

# Utilization of Corn Skin Fiber (*Zea mays*) as a Gypsum Mixture for Making Ceiling with Epoxy Resin Binder

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## ABSTRACT

Gypsum materials have been prepared for ceiling applications from a mixture of raw materials: gypsum powders, corn husk fibers and epoxy resins by heat compression method with variations of gypsum powder composition: corn fiber: epoxy resin 25%: 0%: 40%, 23%: 2 %: 40%, 21%: 4%: 40%, 19%: 6%: 40%, 17%: 8%: 40%, and 15%: 10%: 40% wt. Sampling is done in three stages. The first stage of gypsum flour is sifted 100 mesh while the corn husk fiber is treated by immersing 2% NaOH then blended and sieved with a particle size of 100 mesh. The second stage of the filler (gypsum powder and corn husk fiber) is mixed with dry mixing and then mixed with epoxy resin as a matrix and thinner as a catalyst. The third stage of the homogeneous mixture is then inserted into the mold and compacted by heat to be more dense with 1 atm pressure held for 20 minutes at 70 °C. Each ready-mixed gypsum ceiling sample includes: physical properties (density, water absorption, and functional groups), mechanical properties (fracture strength, tensile strength, modulus of elasticity, and impact strength) and thermal properties (melting point) . The results of characterization showed that optimum composition in the composition of gypsum powder: corn husk fiber: epoxy resin 15%: 10%: 40%wt have density value  $1,589 \times 10^3 \text{ kg/m}^3$ , water absorption 2,84%, composed of OH and CH from cellulose and C = C groups of lignin. Mechanical properties with fracture strength 335,47 MPa, tensile strength 1845,43 MPa, modulus of elasticity 238,53 MPa and impact strength 278,9719 kJ/m<sup>2</sup>. Thermal properties with a melting point of 452.07 oC whose characterization results have met the conventional ceiling board standards. The results of gypsum-based composite gypsum powder material and reinforced epoxy resin fiber skin fiber can be applied as a ceiling roof.

**Keywords:** Epoxy Resin, Corn Skin Fibers, Gypsum Powder, Material Ceiling

## I. INTRODUCTION

Ceiling is one of the composite industry products that have a pretty good prospect in the present and the future. Basically asbestos raw materials come from the rest of the paper processing with lime mixture, so it does not require high quality raw material requirements. However, the ceiling that comes from asbestos has several disadvantages, such as: asbestos is not resistant to water, if the asbestos is easily broken (brittle) and asbestos can cause asbestosis disease,

because after being investigated asbestos is classified as toxic. Asbestos is made up of very small fibers, approximately thinner than 1/7 of our hair. These fibers evaporate in the air and do not dissolve in water, if inhaled by the lungs will settle there and can cause various diseases. Asbestos can harm our body if there is a part of asbestos damaged, so the fibers can be released, this is very dangerous because it is difficult to detect how broken asbestos said, and sometimes we are not aware that the asbestos we use is damaged<sup>[8]</sup>.

Asbestosis diseases include lung injury to breathing difficulty and can lead to death, mesothelioma which is a type of cancer that attacks the membranes of the abdomen and chest, symptoms appear after 20-30 years since first inhaling asbestos fibers, Cancer lungs are usually white asbestos main cause of lung cancer. These asbestos materials in some countries have been banned from use such as in China, USA, Columbia and other developed countries. This is because this material can cause cancer risk for the workers and the wearer<sup>[7]</sup>. Asbestos ceiling replacement solution is gypsum ceiling board<sup>[11]</sup>. Gypsum is a basic material in the manufacture of ceilings that have the chemical formula  $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ . So it is cooler and resistant to fire. Maize fiber (*Zea Mays*) is a lignocellulosic material that can be utilized as one of alternative raw material for ceiling making. The optimization of the ceiling-making process is strongly influenced by the adhesive and density levels of physical and mechanical properties<sup>[1]</sup>.

Corn skin is an example of waste of agricultural products that are very abundant. Corn crops can grow almost throughout the mainland of Indonesia, so no doubt if most people are familiar with this plant. Utilization of corn crop waste in the form of leather or corn klobot until now less than the maximum. People generally use corn waste as a traditional food wrapper, as animal feed, mats and handicrafts in the form of ornamental flowers. Corn waste is largely a lignocellulosic material. Corn skin content consists of 44.08% cellulose, 5.09% ash, 15% lignin and cyclohexane alcohol 57.01%<sup>[2]</sup>. The process of making the ceiling made from raw corn fiber fiber can be made by using epoxy resin adhesive. In general, the constituent in the friction material comprises fibers, fillers and binders. The binder comprises various types of resins including phenolics, epoxy, silicone and rubber. The resin serves to bind various constituents in the friction material. The binder may form a matrix at a relatively stable temperature<sup>[9]</sup>.

Gypsum is a white stone formed by seawater deposition, then heated at a temperature of 175 °C which is often referred to as STUCCO. Gypsum is one

of the most mineral in sedimentary environments that is rock consisting of massively produced minerals usually with the persitation of saltwater. Gypsum is a natural insulator, warm to the touch compared to bricks. Chemical composition of gypsum materials are: Calcium (Ca) 23.28%, Hydrogen (H) 2.34%, Calcium Oxide (CaO) 32.57%, Water (H<sub>2</sub>O) 20.93% and Sulfur (S) 18.62%<sup>[4]</sup>.

The physical properties of gypsum are white, yellow, gray, orange, black if impure, density 2.31 - 2.35 gr/cm<sup>3</sup>, hard as pearls, especially surfaces, mineral-shaped like crystalline, fibers and massive , luster like silk, low conductivity and crystalline systems are monoclinic. While the chemical properties of gypsum that contains SO<sub>3</sub> 46.5%; CaO 32.4%; H<sub>2</sub>O 20.9%, water solubility is 2.1 grams per liter at a temperature of 40 °C; 1.8 grams per liter of water at 0 °C; 1.9 grams per liter at a temperature of 70 °C – 90 °C, the solubility increases with the addition of HCl or HNO<sub>3</sub><sup>[6]</sup>.

## II. METHODS AND MATERIAL

### A. Applience and Materials Research

The applience used are 100 mesh sieves, oven, mixer, digital balance, moulding, hot press hydraulic, Universal Testing Machine, Fourier Transform Infrared Spectroscopy (FTIR), and Differential Scanning Calorimetry. The material used is gypsum flour, corn skin fiber (*Zea mays*), epoxy resin, 2% NaOH, Aquadest, paraffin and thinner.

### B. Research Variables

Research variables on the manufacture of ceiling materials include raw material composition and characterization.

**Table 1.** Percentage Of Ceiling Based On Gypsum Powder And Corn Skin Fiber Reinforced Epoxy Resin

Sample Code	Gypsum Powder (%wt)	Corn Skin Fiber (%wt)	Epoxy Resin (%wt)
A	25	0	40

B	23	2	40
C	21	4	40
D	19	6	40
E	17	8	40
F	15	10	40

As for the characterization of ceiling materials include: physical properties (density, water absorption, and functional groups), mechanical properties (tensile strength, modulus of elasticity, flexural strength and impact strength) and thermal properties (melting point/DSC).

### C. Research Procedures

#### Preparation of corn skin fiber and gypsum flour

Selected a fairly old corn husk fiber (brownish yellow). Cleansed corn husk fibers from dirt by soaking in water for 3 weeks. Dry corn fiber was cleaned in the oven at 37 °C for 7 hours. After drying, the corn husk fiber is soaked in fiber with NaOH (2%) for 24 hours to remove peptin and lignin levels. Cleansed corn husk fibers from 2% NaOH with running water until neutral pH. Re-dried corn husk fibers that have been soaked with 2% NaOH in the oven at 40 °C. After dry the corn husk fibers are cut to a random size of 0.5 - 2 cm and then sieved with 100 mesh sieves to obtain a homogeneous fiber size. Conducted preparation for gypsum flour by sieving it with a mesh size of 100 mesh.

#### Manufacture of Ceiling

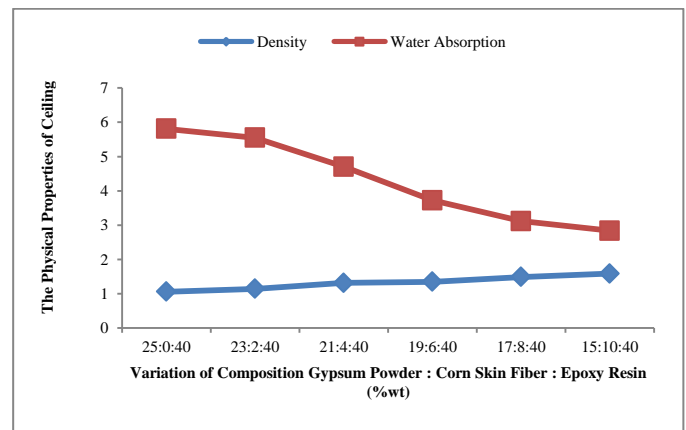
Weigh the basic ingredients as reinforcement: gypsum flour, corn fiber and epoxy resin with various composition (see Table 3.1). Mixed two ingredients of gypsum flour and corn fiber fibers with a total mass of 65 grams in a beaker glass then stirred dry mixing for 1 minute until homogeneous. Then the epoxy resin is inserted into the mixture with a resin and hardener ratio of 1: 1 of total mass mixed and stirred for 5 minutes and added a thinner catalyst to make the mixture homogeneous faster. Poured materials that have been mixed into the mold of iron and then compacted in hot press at 1 atm pressure at 70 °C and

held for 20 minutes. Released samples that have been compacted from the mold are then dried for 5-7 days at room temperature. Characterized samples include physical properties (density, water absorption, and functional groups), mechanical properties (tensile strength, modulus of elasticity, flexural strength and impact strength) and thermal properties (melting point/DSC).

## III. RESULTS AND DISCUSSION

### A. Characterization of Physical Properties For Ceiling

The physical properties of ceiling based on gypsum powder and corn skin fiber - reinforced by epoxy resin tested include density, and water absorption.



**Figure 1.** The physical properties (density and water absorption) behaviour for ceiling based gypsum powder/corn skin fiber/epoxy resin composite on various variations of composition

Figure 1 illustrates the effect of composition variation with density and water absorption values. From the figure it can be seen that the optimum density and water absorption value of the ceiling occurs in the composition of gypsum powder: corn skin fiber: epoxy resin (15:10:40)%wt with density of 1,589 x 10<sup>3</sup> kg/m<sup>3</sup> and water absorption 2,84%. Whereas poor density and water absorption in the composition of gypsum powder: corn skin fiber: epoxy resin (23: 2:40)%wt has a density of 1.145 x 10<sup>3</sup> kg/m<sup>3</sup> and water absorption of 5.548% is due to very little filler composition so that the bond imperfect composites

that result, at the time of compaction process then the particles that make up the ceiling bind very weak consequently oxygen molecules enter and form cavities. The results of the water absorption test of ceiling in this study have met the standard of gypsum material for conventional ceiling with density interval  $(0,55 - 1,2) \times 10^3 \text{ kg/m}^3$  and water absorption of  $(6 - 12)\%$  at water damping temperature of  $25 \text{ }^\circ\text{C}$ .

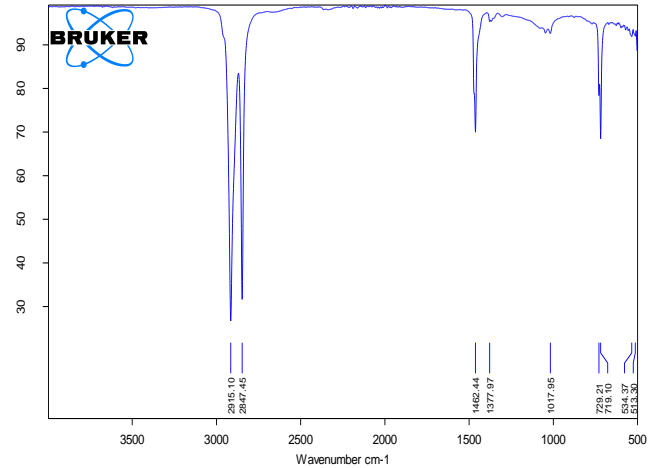
The density value is influenced by the addition of gypsum powders and corn husk fibers so that at the time of the emergence of air cavities due to the stirring process and even the compaction causing cohesiveness bonds (interfaces) gypsum powder and corn husk fibers with an imperfect epoxy resin matrix which affects the composite bond becomes weak. Thus, with the addition of maize fiber fibers having the composition of cellulose compounds having free groups of  $-\text{OH}$  and  $-\text{CH}$  such that the group will reach and bind the empty cavities to form strong and tight covalent bonds. In addition, the density is also affected by the roughness of the surface of the corn husk fibers where in the presence of friction forces between the fiber surfaces that still contain lignin substances caused by the compaction process (pressure) when administered under the tensile strength of the matrix (epoxy resin) and under the tensile strength of the reinforcement (gypsum powder and corn skin fiber) there is elastic deformation resulting in lower density value<sup>[5]</sup>.

While the water absorption value of the ceiling material is directly proportional to the mass of corn skin fiber, where the corn skin fiber has lignin content of caronyl group ( $\text{C}=\text{C}$ ) which has water-resistant properties, so that the composite in the optimum composition is not easy to enter by water<sup>[7]</sup>.

### **B. Characterization of Functional Group Properties For Ceiling**

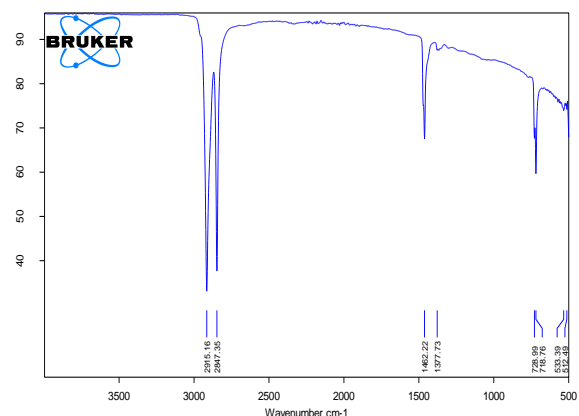
Characterization of chemical bonding function groups on ceiling material based on gypsum powder and corn skin fiber - reinforced by epoxy resin tested by FTIR

Nicolet iS10 type apparatus showing the particular waveform vibration peaks of the materials used for the preparation of gypsum ceiling materials based on the functional groups held by each of the ingredients ceiling.

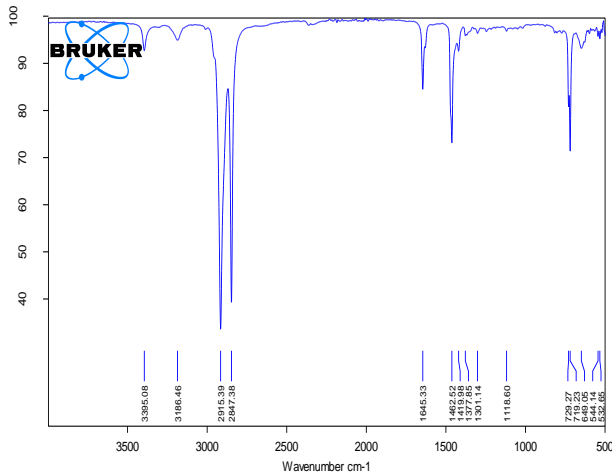


**Figure 2** .Analysis of FTIR ceiling material without the addition of corn skin fibers

In the IR spectra of ceiling material without the addition of maize fiber fibers characterized, an absorbing band of  $3395,08 \text{ cm}^{-1}$  waves indicated the overlap of vibration of the  $-\text{OH}$  group span, which is a gypsum powder group and a more dominant epoxy resin of 40% wt characterized strong and moderate absorption bands appeared at wave numbers  $3186,46 \text{ cm}^{-1}$  and  $2915,39 \text{ cm}^{-1}$  showing the overlap of the group  $-\text{CH}$  vibration of alkanes and the sharp and moderate absorption of wave numbers  $1377,85 \text{ cm}^{-1}$  and  $1301,14 \text{ cm}^{-1}$  showing the  $\text{C}-\text{NO}_2$  group of Nitro Aromatic is an epoxy resin compound mixed by thinner.



**Figure 3.** Analysis of FTIR ceiling material based on gypsum powder/corn skin fiber/epoxy resin on variation (23: 2: 40)%wt

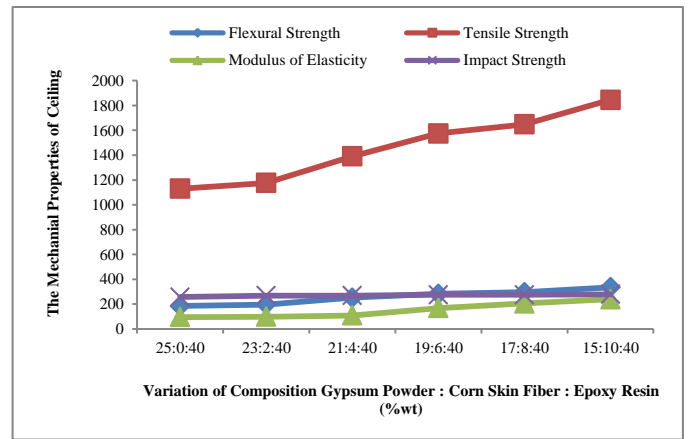


**Figure 4.** Analysis of FTIR ceiling material based on gypsum powder/corn skin fiber/epoxy resin on variation (15:10: 40)%wt

Band absorption at wave number 2915,39  $\text{cm}^{-1}$ , 2915,10  $\text{cm}^{-1}$  and 2915,16  $\text{cm}^{-1}$  showing the vibration of the C-H span of alkanes. In the IR spectral spectra of the preparation results with the addition of maize fiber fibers also gave rise to the -CH vibration of aldehydes in wave numbers 2847.45  $\text{cm}^{-1}$  and 2847.35  $\text{cm}^{-1}$  and is a cellulose compound and absorption band wave number 1462.44  $\text{cm}^{-1}$  and 1462.22  $\text{cm}^{-1}$  showing the vibration of the C = C range of the alkene which is the carbonyl group of the lignin compound group. This result when compared to unfilled ceilings with corn husk fillers still shows similarities in functional groups where there is no new and sharp peak. Because the ceiling is a composite derived from a mixture of different materials that produce new properties without altering the bonding structure<sup>[8]</sup>.

### C. Characterization of Mechanical Properties For Ceiling

The mechanical properties of ceiling based on gypsum powder and corn skin fiber - reinforced by epoxy resin tested include flexural strength, tensile strength, modulus of elasticity and impact strength



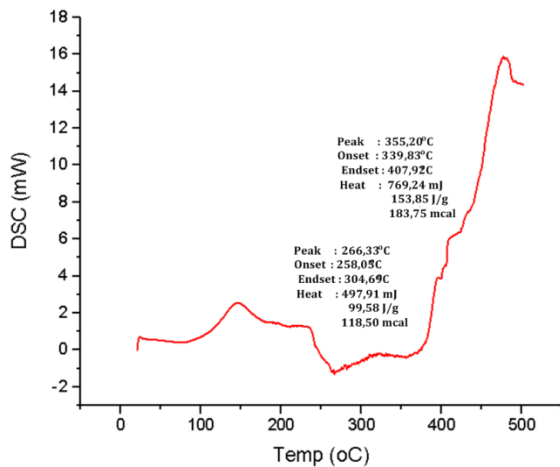
**Figure 5.** The indentation mechanical properties (flexural strength, tensile strength, modulus of elasticity and impact strength) for ceiling based on gypsum powder/corn skin fiber/epoxy resin composite on various variations of composition

From the results of the graph above shows that the mechanical properties increased in proportion to the increase of gypsum powder filler composition and corn skin fiber. It is shown from the result of research that optimum condition is obtained by optimum mechanical properties on gypsum powder composition: corn husk fiber: epoxy resin (15:10:40)% wt ie flexure strength 335.47 MPa, tensile strength 1845,43 MPa, modulus of elasticity 238.53 MPa, and impact strength 278,9719  $\text{kJ/m}^2$ . While on the bad conditions on the composition of gypsum powder: corn skin fiber: epoxy resin (23: 2:40) wt% with a flexure strength value of 195.89 MPa, tensile strength 1175,85 MPa, modulus of elasticity 97,99 MPa and impact strength 267,9356  $\text{kJ/m}^2$ .

The results of this study can be concluded that, when the gypsum ceiling material conditions have a low impact strength, due to the composition of the corn fiber fibers so low that the bonding of cellulose and lignin compounds is composed by a combination of hydroxyl (-OH), carbonyl (C = C) and CH an alkaline group having a low specific surface area that is not capable of maximally binding to the epoxy resin matrix bond which results in an unoccupied blank region as opposed to an optimum ceiling impact on the addition of 10% maize fiber fibers having a higher impact strength<sup>[3]</sup>.

**D. Characterization of Thermal Properties For Ceiling**

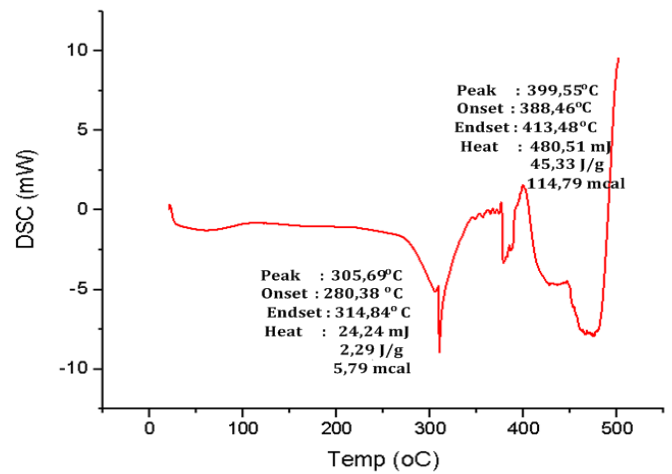
The thermal properties of ceiling based on gypsum powder and corn skin fiber - reinforced by epoxy resin tested include glass transition point (Tg), the point of crystallization (Tc), melting point (Tm) and decomposition point (Td). Where the peak changes by the DSC (Differential Scanning Calorimetry) occur as a result of changes and chemical reactions followed by temperature changes in the test sample. The chemical reactions that occur in DSC devices are exothermic and endothermic reactions<sup>[10]</sup>.



**Figure 6.** The Thermal Analysis of DSC ceiling material without the addition of corn skin fibers

Based on the results of DSC testing, in stage I that is Figure 4.10 shows the results of analysis of the thermal properties of the ceiling without the addition of corn husk fiber with variations of Gypsum Powder, Corn Fiber Composition, and Epoxy Resin (25: 0: 40) wt% given by the first maximum peak for the process of thermal change of ceiling material starting at 258.05 °C - 304.69 °C gives the valley peak which informs the point of crystallization (Tc) where the polymer is crystallized at 266.33 °C and there is an endothermic process in which the material composition of the ceiling began to absorb heat heat energy of 479.91 mJ. In the endothermic process the material of the ceiling material undergoes a deformation of rubber at a glass transition point (Tg) of 304.69 °C. After that, a maximum peak is formed at a temperature of 339.83 °C - 407.92 °C where at that temperature the ceiling material has undergone an

exothermic process in which the material starts to emit heat of 769.24 mJ resulting in physical and chemical changes resulting in a melting point of 355,20 °C.

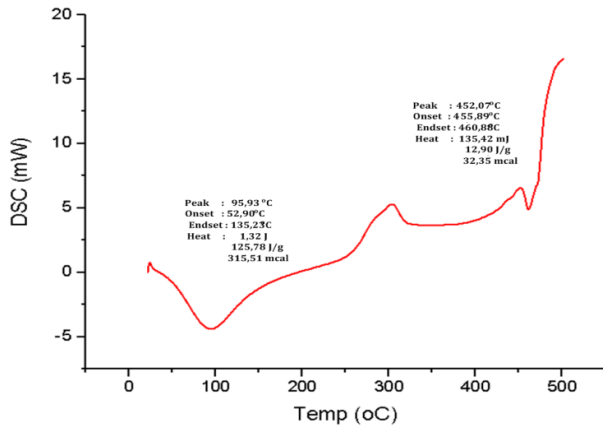


**Figure 7.** The Thermal Analysis of DSC ceiling material based on gypsum powder/corn skin fiber/epoxy resin on variation (23:2:40)%wt

Based on the graph of Figure 7 shows the results of the analysis of the thermal properties of the ceiling on variations in the composition of gypsum powders, corn skin fibers, and epoxy resins (23:2:40) wt% given by the first maximum peak for thermal change process of ceiling material starting at 280,38 °C - 314.84 °C produces a valley peak that informs the point of crystallization (Tc) where the polymer is crystallized at a temperature of 305.79 °C and then occurs an endothermic process in which the composition of the absorber material begins to absorb heat with a large amount of heat energy absorbed ie 24, 24 mJ. In the endothermic process the material of the absorber material undergoes a rubber deformation at the glass transition point (Tg) of 314.83 °C and the highest peak for the exothermic reaction at 388.47 °C - 413.48 °C with the thermal energy released equal to 480.51 mJ yields a melting point of 399.55 °C.

In the less optimum composition of lignin content as an anti-heat substance in the ceiling material is very little so that the melting point is very low, but the influence of addition of lignin substance and cellulose fiber skin corn on the ceiling material that is the

increase of melting points before and after given the addition of skin fiber composition corn ie from 355.20 °C to 399.55 °C.



**Figure 8.** The Thermal Analysis of DSC ceiling material based on gypsum powder/corn skin fiber/epoxy resin on variation (15:10: 40)%wt

Figure 8 shows the results of thermal properties analysis of gypsum material for ceiling application on the most optimum composition variations in gypsum powder variation, corn skin fiber and epoxy resin (15:10:40)% wt with a crystallization point ( $T_c$ ) of 95.93°C then occurs endothermic process of 1.32 Joule. Then the ceiling undergoes a rubber deformation at a glass transition point ( $T_g$ ) of 135.23 °C and a peak for an exothermic reaction at 455.89 °C - 460.88 °C with a heat energy released of 135.42 mJ yields a melting point of 452, 07 °C.

#### IV. CONCLUSION

In the study, gypsum material was obtained for gypsum powder-based composite application of powder and maize fiber reinforced with epoxy resin yielding the optimum composition (variation of composition (15:10:40)% wt has good physical properties with density  $1,589 \times 10^3 \text{ kg/m}^3$ , and water absorption of 2.84%. Mechanical properties with flexure strength 335,47 MPa, tensile strength 1845,43 MPa, modulus of elasticity 238,53 MPa and impact strength 278,9719 kJ/m<sup>2</sup>. Thermal properties with a melting point of 452.07 °C whose characterization results have met the conventional ceiling board

standards which has good physical, mechanical and thermal properties due to the presence of hydroxyl, carbonyl and CH alkene groups by compounds cellulose and lignin of corn husk fibers that can form a covalent cross link that can cover the hole (vacancies) caused by the presence of oxygen that is trapped so that it is not easily damaged which has been proven and tested by FTIR (Fourier Transform Infra Red).

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