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# Moisture Absorption Behavior of CP5 Composite Materials Used in Industry

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**Abstract**: In engineering practice, perhaps the most interesting aspect of woodworking deals with the relationship between wood and moisture. The plywood composite presents hygroscopicity characteristic, as the wood and reaction almost like a sponge, will gain or lose moisture from the air based upon the conditions of the surrounding environment. When the tree is in the green state, is first felled, it contains a very large amount of moisture existing in two different forms: as free water that is contained as liquid in the pores or vessels of the wood itself and as bound water, trapped within the cell walls. After that the wood is exposed to the air and immediately loose free water and the wood does not contract or otherwise change in dimension, it is in the state of drying and it is called the fiber saturation point. The moisture content in each piece of CP5 composite material is expressed as a percentage of the weight of the water and oven-dry weight of CP5 composite material. The moisture absorption depends on the wood type, density of wood and it is influenced by the environmental temperature, this is an aspect very important in the furniture industry. The moisture absorption test is generally used for quality control purposes and to measure the degradation of the quality for the wood and composite materials.

**Keywords:** Isotherm absorption, Composite materials, Rate of moisture, SEM analysis, Thermostat enclosure

## Introduction

Variation of the moisture content can cause wood to shrink and swell and alter its dimensions, affecting all wood properties. In the same time, the manufacturing, gluing, and finishing of wood and its mechanical, thermal, and acoustic properties are influenced by moisture content, this can increase weight 100 percent or more, with great effects on transportation costs. For realizing traction tests for the CP5 composite samples on the temperature and hydroscopic control, it was used an enclosure thermostat controlled in temperature and humidity.

The humidity can influence too, the processing operations, especially drying, preservative treatment, and pulping. The moisture content of CP5 composite material can be calculated based on its current and oven-dry weight. In the case of wood, the hygroscopic value varies between 30 to 100 percent, in function of species, position of the wood in the tree or year seasons. In this article we used a climate room with control system and an electric moisture meter portable that can measure the change of electrical properties of CP5 composite material, in function of changing moisture content. In the case of carbon-fiber-reinforced polymer matrix composites, the high specific strength, stiffness, and good chemical resistance, make them attractive for applications in aerospace components, sporting goods, civil structures, and marine vehicles, but humidity

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absorption can reduce their mechanical properties (Costa, 2006). For the basalt fibre reinforced polymer matrix composites, the moisture absorption influences considerable the mechanical properties (Pandian, 2014). By example for carica papaya fiber reinforced polymeric composites, the moisture absorption affects the thickness swelling behaviors on mechanical performances (Saravanakumaar, 2022).

Fiber-reinforced polymer composites may offer numerous attractive features such as low cost, high specific performance, and ease of production. But their durability and sustained performance depend of severe and changing environmental conditions. Property drop was observed to be much more significant for the samples that were exposed to lower freezing temperatures before moisture absorption (Hamidi, 2017). For the natural fiber composites was investigated the value of Fickian diffusivity constant, moisture equilibrium content and correction factor. Tests were carried out on composite plates, which was a combination of sugar palm fiber and epoxy resins and two different fiber compositions have been chosen which were 10% and 20% by weight and it is shown that, for composite plates that contain higher fiber composition, the moisture absorption rate is even higher (Leman, 2008).

## Method

For establish the moisture value for the CP5 composite samples in function of the temperature and hydroscopic control, it was used an enclosure thermostat controlled in temperature and humidity.  The thermostat enclosure is composed of the following elements:

- the inner tube of welded stainless steel sealed and exhaust bung;
- mineral wool insulation;

Two joints in silicon;

Door opener with wedge-thermal bridges: The principle of heating enclosure it is realized using the caloric resistances in stainless steel, arranged behind a table screen. The cooling is accomplished by a fluid evaporation condenser in a shifter in the form of copper tube. Concerning the adjusting the temperature, the cooling it is regulated using a tuning electro valve, been equipped with a cold circuit. The heating it is made using under voltage heating resistances with a static relay. For controlled humidity it is used a solenoid feed, a cold drying racket, electro valves that inject compressed and dried air.

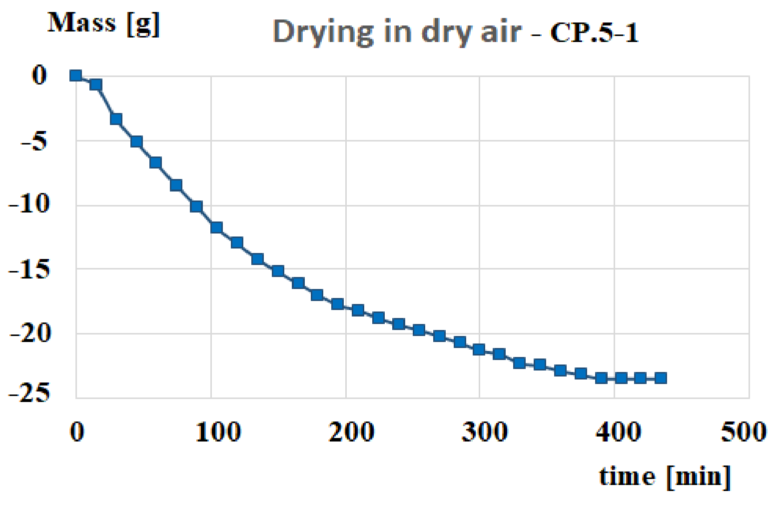


Figure1.Drying in dry air for C.P.5-1 composite material

## Results and Discussion

In this research, it was studied the moisture behavior for traction tests for the CP5 composite material. For CP5 composite material is shown the experimental values of absorption coefficients for moisture 1%H, at the temperature of 100$^{o}$C in the Table 1.

Table 1. Moisture coefficients for CP5 composite material at 1%H and the temperature of $100^oC$

| Temperature [oC] | Time [min] | Humidity [H] | Mass [g] |
|---|---|---|---|
| 25.4 | 0 | 1 | 0 |
| 79.8 | 15 | 1 | -0.7 |
| 102.3 | 30 | 1 | -3.3 |
| 102.3 | 45 | 1 | -5.1 |
| 102.4 | 60 | 1 | -6.8 |
| 102.4 | 75 | 1 | -8.5 |
| 102.4 | 90 | 1 | -10.1 |
| 102.5 | 105 | 1 | -11.8 |
| 102.6 | 120 | 1 | -13 |
| 102.4 | 135 | 1 | -14.2 |
| 102.6 | 150 | 1 | -15.2 |
| 102.7 | 165 | 1 | -16.1 |
| 102.6 | 180 | 1 | -17 |
| 102.4 | 195 | 1 | -17.8 |
| 102.6 | 210 | 1 | -18.2 |
| 102.6 | 225 | 1 | -18.8 |
| 102.6 | 240 | 1 | -19.3 |
| 102.4 | 255 | 1 | -19.7 |
| 102.4 | 270 | 1 | -20.2 |
| 102.5 | 285 | 1 | -20.7 |
| 102.6 | 300 | 1 | -21.3 |
| 102.6 | 315 | 1 | -21.6 |
| 102.6 | 330 | 1 | -22.3 |
| 102.6 | 345 | 1 | -22.5 |
| 102.4 | 360 | 1 | -22.9 |
| 102.4 | 375 | 1 | -23.2 |
| 102.6 | 390 | 1 | -23.5 |
| 102.6 | 405 | 1 | -23.5 |
| 102.4 | 420 | 1 | -23.5 |
| 102.6 | 435 | 1 | -23.5 |

In the Table 2 is presented the variation of the experimental mass values in function of time for the CP5 composite material for temperature of $20^oC$ and different moisture values and in the table 3 are presented the mass value in function of time at the temperature of $40^oC$ and different moisture values (20%H, 40%H, 60%H, 80%H). In the figure 2 is shown the curve of variation between the mass values and time for the temperature of $20^oC$ and different wettability coefficients (20%H, 40%H, 60%H, 80% H) and in the figure 3 it is represented the variation curve in the same conditions, but for the temperature of $40^oC$.

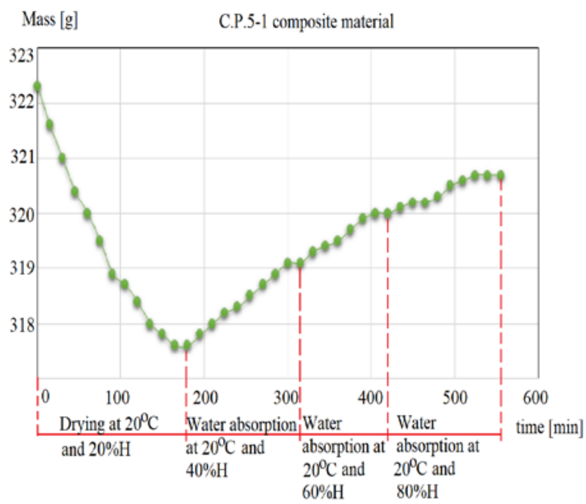


Figure 2. Curve of variation between the mass values and time for the temperature of 20°C and different moisture levels (20%H, 40%H, 60%H, 80% H).

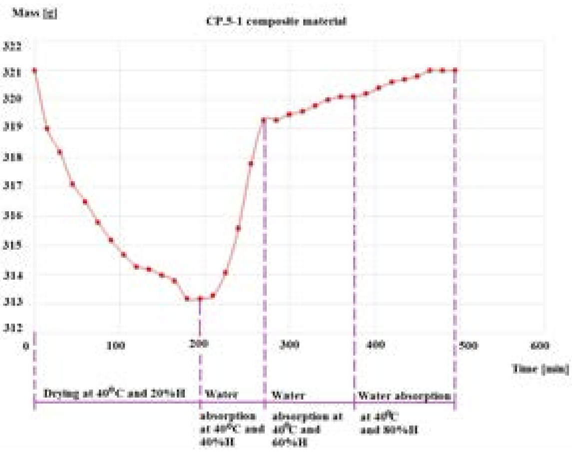


Figure 3. Curve of variation between the mass values and time for the temperature of 40°C and different moisture levels (20%H, 40%H, 60%H, 80%H)

Table 2. Mass variation in time for CP5 composite material at different moisture coefficients (20%H,40%H, 60%H, 80%H) and the temperature of 20°C

| Temperature [oC] | Time [min] | Humidity [H] | Mass [g] |
|---|---|---|---|
| 19.8 | 0 | 20 | 323.3 |
| 19.8 | 15 | 20 | 322.6 |
| 19.9 | 30 | 20 | 322 |
| 19.9 | 45 | 20 | 321.4 |
| 19.9 | 60 | 20 | 321 |
| 19.8 | 75 | 20 | 320.5 |
| 20 | 90 | 20 | 319.9 |
| 19.9 | 105 | 20 | 319.7 |
| 19.9 | 120 | 20 | 319.4 |
| 20.1 | 135 | 20 | 319 |
| 20.1 | 150 | 20 | 318.8 |
| 20 | 165 | 20 | 318.6 |
| 20 | 180 | 20 | 318.6 |
| 20 | 195 | 40 | 318.8 |
| 19.9 | 210 | 40 | 319 |
| 19.9 | 225 | 40 | 319.2 |
| 19.8 | 240 | 40 | 319.3 |
| 19.8 | 255 | 40 | 319.5 |
| 20 | 270 | 40 | 319.7 |
| 20 | 285 | 40 | 319.9 |
| 20 | 300 | 40 | 320.1 |
| 20 | 315 | 40 | 320.1 |
| 19.9 | 330 | 40 | 320.3 |
| 20.1 | 345 | 60 | 320.4 |
| 20.1 | 360 | 60 | 320.5 |
| 20 | 375 | 60 | 320.7 |
| 20 | 390 | 60 | 320.9 |
| 20 | 405 | 60 | 321 |
| 20.1 | 420 | 60 | 321 |
| 20.1 | 435 | 80 | 321.1 |
| 20.1 | 450 | 80 | 321.2 |
| 19.9 | 465 | 80 | 321.2 |
| 19.9 | 480 | 80 | 321.3 |
| 19.9 | 495 | 80 | 321.5 |
| 20 | 510 | 80 | 321.5 |
| 20 | 525 | 80 | 321.7 |
| 20 | 540 | 80 | 321.7 |
| 20 | 555 | 80 | 321.7 |

Table 3. Mass variation in time for CP5 composite material at different moisture coefficients (20%H, 40%H, 60%H, 80%H) and the temperature of 40°C

| Temperature [°C] | Time [min] | Humidity [H] | Mass [g] |
|---|---|---|---|
| 39.8 | 0 | 20 | 301.8 |
| 39.7 | 15 | 20 | 302.6 |
| 39.9 | 30 | 20 | 304.2 |
| 39.8 | 45 | 20 | 306.2 |
| 39.9 | 60 | 20 | 309.8 |
| 40 | 75 | 20 | 311.8 |
| 39.8 | 90 | 20 | 312.3 |
| 39.7 | 105 | 20 | 314 |
| 40 | 120 | 20 | 315.7 |
| 39.9 | 135 | 20 | 316.8 |
| 39.8 | 150 | 20 | 317.2 |
| 40 | 165 | 20 | 317.6 |
| 39.9 | 180 | 20 | 318.2 |
| 40 | 195 | 20 | 318.2 |
| 40 | 210 | 40 | 318.3 |
| 40.1 | 225 | 40 | 318.8 |
| 39.8 | 240 | 40 | 319.2 |
| 39.9 | 255 | 40 | 319.4 |
| 39.9 | 270 | 40 | 319.3 |
| 40 | 285 | 60 | 319.3 |
| 40.1 | 300 | 60 | 319.5 |
| 40.1 | 315 | 60 | 319.6 |
| 39.9 | 330 | 60 | 319.8 |
| 39.9 | 345 | 60 | 320 |
| 40 | 360 | 60 | 320.1 |
| 40.1 | 375 | 60 | 320.1 |
| 40 | 390 | 80 | 320.2 |
| 40 | 405 | 80 | 320.4 |
| 40 | 420 | 80 | 320.6 |
| 40.1 | 435 | 80 | 320.7 |
| 40.1 | 450 | 80 | 320.8 |
| 40 | 465 | 80 | 321 |
| 40 | 480 | 80 | 321 |
| 40.1 | 495 | 80 | 321 |

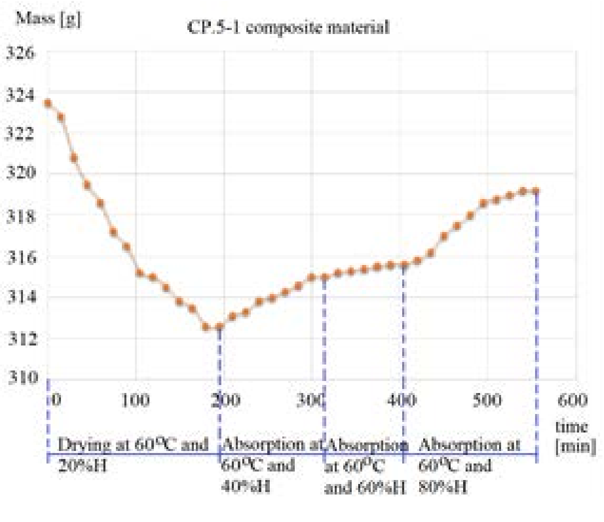


Figure.4. Curve of variation between the mass values and time for the temperature of 60°C and different moisture levels (20%H, 40%H, 60%H, 80% H).

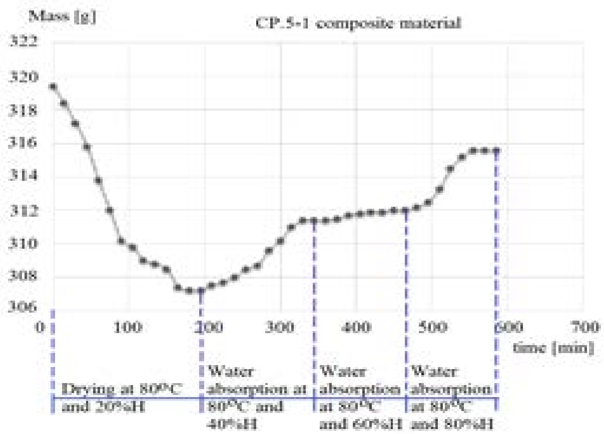


Figure 5. Curve of variation between the mass values and time for the temperature of 80°C and different moisture levels (20%H, 40%H, 60%H, 80%H)

Table 4. Mass variation in time for CP5 composite material at different moisture coefficients (20%H,40%H, 60%H, 80%H) and the temperature of 60oC

| Temperature [°C] | Time [min] | Humidity [H] | Mass [g] |
|---|---|---|---|
| 59.8 | 0 | 20 | 323.5 |
| 60 | 15 | 20 | 322.8 |
| 59.9 | 30 | 20 | 320.8 |
| 59.9 | 45 | 20 | 319.5 |
| 59.8 | 60 | 20 | 318.6 |
| 59.8 | 75 | 20 | 317.2 |
| 59.9 | 90 | 20 | 316.5 |
| 59.9 | 105 | 20 | 315.2 |
| 59.9 | 120 | 20 | 315 |
| 60.1 | 135 | 20 | 314.5 |
| 60 | 150 | 20 | 313.8 |
| 60.1 | 165 | 20 | 313.5 |
| 59.9 | 180 | 20 | 312.6 |
| 59.8 | 195 | 20 | 312.6 |
| 59.9 | 210 | 40 | 313.1 |
| 60 | 225 | 40 | 313.3 |
| 60 | 240 | 40 | 313.8 |
| 59.8 | 255 | 40 | 314 |
| 60 | 270 | 40 | 314.3 |
| 59.9 | 285 | 40 | 314.6 |
| 60 | 300 | 40 | 315 |
| 60.1 | 315 | 40 | 315 |
| 59.9 | 330 | 60 | 315.2 |
| 60 | 345 | 60 | 315.3 |
| 60 | 360 | 60 | 315.4 |
| 59.8 | 375 | 60 | 315.5 |
| 59.8 | 390 | 60 | 315.6 |
| 59.9 | 405 | 60 | 315.6 |
| 60.1 | 420 | 60 | 315.8 |
| 60.1 | 435 | 80 | 316.2 |
| 60.1 | 450 | 80 | 317 |
| 59.9 | 465 | 80 | 317.5 |
| 59.9 | 480 | 80 | 318 |
| 60 | 495 | 80 | 318.6 |
| 59.8 | 510 | 80 | 318.8 |
| 60 | 525 | 80 | 319 |
| 60 | 540 | 80 | 319.2 |
| 60 | 555 | 80 | 319.2 |

Table 5. Mass variation in time for CP5 composite material at different moisture coefficients (20%H, 40%H, 60%H, 80%H) and the temperature of 80°C

| Temperature [°C] | Time [min] | Humidity [H] | Mass [g] |
|---|---|---|---|
| 79.7 | 0 | 20 | 319.4 |
| 79.7 | 15 | 20 | 318.4 |
| 79.6 | 30 | 20 | 317.2 |
| 79.6 | 45 | 20 | 315.8 |
| 79.6 | 60 | 20 | 313.8 |
| 79.7 | 75 | 20 | 312 |
| 79.7 | 90 | 20 | 310.2 |
| 79.6 | 105 | 20 | 309.8 |
| 79.8 | 120 | 20 | 309 |
| 79.8 | 135 | 20 | 308.8 |
| 79.7 | 150 | 20 | 308.5 |
| 79.7 | 165 | 20 | 307.4 |
| 79.8 | 180 | 20 | 307.2 |
| 79.8 | 195 | 20 | 307.2 |
| 79.7 | 210 | 40 | 307.5 |
| 79.8 | 225 | 40 | 307.7 |
| 79.8 | 240 | 40 | 308 |
| 79.8 | 255 | 40 | 308.5 |
| 79.6 | 270 | 40 | 308.7 |
| 79.7 | 285 | 40 | 309.6 |
| 79.7 | 300 | 40 | 310.2 |
| 79.8 | 315 | 40 | 311 |
| 79.8 | 330 | 40 | 311.4 |
| 79.8 | 345 | 40 | 311.4 |
| 79.9 | 360 | 60 | 311.4 |
| 79.9 | 375 | 60 | 311.5 |
| 79.9 | 390 | 60 | 311.7 |
| 79.8 | 405 | 60 | 311.8 |
| 79.8 | 420 | 60 | 311.9 |
| 79.7 | 435 | 80 | 311.9 |
| 79.7 | 450 | 80 | 312 |
| 79.9 | 465 | 80 | 312 |
| 79.8 | 480 | 80 | 312.2 |
| 79.9 | 495 | 80 | 312.5 |
| 79.7 | 510 | 80 | 313.3 |
| 79.8 | 525 | 80 | 314.5 |
| 79.8 | 540 | 80 | 315.2 |
| 79.8 | 555 | 80 | 315.6 |
| 79.8 | 570 | 80 | 315.6 |
| 79.7 | 585 | 80 | 315.6 |

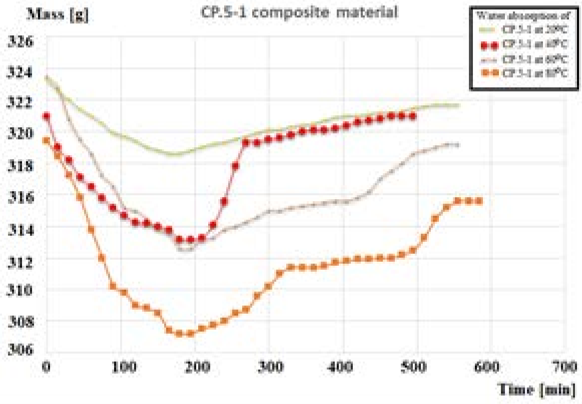


Figure 6. Curves of the variation of the mass during the time in function of different temperatures

Figure 7. SEM analyses plywood CP5 composite

In the Table 4 is establish the variation of the mass values during on time for the CP5 composite material for temperature of 60$^{o}$C and different moisture values and in the table 5 is shown the mass value variation in function of time at the temperature of 80$^{o}$C using different moisture values (20%H, 40%H, 60%H, 80%H). In the figure 4 is presented the curve of variation between the mass values and time for the temperature of 60$^{o}$C and different wettability coefficients (20%H, 40%H, 60%H, 80% H) and in the figure 5 it is shown the variation curve in the same conditions, for the temperature of 80$^{o}$C. In the figure 6 can remarck the different curves that show the variation of the mass during the time for the CP5 composite material. In figure 7 is presented the microscopic structure of CP5 composite material.

## Conclusion

Due to the urge of developing environmentally friendly materials, researches in new dimensions evolved .This new dimension focuses on developing eco friendly material with good mechanical strength. The CP5 composite materials presents a higher moisture resistance in comparisons with different other composites. At the humidity value of 20%H, can remarck a drying process for the composite materials, if it increases the humidity values, can remarck an increase of mass values proportional with the humidity percents, because of the water absorption in the composite materials, although the temperature rises. Its superior properties will certainly help Composite engineers, researchers, manufacturers in developing environment friendly materials for a better tomorrow in future and could substitue the synthetic plastic and non degradable plastic.

## Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in EPSTEM journal belongs to the authors.

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