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Research Article

Physical Exploration of Materials as a Method to Determine the Maximum Limit of the Attainment Shapes of Three-Ply Plywood

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Abstract

Three-layer plywood is a material produced from processed wood in sheet form. As a wood material in sheet form, plywood is known to have advantages over solid wood. So Three Layer plywood has the potential to be exploited in terms of its shape. Physical exploration of a material is one way to determine the potential of a material. So with physical exploration, materials can be maximized in various forms that can be produced. By using research and development methods, physical exploration studies of this material can be one way to increase knowledge about harness materials. In addition, with this method the material can have various opportunities to be applied to various types of objects. Because three-layer plywood is a material that has several stages and criteria in its manufacture, and reaches the final stage of using the material in the form of the material not being used. The stages and criteria involved in the production of three-layer plywood are beyond the control of the manufacturer to be able to continue producing three-layer plywood. Physical exploration carried out on three-layer plywood material shows that this material has other potential. Because the material is in sheet form, three-layer plywood has the potential to be a processed material that can be recycled into other materials. And the results obtained also prove that three ply plywood material has the potential to be used in forms other than sheets on various objects other than its use in sheet form.

Keywords: *Physical, Exploration, Material, Three-ply, Plywood*

1. Introduction

At present, various types of materials have been used to support daily life. individually and in industrial contexts. The useof materials will also depend on the nature of the material. It is known that material or material is one component that must exist on an object or can also be interpreted as substances from which something can be made (Ashby & Johnson, 2013). When viewed from the context of design, the material is one of the important elements because every object that will be designed must also be considered the material (Lewis et al., 2017).

Based on some of the meanings that can be obtained, the material can be interpreted as something related to a physical matter that becomes an important component, or it can also mean substances from which something can be made. With material, an object will be created (Kim et al, 2016). In the process of making an object, it is necessary to know the characteristics of the material that can be used as a reference for the work process of the material. So that the material canbe used optimally (Everton et al, 2016).

Every material is known to have its visual quality which is influenced by the shape produced by each material utilizationin building an object (Rose, 2016). In addition to the quality presented by the presence of visual characteristics, the material also has structural characteristics that become the characteristic possessed by the material so that it can receive different treatments compared to other materials (Liang et al., 2016).

Talking about the treatment of material, it is necessary to have an exploration that can provide another approach (Yawar& Seuring, 2017). The creative process is to get the most optimal form of material and this can be done by conducting anexploration process on the material (Ford, & Despeisse, (2016). That is by trying to make observations on the material, one of which is a physical exploration to determine the possibility that the material can be processed to get a typical response (Hanington & Martin, 2019). To describe physical exploration, the word exploration and physical to be able tofind out the definitions of the two words (Eitzel, et al., 2017).

Material processing through physical exploration can provide various kinds of information through visual forms producedby the processing method (Russ, 2016). Because the existence of physical exploration can provide a certain uniqueness that can be directly seen (Goodwell & Kumar, 2017). Physical exploration of the structural characteristics of the material can be done by arranging the material through the selection of forms that are not too visually dominant through steps thatdisplay visual characteristics through simple forms (Rose, 2016).

Exploration is an activity to obtain new experiences from a new situation (Arnott, 2016). Exploration is explained as a work process in facilitating the learning process from not knowing to knowing (Dutton & Ragins, 2017). By connecting the previous thoughts with the learning experience (Goldie, 2016). While physical can be interpreted as a term that meanssomething that is visible and can be seen by the naked eye, which is also defined by the mind. Physical words are usuallyused for visible and tangible objects (Varela et al, 2016). Physical can be used

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to describe the shape of an object or for infrastructure in a building (Belsky et al, 2016). The definition of physical exploration is one of three stages of material exploration which is a type of treatment imposed on a material that allows the material to be processed to get a typical response This treatment affects the structural characteristics of the material.

Plywood is one of the materials used for making products and can be used for various purposes (Pommier et al, 2016). Plywood material is made of several thin sheets obtained from the log rotary wood stripping process (Leggate et al., 2017). The process produces sheets that have a length and width with a small thickness (Labans et al., 2019). Based on the construction used to make it, then this material is very resistant to the risk of breaking/cracking, curving or twisting which depends also on its thickness (Wu et al, 2016). Three-ply plywood or triplex includes one type of plywood and is

a processed product of wood made from thin sheets of wood glued together and then pressed with high pressure and glueusing special glue into one (Tuczek, 2016). The term plywood is due to three layers.

As a material produced from processed wood, plywood has the potential as a material that can be used to make an object (Allen & Iano, 2019). Because there are various kinds of objects that have been made from wood (Yang et al., 2018). It is known that each material indicates that the quality of the material to be used has high potential (Brunner & Rechberger, 2016), which can be utilized through the use of various forms that can be started from simple forms so that the visual characteristics (Sanoff, 2016) possessed by the material can be displayed properly. Due to the potential of each material.Then there needs to be a trial that needs to be done to find out the potential (Shaheen et al., 2019). The testing of plywoodmaterial is intended to obtain various forms obtained by the material (Tsai, 2018). Besides due to the potential possessedby the material with the increase in information obtained not only the form produced but also the method in the process of forming based on desire (Ma et al., 2017). In carrying out this research, to get the uniqueness of the form produced, the researcher must be able to hold himself back from pretending to be anything functional (Dawson, 2019), especially beauty. What was given in response to the material when he was given treatment was captured with a visual attitude, captured as something special.

The focus of this research will be limited to conducted on plywood material objects whose physical exploration is carriedout to obtain the shape and method of forming it (Lune & Berg, 2016).

2. Methodology

2.1 Research methods

In this study, the method applied is research and development methods", namely methods that emphasize productdevelopment so that it can be applied in a broader context (Ramadhan et al., 2022). Research and development methods are "research methods used to produce certain products, and test the effectiveness of these products (Sulistyono, 2018). The research method used is a qualitative method which is an approach whose research findings are not obtained throughstatistical procedures or other forms of calculation, this procedure produces findings obtained from data collected usingvarious means (Ghauri, et al., 2020). The facilities include observations and interviews but can also include documents, books, videotapes, and even data that has been calculated for other purposes, such as census data. (Grace, 2009). The development was carried out using the pure experiment method (Subramaniam et al., 2019).

Both forms of research are used to obtain results in the form of physical exploration of plywood material (Bonfante, 2019). Its implementation will be carried out in the laboratory and influenced and controlled by researchers to produce forms that can be produced from plywood material (Bekhta & Salca, 2018).

2.2 Research material tools

In conducting physical material exploration, the procurement of the material to be used is the initial stage of the process (Ajayi et al., 2017). In implementing the procurement of materials, there is a need to obtain material stages (Mahendrawathi, 2017). To get plywood material, it is known that the material can be in two ways, namely by buying through a place that sells building material or by taking used plywood material (Herianto et al., 2018). In addition to this,

during the selection process, interviews were also conducted with sellers about the plywood available. Viewed from type, category, dimension, and price (Mothagodi & Mothagodi, 2018).

Material cutting

Based on the results of interviews regarding the specifications of the material received, then the cutting process is then carried out according to the desired size (Akinade et al., 2017). But before cutting, plywood material is explored accordingto its dimensions so that the amount to be obtained if using a predetermined dimension can be known (Grimaud & Cassen,2019).

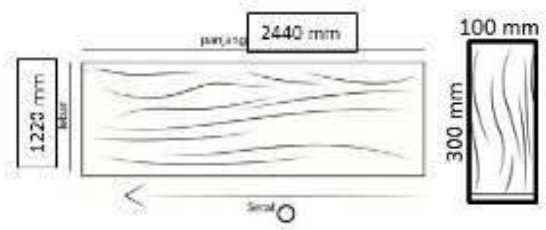


Fig 1**.** Variety of dimensions of plywood material(Source: Dungani et al, 2019)

From the process of cutting available material measuring 2440 mm x 1220 mm, the results were 96 sheets of truncated plywood material with dimensions of 300 mm x 100 mm (Dungani et al., 2019). In this exploration process, material cutting is the beginning of physical exploration carried out (Fauziah & Pujiraharjo, 2018).

Material selection

After the process of cutting plywood material. Then the

selection of material to be used is done. Plywood used is plywood material with elongated pieces following the initial plywood fiber (Reh et al., 2019). By using wood that is in the same direction it is known that the material can be explored (Ramage et al., 2017). In addition to this, there is no special requirement in selecting the material to be explored because in the exploration process using cutting techniques (Sun et al., 2018), the initial requirements have certainly been fulfilled. However, in its application, the cutting results are not always the same dimensions (Raffel et al., 2018). In addition to manual cutting, careful constraints can be the cause for every cut sheet having a slight shift from the planned one in shifts that occur up to -/ + 3-5 mm (Rill & Hämäläinen, 2018).

2.3. Exploration method

Physical exploration is another approach in the creation process that aims to get a form that can be done through an exploration process on material by observing material characteristics visually and structurally to dimensions (Hanington& Martin, 2019). Besides, physical exploration aims to obtain direct uniqueness based on some treatment carried out on material (Hepworth et al, 2016).

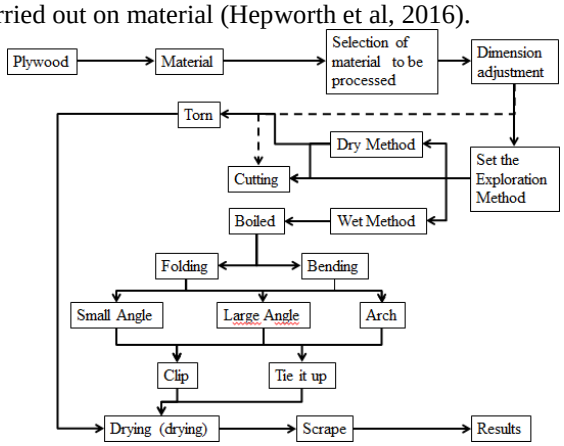


Fig 2. Plywood Material Physical Exploration Scheme

In conducting material exploration, especially plywood, several processes need to be passed or carried out (Pöllänen, 2019). Some of the processes carried out aim to be a reference in conducting exploration methods to achieve the objectives(Kumar, 2019).

3. Results

3.1 Three-Ply plywood

Plywood is included in one of the processed products made. Plywood is one of the composite products made of sheets ofveneer which are glued together with the arrangement of perpendicular crossings (Khirey, 2019). Plywood belongs to oneof the structural panel groups, where the use of this plywood is for structural panels (Xi et al., 2018).
It is known that Triplex (three-ply) is an included in the type of plywood in the form of artificial boards of a certain size made of several layers of veneer (Van Hinte, 2016). Various forms of plywood are available. For plywood with three layers, it is called triplex or three-ply, whereas plywood with five layers, and the rest is also called multi-ply plywood (Whitsitt & McKee, 1958).

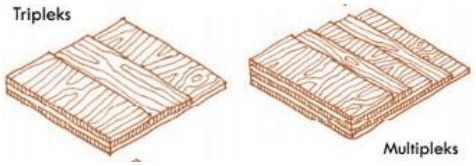


Fig. 3. Differences in Three-ply and multiply plywood (Source: Lensufie, 2008)

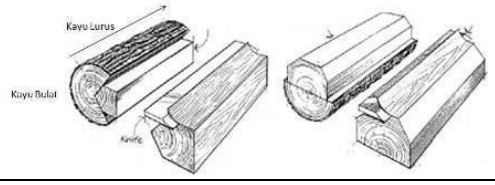
Plywood is plywood made in an odd form, namely in the form of 3,5,7,9 layers. This is because of the layers that form the core of plywood making (Fauziah & Pujiraharjo, 2018). For plywood material itself has 3 parts, namely the face which is the face of the plywood itself, and the particleboard which is the middle part of the plywood.

Table 1. Differences between three-ply plywood and multi-ply plywood (Source: Dumanaw, 1990)

		Vinir Coating	Thickness (mm)	Size (ft)	Size (mm)
Three-ply	Ordinary plywood	3 layers	4 mm	8 ft x 4 ft	2440 x 1220 mm
				7 ft x 3 ft	2130 x 915 mm
			6 mm	8 ft x 4 ft	2440 x 1220 mm
	Teak plywood	3 layers	4 mm	7 ft x 3 ft	2130 x 915 mm
Multi-ply		5 layers	9 mm	8 ft x 4 ft	2440 x 1220 mm
		5 layers	12 mm	8 ft x 4 ft	2440 x 1220 mm
		5 layers	14 mm	8 ft x 4 ft	2440 x 1220 mm
		5 layers	15 mm	8 ft x 4 ft	2 440 x 1220 mm
		7 layers	18mm	8 ft x 4 ft	2440 x 1220 mm
		7 layers	24 mm	8 ft x 4 ft	2440 x 1220 mm

1. Types of Wood for Plywood Production
Plywood is one of the processed wood products. However, not all types of wood can be used to make plywood because in plywood production it is necessary to pay attention to the quality produced (Ramage et al., 2017). In the current development, there are 3 main criteria for wood that can be used to produce plywood.

Table 2
Criteria for wood for plywood production

No	Criteria
	Picture
	
1	The physical shape of the wood must be round
	Wood that is suitable as raw material for making plywood is wood that has a perfect level of roundness on the trunk. because the wood has a good level of roundness, its utilization can be maximized because there will not be much wood wasted
2	The physical form of wood must be straight
	In addition to the level of roundness, the level of wood straightness is also one of the requirements for producing plywood with good quality. This is because the straightness of the wood can affect the wood *veneering* process using a long blade. Because the physical wood is not straight will result in an incomplete stripping.
3	Wood supply factor
	The supply factor will be related to the speed of growth of the wood-producing trees that will be used to produce plywood. This is because if the supply factor is not met, the production process will experience disruptions caused by the supply of wood as raw material becomes inconsistent.

(Source: Dumanaw, 1990)

Based on these three conditions. Several kinds of wood are often used to produce plywood, namely "jabon" wood and "sengon" wood because the two types of wood are known to have characteristics of round and straight trunks (Herianto et al., 2018), and are known as woody plants that have a fast-growing period compared to other woody plants so that supplies of both types of wood it is not small and can be maintained. Apart from the two planks of wood, there is wood which has better quality such as teak wood which can be known as a teak block (Tripati et al, 2016).

However, the conditions must be adjusted to the three existing criteria, especially for teak wood, which needs to be emphasized in the supply factor (Astini & Tafiprios, 2017). Because it is known that the growth of teak wood is quite long it needs special attention to its growth (Rizanti et al., 2018).

Plywood is known to be included in the category of plywood in the form of sheets of a board made from several layers (Bekhta et al., 2020) of veneers (thin sheets of wood 0.25-6mm) which are produced from the stripping process of woodstacked with each other in a cross (Sydor et al, 2020). There are several purposes for producing plywood, namely:

- Save wood usage

Because the time needed to produce timber cannot be ascertained, it is necessary to use wood to be processed so that it can be utilized (Csanady et al., 2019).

- Get a big/big board

By using plywood, the wood obtained can be maximized in terms of size because of the process, the process of woodcutting is done until the wood cannot be used again. So that it can maximize the size of the wood (Martínez-Conde,2017).

- Utilizing low-value wood species

In its application, parts of plywood can use various types of wood so that the type of wood with a low value can be used for one part of plywood (Bekhta & Salca, 2018)

- Increase the strength and quality of wood

With the combination of wood materials with various values. It can produce quality for the category of plywood (Oncel et al., 2019).

- It can beautify the decorative elements of the wood surface.

Utilizing some of the decorative elements that are naturally found in sliced trees can be a value-added decorative elementthat can be used for various purposes (Chen & Hong, 2017).

Characteristics of plywood

Plywood is included in the type of plywood due to its sheet shape. Wood sheets are obtained from processing in the form of stripping wood blocks to produce several thin sheets. The stripping process is done using a machine (Beorkrem, 2017:26)

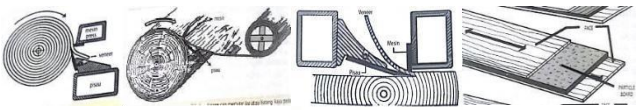


Fig 4. Illustration of the wood stripping, veneering process, and main structure of three-ply plywood

Broadly speaking, a wood paring machine has two parts, namely a knife and a press machine. The function of the knife on the machine is to peel the wood into sheets and the press machine is used to press the wood when it is peeled using a knife (Jia et al., 2018). In the current development, there are two types of wood stripping processes, namely veneering log and veneering board (Ashaari et al, 2016)

The veneering log process is intended for spinning wood in a way that aims to produce a piece of wood that is intact in terms of length and width (Leggate et al., 2017). For thickness, the veneering log process can be adjusted to the cooled thickness (Bekhta et al., 2017). While the veneering board is used to get thin slices from the shape of a wooden board intosheets. The two veneering processes have their respective advantages (Denes et al., 2017). Veneering logs are used to getwhole wood sheets without connection. The veneering board is intended to get the motif found in wood. Because it is known that the motive will affect the selling price (Broun, 2018: 15). Three-ply plywood has three main

parts as its constituent. The section consists of 2 outermost layers or faces (Steiger, 2017: 45) which are upper and lower layers, andinner layers of particle boards which are wood chips pressed with an adhesive mixture to form a dense plane (Benthien, 2019).

There are several advantages of plywood compared to solid wood, the dimensions of plywood can be thicker using the method of adding plywood (Bekhta et al., 2018). This is because each additional layer will affect the amount used. Because it is known that the layer of plywood which must be of an odd number must at least add to the face or outer layer(Van Damme et al., 2017). In the case of plywood itself, the layers of the plywood can be arranged in thickness in each layer (Shrivastava et al., 2019).

Three-Ply Plywood consumers

Companies that produce plywood include companies that distribute plywood. There are two methods for distributing to consumers (Miranda, 2018), namely in the form of distributed plywood and distribution services that also provide payment determined in the future (Ivanov et al., 2017). In its application, the distribution process of plywood products is carried out routinely according to certain situations and conditions (Zaki et al., 2019). Beginning with a factor in the number of items ordered to the same distribution location (Ivanov et al., 2017).

Fig. 5. Plywood consumers

Plywood consumers in more conditions buy products in large volumes in the sense of reaching 100-200 pieces of plywood boards and multiplexes which are redistributed according to their thickness (Miranda, 2018). Plywood consumers are not only limited to stores that provide building materials. However, consumers of plywood are sometimes developers who are developing (Ivanov et al., 2017). So that the function of plywood material becomes diverse. In a particular case, distribution sometimes has problems because of the availability of existing company resources (Kesen, & Bektaş, 2019). Plywood consumers consider that the quality of plywood material obtained is not always good and is included with a fulfillment capacity that is not always stable so the desired amount is sometimes not as promised (Zaki et al., 2019).

Physical Exploration of Plywood Plywood production

Plywood is known to be one type of plywood and is included in the material produced from the production process and consists of three layers in the form of sheets of wood arranged with crossed fibers and usually has an odd number of layers(Makowski, 2019). Based on the number of layers, two types of plywood are known today, namely, plywood which consists of only three layers of veneers, and wood which has more than three layers called multiplex (Rohrbacher et al., 2017), it is known that because multiplexes have more thickness and number of veneer than plywood, multiplexes have a more solid level of strength compared to plywood (Steiger. 2017).

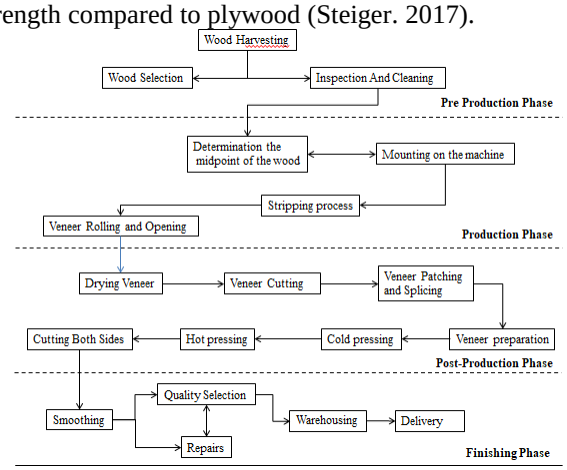


Fig. 6. Plywood and multiplex production processes

In its application, 4 phases need to be passed in plywood and multiplex production. The four phases are interrelated because in each phase there is a process. Which from the beginning to the end is a process that cannot be separated fromone another (Chen et al, 2016). The four phases consist of the pre-production phase, production phase, post-production phase, and finishing phase. The four phases have their positions (Jia et al., 2019).

- Pre-production phase

The initial phase of plywood production which is included in it is the timber extraction process, followed by the selectionof wood that is adjusted to the required conditions such as round shape and straight wood (Barata et al., 2017). Also included is the cleaning of wood from foreign materials such as rocks and metals that can interfere with the cutting process. As well as the selection process to find out if it turns out there is still timber that does not meet the requirements(Ji et al., 2018).

- Production phase

It is a phrase that is devoted to wood processing to be used as sheet forms. This begins with the installation of wood material on the machine that is included with the determination of the middle point of the wood to be processed (Barcík et al., 2019). This is continued with stripping/woodcutting to get the shape of the sheet/layer until the wood cannot be utilized After the process is complete, it is followed by a process of rolling and releasing the veneer layer (Parthiban et al., 2019).

- Post-production phase

It is the phase after the wood has become a sheet that will be used and processed to be made into a strip or multiplex. Two processes can be done because this process is adapted to the conditions of the plywood production site itself (Lestari & Ozarska, 2016). Such as the process of cutting and drying of veneers. Both of these processes can be carried out in reverse according to the workflow from the place of production. After the process can be done patching and connecting each veneer to be used as plywood or multiplex material (Bialasz & Klepka, 2017). This process needs a

glue coating processfor each veneer arranged. After the connection and preparation of each veneer using a layer of glue, proceed with the pressing process to get perfect adhesion (Leszczyszyn, 2018). There are two press processes from plywood materials, namely cold and hot press. Each process has a function that is not much different because it functions to form a permanent bond between veneers (Bekhta et al., 2018). However, it should be noted that the machine and the time and temperature used are different. The pressing process is carried out in two stages followed by cutting on the sides of plywood and multiplex material to obtain the desired size (Chang et al., 2018).

- Finishing phase

It is the last phase after getting the material of the desired size. In this phase plywood or multiple plywood material can be said to have been produced (Sulistyono, 2018). But to get good material, the finishing phase is done. This phase beginswith the cleaning process by smoothing the surface of the plywood or multiplex using a machine (Shaikhutdinova et al., 2017). Also, note that in this process there is always a production defect found in plywood or multiplex. So that the defectcan be seen to be returned to the work process (Bekhta & Salca, 2018). Therefore, the process can determine the production results achieved from the use of wood material at the beginning (Park & Jo, 2020). After going through the smoothing process, it will continue with the quality selection process. In this selection process, plywood is chosen according to existing quality standards, namely grade A for very good quality to grade C for the lowest quality (Yalcinkayaet al, 2016). After the selection process is complete, the material will be put into the warehouse to be stored and will be sent/sold to the consumer. In this case, the warehousing process does not always take days. Because the warehousing process is traversed to temporarily place plywood or multiplex before delivery (Gayda, 2016).

Physical exploration

Physical exploration of material is one of the other approaches in creative processes that aim to get optimal results and get new forms (Fauziah & Pujiraharjo, 2018). Physical exploration is done by method design by applying direct visual observations of physical material to obtain the uniqueness that results from the physical treatment of the material (Lestariet al., 2019).

Physical exploration of material is carried out in the form of physical treatment of the material to get a typical response from materials such as cutting, tearing, folding, buckling, bending, etc. The physical treatment of the material is intendedto obtain new elements that can be used for the material needs of an object (Fauziah & Pujiraharjo, 2018).

In line with the objectives of the study, the physical exploration of plywood material is intended to determine the potential(Lestari et al., 2019) that can be obtained from plywood material and its physical visual treatment.

Cutting

The cut is one of the material explorations. Exploration of material with a cut method is intended to divide the material into several using tools (Pangestu et al., 2019). The tools used in cutting plywood use saws. In its application, at the timeof cutting do not always use a sawmill, but use a saw. Physical exploration using the cut method means that the divided plywood material can be used according to the size obtained. And from the use of cutting methods, the results are that the plywood material can be cut according to the size of the cooled (Fahrussiam et al, 2016). In its implementation, not all plywood can be cut perfectly according to the size cooled because cutting which still uses a combination of tools manually is not automatic (Romagnoli et al., 2017)

Fig. 7. Exploration of cutting methods and results obtained

The cutting process in the physical excavation of the material produces plywood material which initially in the form of sheets measuring 1220 x 2440 mm can be cut into sizes 100 x 300 mm and produce 96 plywood (Wang et al, 2018). Thedistribution of material can be used for further material exploration (Unwin et al., 2018).

Boil

The method used in further material exploration research is to use the boiled method. It is known that boiled is the processof soaking an object in water heated with fire to boiling (Zhang et al., 2018). In the exploration of plywood material usingthe boiled method, the plywood is immersed in a container filled with water that can accommodate the entire body of the

plywood, this is done to soften plywood so that it can be easily formed because the plywood becomes soft (Song et al, 2017). The method of boiling in the exploration of this material is intended to be able to change the nature of plywood material that is initially stiff so that it can become soft through the absorption of water through the material process (Prasad et al., 2019).

Fig. 8. Method of boiling on plywood material

The process of boiling plywood as a method of material exploration can be carried out one by one from sheets of materialor with more than two quantities (Ugryumov et al., 2019). In this method, boiling plywood material is done by soaking the plywood since the water is still cold to boiling to make sure the water is more permeated into the plywood (Biadala et al., 2020). Besides, plywood must be ensured to be completely submerged in water. So it is necessary to have pressureon the top so that the material is submerged because based on its nature the plywood material does not sink. After all, it is light (Prasad et al., 2019).

Drying

In material exploration using the drying method. The drying method is a way or the drying process to remove the watercontent in objects, usually done by using sunlight to evaporate the water contained in the material (Ozturk et al., 2019). The method of drying in the exploration of plywood uses a method of placing the material in a place that is exposed tosunlight to be able to remove the water absorbed after the boiling process so that the form produced from the explorationprocess can be maintained (Bekhta et al, 2020). Drying using sunlight is intended so that this material exploration can bedone simply (Jia et al., 2019).

Fig. 9. Drying of exploration material

The method of drying the material is done after the plywood is formed. And used to be able to maintain the desired shape. In addition to the drying method, the method used is also used to maintain the shape (Khalid, 2018). Because after the drying time is finished the plywood material will return to being rigid. The disadvantage of this method is that in additionto the need for sunlight as a heat source, weather factors can also affect the drying speed (Phan Thi et al., 2018). Becauseif there is rain, the plywood material will return to wet conditions that can make the material weathered. Besides, the timeneeded cannot be known with certainty because of the difference in heat that occurs per day. So that the manual drying process can be longer than the planned time (Burnard et al., 2018).

Tearing

Tearing as a verb is known as an attempt to separate or divide two things by using a hand or other object by drawing theopposite side so that the fiber fibers that unite the two are cut off and the object becomes split (Barcík et al., 2019). The tear method is done manually to separate one field of plywood which is the object of research. In the case of plywood material, the plywood is torn after one part is cut to reduce the tension and also increase the level of flexibility to allow for the tear method (Laskowska et al., 2018).

Fig. 10. The tearing method in material physical exploration

The tear method itself is done by pulling the triplex side up on one part and down on the other so that the triplex will split in small increments (Rohuma et al., 2017). To be included in the tear method, the method used by hand after the triplex is slightly inline/split using a cutter, pulled out at the same time up on one side and down on the other side (Grabner et al., 2016), so that the fiber in the existing plywood is broken and broken and the plywood can split, although in this process the results obtained are not neat halves, and in certain parts, there will be faults (Way et al, 2020).

Slicing

Slicing can also be categorized including cutting thinly to separate the skin or skinning (Alexa et al., 2017). In plywood,this process is done by cutting into the edge with the cutter or other cutters very thinly to be able to separate the layers from the plywood (El Haouzali et al., 2020).

Fig. 11. The method is in material physical exploration

Method of incision or slice on plywood. Done to get a simple technique for separating plywood skin. However, my method was not successful because of the damage that occurred on the separate skin parts in parts that cannot be ascertained (Burnard et al., 2018). Simply, the plywood material was initially slashed using a cutter tool to separate the outer part ofthe plywood, this was done to be able to reduce the stiffness of the plywood so that plywood is easier to separate (Grubîi& Johansson, 2019). This process is difficult to do because the layers on the plywood are very thin and susceptible to slashing without being followed by the inside of the plywood. This is due to the process of making plywood parts stickingtogether due to the press during production (Grabner et al, 2016).

Bending

Bending is one method that is used to form sheets that are rigid enough to have an angle on a line that is specified (Ferreiraet al., 2017). Plywood is formed so that it has an angle on a line that runs in the middle of the field where the line shouldnot be parallel to the fiber in the plywood to be bent (Demikir et al., 2017).

Fig. 12. Bending method plywood material

The buckling method in the physical exploration of the material is carried out, using a manual system that is assisted by using iron equipment as a barrier and a ruler as a slope measuring instrument, the result of bending (Makowski, 2019).

Inits implementation, the buckling method in this study is divided into three bends, namely bending a small angle, bendinga large angle, and bending the bend (Panic, 2016).

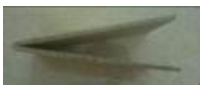
a. Small Angle

The small corner bend method is done by way of bending the plywood material at a 10-90-degree angle (Makowski, 2019). And this method is intended to determine the limits that can be obtained from the physical material so that it can be utilized following the desired conditions (Chen et al., 2018).

In the method used to get a small angle bend, the stages of implementation in each bend method use the same process (Byeon et al., 2018). That is preceded by eroding the plywood material, followed by making a reference line for bucklingand proceeding by using the boiled method to flex the material and then using the bend method to find the desired angle(Wareing et al., 2016). Then the material is bound and continued with drying the material. Based on the physical exploration of the material carried out, it was found that at an angle of 20-90 degrees, the physical plywood material canbe bent without any change in shape, and for bending 10 degrees the physical material cannot be maintained because thephysical material expands to reach 20 degrees (Byeon et al, 2018).

Besides, plywood material that has been formed and returned to rigid properties has the disadvantage of being easily damaged if pressed when the position is more than a degree (Makowski, 2019).

Table 3
Bend a small angle

	PICTURE				
					
ANGLE (DEGREES)	10	20	30	40	50
IMPLEMENTATION	- Triplex sandpaper to erode and reduce the thickness of the triplex, so that the triplex becomes more flexible when bent. - Make a line using triplex perpendicular to the triplex fiber line, as many as 5 or 7 lines with a distance of ± 2mm - Boil the Triplex in a container that can accommodate the entire triplex. - Bend slowly, bend it with the help of a solid object that has an angle on the middle line. - Tie triplex when it has reached the desired degree of bending. - Triplex under the sun directly to remove the water content that has been absorbed, so that the triplex is stiff again. - let stand triplex which is still bound for 1 week				
CHANGE	The plywood again expands to nearly 20 degrees	The final form can be maintained, it's just that the plywood is easily damaged in the corner if pressed toward the outside (open)	The final form can be maintained, it's just that the plywood is easily damaged in the corner if pressed toward the outside (open)	The final form can be maintained, it's just that the plywood is easily damaged in the corner if pressed toward the outside (open)	The final shape can be maintained only with plywood easily damaged at an angle if pressed towards the outside (open)
	PICTURE				
					
ANGLE (DEGREES)	60	70	80	90	
IMPLEMENTATION	- Triplex sandpaper to erode and reduce the thickness of the triplex, so that the triplex becomes more flexible when bent. - Make a line using triplex perpendicular to the triplex fiber line, as many as 5 or 7 lines with a distance of ± 2mm - Boil the Triplex in a container that can accommodate the entire triplex. - Bend slowly, bend it with the help of a solid object that has an angle on the middle line. - Tie triplex when it has reached the desired degree of bending. - Triplex under the sun directly to remove the water content that has been absorbed, so that the triplex is stiff again. - let stand triplex which is still bound for 1 week				
CHANGE	The final shape can be maintained only with plywood easily damaged at an angle if pressed towards the outside (open)	The final shape can be maintained only with plywood easily damaged at an angle if pressed towards the outside (open)	The final shape can be maintained only with plywood easily damaged at an angle if pressed towards the outside (open)	The final form can be maintained only easy plywood on the corner if pressed towards the outside (open)	

b. A large angle

Big corner bend methods are not much different from a small corner buckling method by way of bending the plywood material at a 100-170 degree angle (Byeon et al., 2018). Similar to the small angle method, this method is intended to determine the limits that can be obtained from the physical material so that it can be utilized following the desired conditions (Ferrerira et al., 2017). The difference in treatment in the large-angle bend method does not use bonds to maintain the bend angle (Makowski, 2019).

Table 4
Large Angle Bend

	PICTURE				
					
ANGLE (DEGREES)	100	110	120	130	140
IMPLEMENTATION	- Plywood sandpaper to erode and reduce the thickness of the plywood, so that it becomes more flexible when bent. - Make a reference line perpendicular to the plywood fiber line, as many as 5 or 7 lines with a distance of ± 2mm - Boil Triplex in a container that can hold the plywood as a whole. - Slowly bend, bend with the help of a solid object that has an angle on the middle borderline. - Plywood if it has reached the desired degree of bending. - Dry plywood under direct sunlight to eliminate the moisture content that has been absorbed, so that the plywood returns stiff. - Let stand plywood that is still bound for 1 week				
CHANGE	There is a degree shift from the desired angle of change reaching 10 degrees	Triplex is successfully formed, and the final form can be maintained	Triplex is successfully formed, and the final form can be maintained	Triplex is successfully formed, and the final form can be maintained	Triplex is successfully formed, and the final form can be maintained
	PICTURE				
					
CORNER(LEVEL)	150	160	170	180	
IMPLEMENTATION	- Plywood sandpaper to erode and reduce the thickness of the triplex, so that the triplex becomes more flexible when bent. - Create a reference line perpendicular to the triplex fiber line, as many as 5 or 7 lines with a distance of ± 2mm - Boil the plywood in a container that can hold the entire triplex. - Slowly bend, bend with the help of a solid object that has an angle on the middle borderline. - Tie plywood if it has reached the desired degree of bending. - Dry plywood under the sun directly to eliminate the water content that has been absorbed, so that the triplex is stiff again. - Let stand plywood that is still bound for 1 week			It does not require any process.	
CHANGE	Triplex is successfully formed, and the final form can be maintained	Triplex is successfully formed, and the final form can be maintained	Triplex is successfully formed, and the final form can be maintained	No changes	

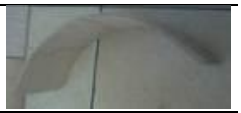
In the method used to obtain large-angle bends, the implementation phases in each bend method use the same process asthe small bend method with the difference of not using a binder to maintain its shape (Chen et al., 2018). That is precededby eroding the plywood material, followed by making a reference line for buckling, and proceeding by using the boiled method to flex the material, and then using the bend method to find the desired angle. Furthermore, drying the material (Ferreira, 2017). Based on the right physical exploration of materials is done, the result that the angle of the bend angle of 110 -170 degrees physically plywood material (Chanda et al., 2020) can be bent without any change in shape, and bend100 degrees of physical material can't be maintained because of the physical material re-inflate the angle reaches120 level (Byeon et al, 2018).

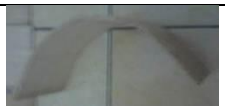
Besides, just like bending a small angle, plywood material that has formed and returned to its rigid nature has the disadvantage of being easily damaged if pressed when its position is more than a degree (La Magna et al, 2016).

c. Bend the arch

Methods of curved bend are not much different as the bending angle method is by way of bending the plywood material resulting in an arch. It is known that an arch is a form that resembles an arc (Yalcinkaya et al, 2016). The plywood is madeto resemble an arc on the side parallel to the fibers of the triplex to bend it (Chen et al., 2018)

Table 5
Bend the arch

PICTURE				
				

IMPLEMENTATION	- Plywood sandpaper to erode and reduce the thickness of the plywood, so that the plywood becomes more flexible when bent. - Boil the plywood in a container that can hold the plywood as a whole. - Gently bend it, trying to avoid any faults, if the plywood turns cold soak it back in hot water for a while. Then repeat the bending process. - Tie plywood if it has reached the desired level of curvature. - Dry plywood under the sun directly to eliminate the water content that has been absorbed, so that the triplex is stiff again. - Leave the plywood still attached for 1 week			
CHANGE	Triplex does not experience changes in the curvature of the final result.	Triplex does not experience changes in the curvature of the final result.	Triplex does not experience changes in the curvature of the final result.	Triplex does not experience changes in the curvature of the final result.
	PICTURE			
				
IMPLEMENTATION	- Plywood sandpaper to erode and reduce the thickness of the triplex, so that the triplex becomes more flexible when bent. - Boil plywood in a container that can accommodate the entire triplex. - Gently bend it, trying to avoid any faults, if the plywood turns cold soak it back in hot water for a while. Then repeat the bending process. - Tie plywood if it has reached the desired level of curvature. - Dry plywood under the sun directly to eliminate the water content that has been absorbed, so that the plywood is stiff again. - Leave the plywood still attached for 1 week			
CHANGE	Triplex does not experience changes in the curvature of the final result.	Triplex does not experience changes in the curvature of the final result.	Triplex does not experience changes in the curvature of the final result.	

In the method carried out to get the bend buckling the implementation stages in each bend method use the same process as the bend method which is done with the difference of not using a binder to maintain its shape (Gutowski, 2019). That is preceded by eroding the plywood material, followed by making a reference line for buckling and proceeding by using the boiled method to flex the material and then using the bend method to find the desired angle (Chanda et al., 2020). Furthermore, drying the material. However, when doing the arch method, the curvature process is carried out slowly so that it often recurs the coldness of the material so it is necessary to re-boil the plywood material (Byeon et al., 2018).

Based on the physical exploration of the material carried out, it was found that the bending of the arch did not change after physical exploration (Makowski, 2019). However, the weakness of the arch method is the occurrence of fractures and cracks in the curved parts (Yalcinkaya et al, 2016).

Scraping

The scraping method is a process of reducing something little by little, especially the thickness of a material (Yalcinkayaet al, 2016). The scraping method is intended to reduce the thickness of the plywood gradually by rubbing the sandpaper on the surface of the plywood (Kajaks et al., 2019). In addition to reducing the thickness of plywood, the scraping methodis done to clean damaged parts of plywood caused by material exploration (Wascher et al., 2017).

Fig. 13. Methods of erosion of material

The scraping method is carried out on plywood using sandpaper. The sandpaper used in this method is divided into 3, namely rough, medium, and smooth (Jones et al., 2019). Coarse sandpaper is used to speed up the erosion process, this process aims to make three-ply plywood more flexible when the fine is curved or bent (Kajaks et al., 2019). The sandpaperis being used to reduce the rough texture produced by the process of using coarse sandpaper (Jones et al., 2019). Fine sandpaper is used to smooth the texture of plywood material and can also be used to disguise the damage resulting from material physical exploration (Wascher et al., 2017).

Fold

Folding is known to be a bending process so that the field which initially consists of one field into two fields results frombending the initial field to produce fields that meet and overlap and coincide (Cui et al., 2018). the folding method is oftenidentified with materials that have thin physical conditions such as paper or cardboard (Yalcinkaya et al, 2016). Folding exploration method into half of the previous field. The folding method for the exploration of plywood material is done toget results regarding the physical ability of plywood material until it can coincide (Mils & Ajaj, 2017).

Fig. 14. Folding plywood method

Folded plywood can be following the desired conditions. In doing the method of folding plywood previously boiled. In practice, this folding method is carried out manually and is divided into two types of folds, namely half folds and three folds (Vergauwen et al., 2017). The half-fold plywood fold is folded right in the middle so that the results of the two partscoincide with each other. Whereas three folds produced

4 parts of plywood that coincide with each other (Cui et al., 2018).For the fold method that produces 2 parts, the result is that the plywood can be folded perfectly with the addition of the clamping method. However, for the triple method, plywood material can be folded perfectly with deficiencies unable to adjust the distance to the wishes of the researcher (Mils & Ajaj, 2017). With these achievements, plywood can be folded perfectly but with limits regarding the provisions of distance that need to be considered.

Pinch and tie

In the exploration of plywood material is a method of pinning and fastening. The pinch method is the process of squeezingsomething hard. The triplex is clamped using a tool to squeeze the triplex that has been bent so that it is stuck and does not change its position (Kostova et al., 2019). The tie method is the process of using a rope to curb, unite, grip, or hold. In triplex, triplex is tied with a rope-like device or can also be a rope which is then tied with a certain pull to curb plywoodso that it does not change from the desired condition (Guo et al., 2020).

Fig 15. Pinch and tie method

The pinch and tie method is done so that the triplex that has been formed can be confined to the shape that has been made.In addition, the pinch and tie method is also included in the drying method so that when dry, the triplex stays in that position (Oya et al., 2018). The clamping method is done by utilizing the binder clip as a plywood clamping tool. The selection of binder clips due to the clamping process can result in maximum clamping to be able to press material (Kostovaet al., 2019). As for the tie method, the bond utilizes additional material such as cloth or rope to be able to tie. The use ofrope material to tie so that material that has been explored physically can maintain the shape as desired (Tsunenari & Oya, 2016). The tying method is a clamping material that is unable to adjust the shape to the desired one (Chen et al., 2018). Looseness of the bond can be a plus in forming bonding because its flexibility can help to maintain shape. But it can also be a disadvantage if the bond that is too loose changes its orientation/position then the shape can change (Fischeret al., 2017).

4. Discussion

4.1. Testing plywood

In its implementation, to obtain the uniqueness of the resulting form there needs to be testing (Rizzi et al., 2020). Testingis a process that aims to ensure all system functions have worked properly and to look for errors that might occur in the process carried out (Shamaev et al., 2018).

In a material exploration study. The purpose of the test is to detect a situation caused by the treatment carried out on the material and see the response of each treatment given to the material (Choi et al., 2018). because each material will respond to each treatment given according to its characteristics. In testing the exploration of plywood material, the resultsare related to the process of material exploration, namely testing with destructive methods and non-destructive tests (Rohuma et al., 2017).

Destructive test

In testing by crushing. What is done is testing that aims to determine the maximum limits of the material being explored (Shamaev et al., 2018). In its application, destructive tests are carried out in the form of achievement of the resulting formthat includes the damage that is present in the material being explored (Gutowski, 2019).

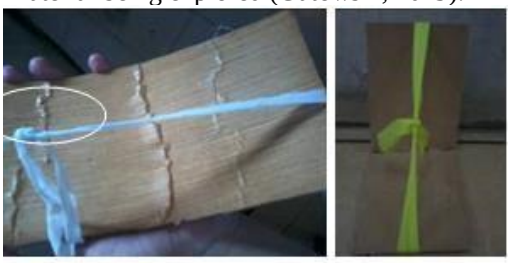


Fig. 16. Form of destructive test

Testing with the destructive test method on an exploration of plywood is produced by a deliberate and accidental process(Iqbal et al, 2016). Intentions that occur due to the physical exploration of plywood material directly are also related to maximizing the achievement of forms which in the process require coercion. Whereas destructive tests are produced accidentally (Gutowski, 2019). Obtained some damage that is not taken into account when carrying out physical exploration of plywood material (Galos et al., 2017). Besides, the damage can be permanent because it directly changes the structure of the material itself as in the case of a curved bend physical exploration that has cracks in some parts that cannot be ascertained to be the same (El Moustaphaoui et al., 2020). As well as dyed the outside of the plywood.

Non-destructive test

In tests that do not damage the material or non-destructive tests. Tests are carried out carefully and include several tools to achieve the desired shape (Gutowski, 2019). Achievement of forms without damage is the purpose of this test.

Fig. 17. Non-destructive test process

In this testing process, the material that has been explored can be seen from the naked eye. Because without the damage displayed and the achievement of the form, a non-destructive test can be a reference of selected material (Iqbal, 2016). The non-destructive test is found in the case of the plywood folding physical exploration process using a tool in the formof a plate as a tool to hold the corners of the plywood when folded without damage to both the outer surface and the insideof the fold (Gutowski, 2019).

4.2. Three-ply plywood application

Plywood is known to have advantages through its resistance to wood shrinkage and its length and width are

not easy to obtain from solid wood in the same quality conditions. But it cannot also be said that the plywood material has the sameresistance to the weather (Ramadhan, 2021). Therefore, plywood material is always recommended to be used as objects placed in the room (Sulityono, 2018). In its development, the material of plywood can be used to meet the needs of wood in the form of wide-sized boards. So that the plywood material has a special function that can be developed (Chang et al.,2018).

Fig. 18. Application of plywood material

In its application, the plywood that has been formed can be utilized as freely as possible, but due to its durability and the thickness factor of the material chosen, it is not recommended to apply it as a support for heavy objects (Ramadhan, 2022). Based on the results of exploration and testing, plywood material is often used even when placed not under the place and function (Sulistyono, 2018). this does not become a problem which means if the material can be modified to bedeveloped or reused. However, it should also be known that the material that has been used directly has decreased in quality. So if you want to use it, you need a broader knowledge to know the maximum limits that can be received from the material that has been used (Chang et al., 2018).

5. Conclusion

Plywood is known as one of the processed wood materials in the form of sheets. Plywood is included in the category of plywood material. What distinguishes plywood from material with other types of plywood is the number of sheets from the layer that forms it. With the amount of 3 layers of veneers, plywood becomes the least plywood material.

As one of the materials produced from processed wood, special attention is needed in producing it. Taking into account several criteria of wood that will be used to produce plywood material. Then plywood can be a material that will be usedor utilized. By considering the level of roundness and straightness of wood that is included with attention to the availabilityof wood, plywood can be one of the materials that will still be produced and utilized.

Plywood material is included in sheet-shaped material. As a sheet material, plywood consists of 3 layers which make it called the "three-ply". Plywood as a material cannot be separated from its formation process through production methods that go through several stages. The stage that becomes a reference by the place that produces plywood cannot be separatedfrom the previous reference. Utilization of plywood so that it becomes a material because of the need for wood material that has the characteristics of sheets. Not only that, but the presence of plywood material can also be due to the demand based on the limitations of existing wood material.

Visually, plywood material is a development of wood that is used as several sheets. Through production techniques that become references, the material is formed based on the utilization of various types of wood combined into sheets. As a wood substitute material obtained from wood as well, plywood material can be a substitute for wood to be used in formsother than sheets.

Plywood material can be explored physically to produce a form that can visually become another form. By using a simpletechnique the plywood material can produce another form. To get another form of plywood material, it is necessary to provide equipment that can support the method to explore the physical material of plywood.

In simple terms, physical exploration can be combined between tools and manuals (hand-working). The achievement of forms from physical exploration carried out not only produces simple techniques in exploring physical material but also can provide knowledge to create using plywood material. Although with a simple method of producing several other forms and producing other responses such as the changes that occur are not under the wishes, physical exploration of this material can be a reference for techniques that can be used.

As one of the materials developed by the manufacturer. Plywood material needs to know its structure in more depth. So that it is not only known in physical appearance. To know the characteristics of the material with certainty.

Plywood material is known to have a different structure compared to the main material of production. Then there is a need for further research to find out how the structure of plywood is certain to be developed into a new material that is equivalent to plywood material.

Plywood material which is physically a sheet material can be used as another form even though there are changes that arenot following the wishes. There needs to be other input on techniques that can be developed but in the context of simplemethods that combine tools with manuals.

With limited tools as support. It is hoped that this will be a creative idea to be able to develop tools that are purposely used for physical exploration of plywood materials. Apart from that, the results of this exploration still require input in the form of further research to determine the strength of the material that has been changed. Therefore, with further research that will produce mechanical values for plywood, it is possible to produce plywood material that has been processed in shape but with good strength. So there is a need for a physical material exploration method that uses simple methods so that people who do not have sophisticated equipment can do it. And this can be the key to being able to utilize materials in simple conditions with achievements in their utilization.

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