wood pulp, paper, or peat moss, may be buried straight into the soil entirely with the plant and eventually, the container will degrade [3]. Moreover, most research has found that consumers are willing to pay a price premium on fiber-based pot products to share favorable environmental attitudes [4]. The forming process of making a fiber-based pot where there are existing forming processes includes press forming, heat treatment, blow molding, compression molding. There have noticed that on forming a planting pot where the existing machine is high in cost, it needs to use skilled workers to operate such forming machines to acquire shapes of planting pot.

Therefore, here is the plan to apply the compression molding process on mold with portable system to help on forming the fiber-based planting pot . By providing design where can be operated by non-skilled operators by creating a high performance of mold compression to make the end product effective. Therefore, this study main aims to develop a design and fabricate the bamboo planting pot-making machine.

2. Materials and Methods

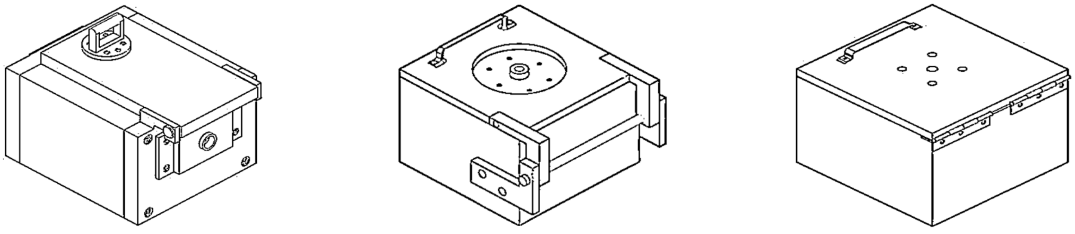
The structure of mold and the compression mechanism were designed with reference from previous research by enable easily operate and make it portable. The study of materials, manufacturing and machining process is significant to fabricate the mold able on produce the planting pot from the bamboo fiber.

2.1 Design concept development

The proposed mechanism for this bamboo planting pot maker mold have been taken considerations as follows:

i. The maker mold undergoes portable system where it can be brought to everywhere.
ii. The post process will be done when the fibers inside the mold itself, such gluing the fibers.
iii. The upper movable half mold designated sideways to make easier open and close up the mold.
iv. The usage of nut and bolt system help in change the part of the compression mechanism diameter and easy for maintenance purposes.

With the reference of considerations above, the design for the planting pot mold created with the help of SolidWorks. This software assist to picturize the complete structure of mold, dimensions, and number of parts. Figure 1 shows various design of the planting pot mold. The third design concept chosen to fabricate the planting pot mold as its meet all the considerations.



(a) (b) (c)

Figure 1: Various design of planting pot mold; (a) First design concept, (b) Second design concept, (c) Third design concept

2.2 Material

The selection of final decision been made upon considering the availability, easy to machined and uncomplicated. Table 1 shows the final selection upon materials and system to move preparation material on aim of fabricate the mold.

Table 1: Final selection upon materials and system

No	Criteria	Mechanism/ Component
1	Base material	Aluminium
2	Operating system	Manual
3	Gluing system	Injection
4	Pathway of glue	In between compression mechanism
5	Connector of two mold	Hinge

2.3 Detailed drawing of mold

The parts were created with the help of SolidWorks software to picturize the complete structure of mold, and dimensions. This design made to prevent from spending over cost to fabricate model. Figure 2 shows the final design of mold in opened position that has been selected from the three design that has been proposed with its dimension which in unit of mm. Figure 3 shows the mold in closed position.

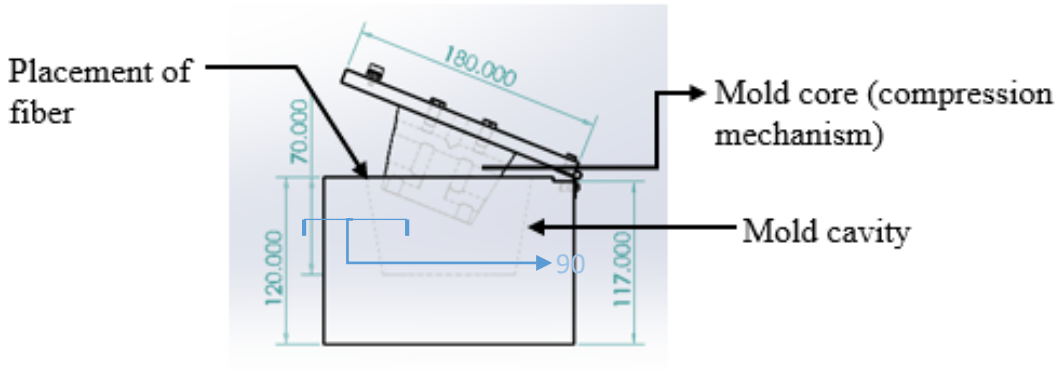


Figure 2: Final design of mold in opened position

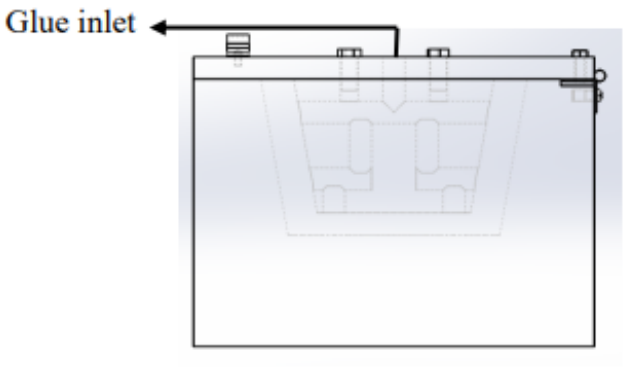


Figure 3: Mold in closed position

2.4 Simulation upon process upon bamboo fiber into planting pot

The simulation done by using SolidWork to get to know that the planting pot can be achieved with the drawing that created. The simulation started by open up the upper mold up to 60° to place the bamboo fiber evenly at top of mold cavity. The proces continued with pressing upon upper plate into

mold cavity with the attached of mold core until 0°. The force applied towards upper plate for 60 seconds to help in shaping up the planting pot. It continued with open up the mold to 60° and bamboo planting pot taken out from the mold cavity. Figure 4 shows the simulation upon process from bamboo fiber sheet into shaped planting pot.

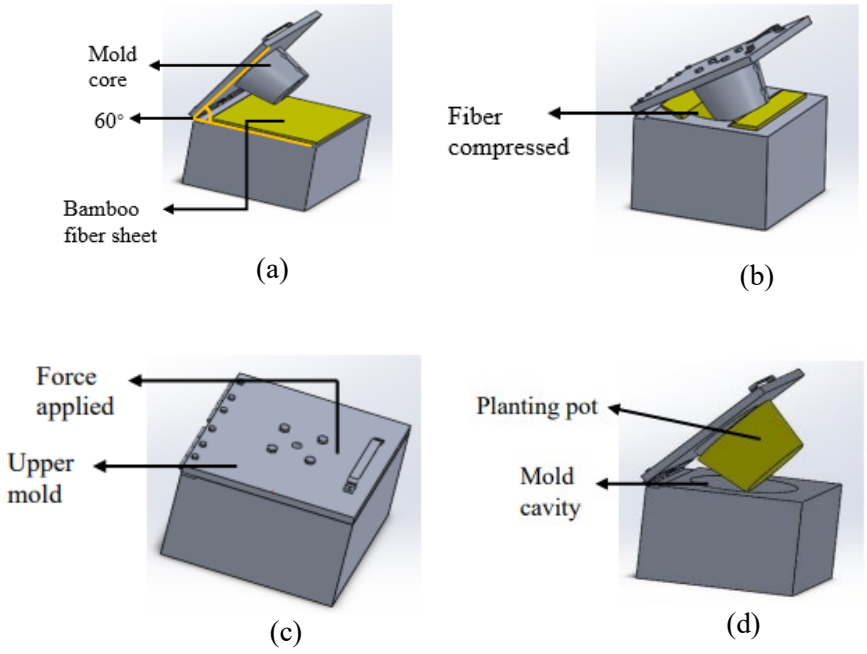


Figure 4: Simulation upon process from bamboo fiber sheet into shaped planting pot; (a) Fiber place on the mold cavity, (b) fiber compressed by compression mechanism, (c) Mold remain closed for 60 seconds, (d) Compression mechanism opened

2.5 Method

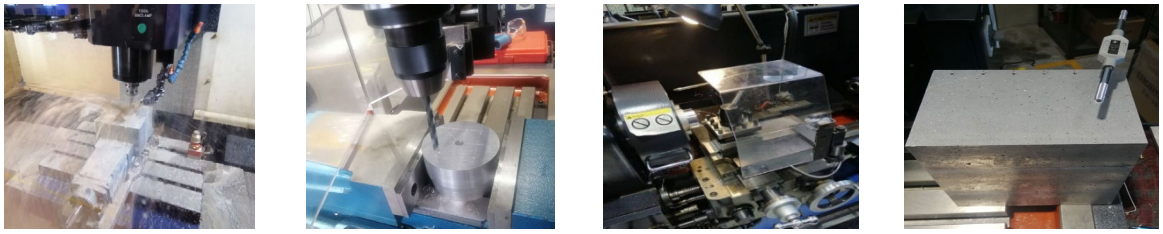
i. Preparation of material

The manufacturing process which is Lost Foam Casting (LFC) used to fabricate the part for further machining purposes of the planting pot maker mold. Figure 5 shows the used of LFC process.

Figure 5: Used of LFC process; (a) Styrofoam cut into desired shape, (b) coating applied, (c) mold filled with green sand and compressed, (d) Molten metal poured through the feed

ii. Machining process

The use of machining process to shape up the part into the dimension needed which includes Hwacheon Vesta 660 Computer Numerical Code (CNC) Milling machine, Hwacheon HMV-1100/1300 High Precision Conventional Milling and Hwacheon HL-460 High Precision Lathe machine and some manual process. Figure 6 shows the machining process.

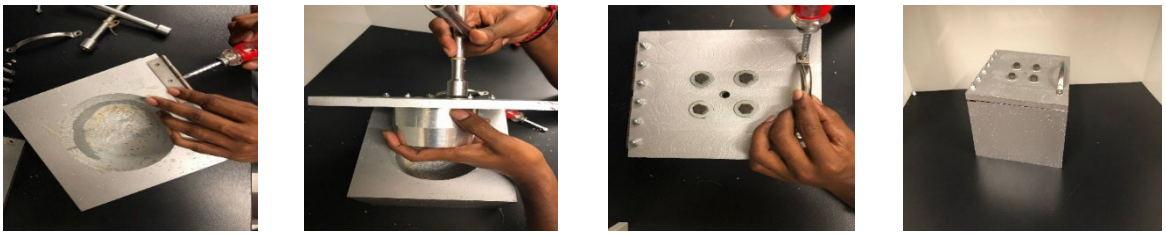


(a) (b) (c) (d)

Figure 6: Machining process; (a) Create pocket using CNC machine, (b) Drill hole using Conventional Milling, (c) Taper angle for compression mechanism using Conventional Lathe, (d) thread manually created

iii. Assembly process

The involvement of wrench and screwdriver in assembled the multiple parts into one complete mold. Figure 7 shows the process of assembly.



(a) (b) (c) (d)

Figure 7: Process of assembly; (a) Hinge connected to mold cavity, (b) Compression mold connected to upper plate, (c) Handle screwed to upper plate, (d) Complete mold

2.6 Compression test

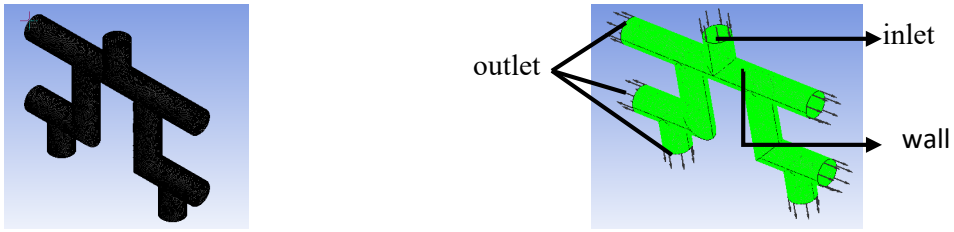
The effectiveness of compression upon bamboo fibers will achieve on condition that the fiber can shape up as designated mold cavity in the form of planting pot. According to study [5] emphasize that the time for the compression used around 60 seconds. Therefore, this study taken upon the parameter used in previous study as minimum time for this study and increase the number of testing with various time includes 180 and 300 seconds. Figure 8 shows the compression test.

(a) (b)

Figure 8: Compression test; (a) Bamboo fiber placed on mold cavity, (b) Compressed using compression machine

2.7 Simulation test on flow of glue

Gluing system is one of the important system that has been designed in a moving mold that compressed towards bamboo fibers. In regard system, the flow of the glue much important to get the shape of pot rigorously when it discharge from the mold cavity. It followed by proposed Computational Fluid Dynamics (CFD) analysis with the help of ANSYS software by executed different diameter which is 3 mm, 6 mm, and 10 mm of pathway inside of compression mold. Figure 9 shows the test setup.



(a) (b)

Figure 9: Test setup; (a) Mesh generated, (b) Boundary condition applied

2.8 Flow of glue with set up volume of injection test

The test will only valid if the glue follow the pathway that design to spread up towards planting pot. The volume of glue injection set up with three different measures which is one-third (80 ml), half (160 ml), and full (320 ml) of glue injector. Figure 10 shows the glue test set up.

(a) (b)

Figure 10: Glue test setup; (a) Glue filled up in the glue injector, (b) Glue injector place in the centre hole of the upper plate

3. Results and Discussion

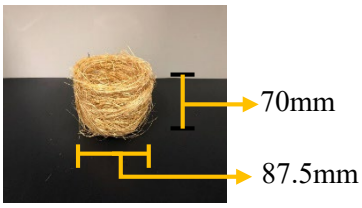
The analysis from the result of effectiveness of compression, flow of the glue on designated pathway, and the effectiveness upon flow of glue with set up volume of injection is significant to get to know achievability of the design.

3.1 Effectiveness of compression

The result on effectiveness of compression measured according to its time where the time set to sixty (60), one hundred eighty (180), and three hundred (300) seconds were presented and visualized in Table 2 below. The result of various seconds picturize that the image number 1 are less in structure of planting pot compared to image numbered 2 and 3, while in image numbered 2 able to get the shape of planting pot but face difficulties in meet the compaction of bamboo fibers into planting pot. The image numbered 3 able to acquire the structure and the high level of compaction upon bamboo fibers compare to image number 1 and 2. Therefore, as an analysis shows that the more the time of compression helps in to get good quality of structure and compaction of bamboo fibers in making planting pot. It can be concluded that, the three hundred (300) seconds compression helps in to get the better structure for the planting pot. Image numbered 2 and 3 of planting pot that being glue outside of the planting pot for the result image purposes. Table 2 shows the result of structure upon bamboo fiber.

Table 2: Result of structure upon bamboo fiber

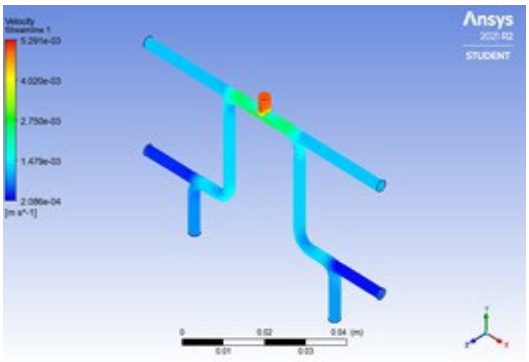
No	Time of compression (seconds)	Result
1	Sixty (60)	

2	One hundred eighty (180)	
3	Three hundred (300)	

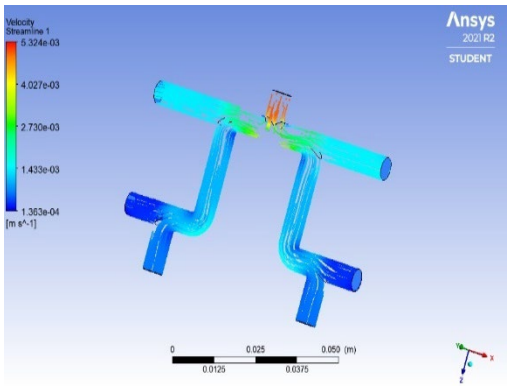
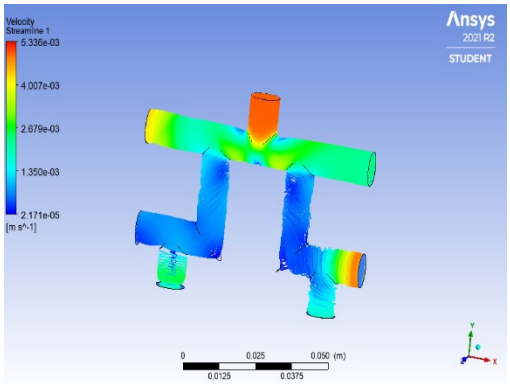
3.2 Flow of glue on designated pathway

The result of different velocity streamline from various diameter of pathway hole were presented in Table 3. As a result, it prooved that maximum velocity streamline for 3mm diameter can reached until 5.29× 10^{-3} ms^{-1}, while it showed the changes to 5.324 × 10^{-3} ms^{-1} and the result which is 5.336 × $10^{-3}ms^{-1}$ for 6mm and 10mm diameter pathway. In this kind cases, the speed is much parameter to assist the flow the of the glue with the designated pathway efficiently. Therefore, the analysis made that the third model which 10 mm selected as a adapt diameter pathway for the gluing flow due to its speed are high enough compare with another two diameters which is 3 mm, and 6 mm.

Table 3: Result of different velocity streamline from various diameter of pathway hole

Default domain		Fluid	
Normal speed	5.00 ms^{-1}	Morphology	Continuous fluid
Relative pressure	0 Pa	Turbulence model	K epsilon
Model No.	Analysis result		Max velocity streamline ms^{-1})
1			5.29× 10^{-3}

Model No.	Analysis result	Max velocity streamline ms^{-1})

2		5.324×10^{-3}
3		5.336×10^{-3}

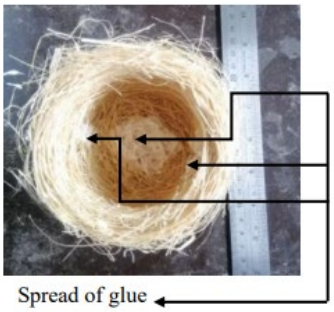
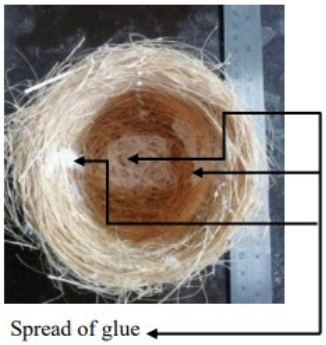
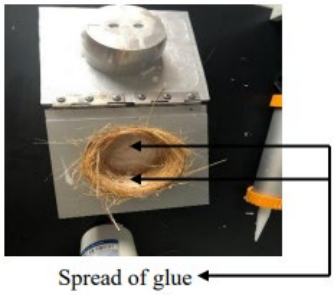
3.3 Evaluation upon flow of glue with set up volume of injection

The result of flow of the glue according to its volume filled in injecting gun visualized in Table 4. The result in the form of image where image numbered 1 shows the spread of glue low compared to image number 2 and 3. The image numbered 3 indicate the most flow of glue to the bamboo planting pot compared to image numbered 1 and 2. In this situation, the volume of glue injector depends on the size of planting pot. The more the volume of glue filled up, the more the glue that traps in below inside of mold cavity where this meets difficulty to take out the planting pot from the mold cavity after the process of injection of glue.

Another observation made towards quality of bamboo planting pot where in terms of similarities in structure of planting pot after it been glued with different volume capacity between the process after compression. In image numbered 1 can observed that the structure of mold same as before been glued, while in image 2 can be observe that the top of planting pot slightly did not follow up the structure of planting before the gluing process of it. Image numbered 3 detected the structure of bamboo planting same as after the process of compression, but in terms of spread of glue can be observed that the overflow of glue happen upon planting pot of it. Besides, the analysis made that there are no changes upon dimension in terms of length which resulted same for three sample after it been compared before and after gluing process towards planting pot.

Therefore, by considered all the possibilities, the analysis made. It made according to adequate volume of glue spread around planting pot where the image numbered 1 was most suitable to coat enough the planting pot with the volume of glue injection which is one-third capacity of glue injector when compared to image numbered 2 and 3. Table 4 shows the result on evaluation upon flow of glue with the set up volume of injection.

Table 4: Result on evaluation upon flow of glue with the set up volume of injection

No	Volume of injector	Result
1	One- third (80 ml)	
2	Half (160 ml)	
3	Full (320 ml)	

4. Conclusion

This project was conducted by designing a planting pot maker mold and then fabricate it to shape up the planting pot manually with a forming process named compression molding. The analysis made by using softwares of SolidWorks and Ansys where this softwares helps in to simulate and visualize the mechanism of project that needed to fabricate and the flow of glue upon the pathway design that been made. The data for this project obtained in terms of effectiveness of compression and flow of glue upon bamboo fibers. The test for the effectiveness upon flow of glue with set up volume of injection towards bamboo planting pot observed by injecting different volume of glue inside the designated pathway of compression mold. Another test carried out to get to know the effectiveness of compression mechanism towards bamboo fibers according to the time that has been set up. The data collected from the test of effectiveness on spread of the glue towards three samples of bamboo planting pot shows that there are significant differences in flow of glue towards feed material. As per result, the accurate volume of glue that need to be filled up is one-third of the glue injector to get the correct spread of the glue upon planting pot while, the result for the effectiveness compression involve time shows the longer the time of compress, the more the nicer structure shape of the planting pot can be obtained. As per result, the most adapt for the compression time of three hundred (300) seconds to get better structure of planting pot plus can produce more planting pot in the short period. Based on the results and observations from this project, concludes that the mold fabricated according to its design that been

proposed where help in forming process named compression molding. The usage of sustainable material which is bamboo fibers tend to shape up according to its fabricated mold and the process of glue flow are smooth enough that travel from the upper plate until it reached the fiber.

On concerning upon improvement of this study and for better result in observing the effectiveness, the following parameter can be considered for the future study where with design an adjustable compression mechanism and mold cavity which help in to make various size of planting pot without changing the mold. Moreover, by Adding up more the hole for glue pathway to increase the spread of glue towards feed materials and need to use of ready-made aluminium block instead of using manufacturing process to prepare the material in the way to eliminate defect from such manufacturing processes. It includes the test can be conduct in terms of different mass of bamboo fiber in making planting pot to get to know the actual mass for making ideal bamboo planting pot.

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