Manufacturing Heatproof Ceiling from Agricultural Wastes

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Abstract

This article introduces the results of researching, manufacturing, testing and application of insulation panels produced from agricultural waste, first in Vietnam successfully studied. The results showed that the insulation panel made from agricultural waste has many advantages and when used as the ceiling of the industrial plants are suitable. This work appreciated by the state, local television stations and newspapers.

1. Introduction

1.1. Demand of settling output for agricultural wastes

Vietnam is an agricultural country, annually wastes ten millions ton of agricultural wastes such as: rice husk, straw, bagasse, coconut fiber, banana, maize, bean cover ... Many surveys used these materials and it was used for combustible, fiber, craft, fertilizer, mushroom planting, flower planting, water filter .... However, its usage is only occupied a little rate, mainly wastes was discarded caused pollution by two main forms:

- Discard uncontrolled caused pollution in the canals, river banks, village roads in the southern area and rural.
- Burnt caused CO₂ to the environment, smoked impacted to the people life.

With that situation, on 13 July 2011 Deputy PM Hoàng Trung Hải assigned Ministry of Natural Resources and Environment urgently to survey, suggest treating straw, avoid burning caused pollution and people life [2].

1.2. Material demand for heatproof ceiling panel

Long time ago, people used different materials for manufacturing ceiling panels, but main use is only for decoration and coverage for concealed equipment, its heatproof is not important element. Thus these materials are
only for decoration. We mark some materials as follows:

- **Plaster ceiling panel**: Only suitable for civil houses, most weakness of plaster ceiling panel is not anti-soak, if being soak it will be damaged immediately. In impulse places, it may be damaged. No use for factory.

- **Plastic ceiling panel**: Only prevent direct radiation through the metal sheet, no ability prevent heat because of its thin. Most weakness of plastic ceiling panel is getting old, dried, brittle and damaged quickly when radiation direct from the metal sheet. Further, it is easy to be burnt and damaged under external force.

- **Alu ceiling panel**: High cost price and no ability to proof heat because its mainly form in net to cover the upper part, conduct heat well, cannot be manufactured for factory, warehouse...

These materials are generally suitable to houses, civil projects, for factories, warehouses, restaurants …. it is not suitable.

From these reasons above, we surveyed to use agricultural wastes to manufacture heatproof ceiling panels with no-old under radiation from the metal sheet in long item, with colorful...

### 2. Survey, manufacturing heatproof ceiling panels

#### 2.1. Panel press equipment

To manufacture heatproof panels, we made simple engineering penal press equipment. It works by manual, to manufacture panel standard size 600×600 (mm), with adjustable thickness. Engineering press permits for suitable press materials for endurance of panel. Further, presser permits dismounted easily for finished panels by lever system (Figure 1).

![Figure 2: Panel presser](image)

#### 2.2. Manufacturing process

By survey and test, we set up manufacturing process for each type of panel. Main processes including:

- **Choosing material**: Material is chosen assured good, mechanical feature, even color and well. No choice fade, moldy, or dirty materials.
- **Drying material:** To make sure not moldy, fade and more important to assure heatproof.
- **Processing material:** Material is cut in piece as in fixed size, to assure equal, flat of finished panel. After cutting into pieces, we have chosen for fixed size to manufacture panels.
- **Mixing glue with material:** Glue is a general glue to adhesive, keep natural color for product, waterproof, assure panel not decay in water … Adhesive is counted for each material and different thickness. Mixing work is important for evenly mixed adhesive, for requirement reached all material mixed with adhesive.

![Figure 3: Mixing material](image)

- **Preparing press:** In mixing material adhesive with material, we prepare mould to press, coating material …
- **Putting material to presser and pressing panel:** Material put to presser evenly then to press it. Pressing with average speed, no quick for evenly pressed, no eccentric, assure flat and even thickness. After pressing to a thickness to stop, fix the presser and wait until material dried about 15-30 minutes based on different panel type and thickness.
- **Dismounting panel:** After panel is dried, it is dismounted. Turning upside pressing crane and button panel pushing. Thus to assure panel pushing up the same time with pressed face, avoid damaged panel because of rub against the mould wall.
- **Drying finished panel:** Finished panel after dismounted to get hardness needed, but not dried 100%, it needs to dry up 8 hours more.

### 2.3. Panel product

We manufactured different panel materials from rice husk, bagasse, shavings, coconut fiber, peanut shells…
In the Figure 4 shown different panels manufactured by us in checking and installation.

2.4. Application deployment

We have chosen Quoc Hoa Co., Ltd. at address: 2 & 4 Nguyen Van Thoai St., Ngu Hanh Son District, Da Nang City to install. This is a convenient place because of its intersection of big streets. The installed room is transaction office of the company, area 30 m², roof by metal sheet. Before installation, the room used plastic ceiling which is hot, caused difficult work condition.

By application, we found:

- Radiation heat from the roof is almost prevented; temperature in the room is colder.
- The ceiling has natural color, satisfied art requirement for luxury projects such as guest house, office, restaurant...
- With alu frame, it responds for panel load, no sag-down phenomenon. In rainy storm condition, the panel weight assures to keep solidly in alu frame.
- Panel covered to ceiling, no sag-down phenomenon, even wet panel because of rain.
- Panel does not attract insects.
3. Checking, assessment on finished panel features

3.1. Assessing heatproof ability of panel

Test description

A material is considered good heatproof if its heat conducting is poor. Heat conducting of material is specified by heat conducting factor \( \lambda \) (W/m.K). When \( \lambda < 0.23 \) W/m.K the material is considered as heatproof.

To confirm heat conducting factor of panel, we make a cube, size 600x600mm, the mid has light bulb capacity 200W. Use thermometer to measure temperature in and out of panel.

Confirming heat conducting factor

When time is enough for stability, we have heat equation:

\[
Q = U.I = Q_B + Q_T + Q_D
\]

\( Q_B \) – Temperature passes in side wall of panel, W:

\[
Q_B = 4.F.\frac{\lambda}{\delta}(t^B_{w1} - t^B_{w2})
\]

\( Q_T \) – Temperature passes in up side of panel, W:

\[
Q_T = F.\frac{\lambda}{\delta}(t^T_{w1} - t^T_{w2})
\]

\( Q_D \) – Temperature passes in lower side of panel, W:

\[
Q_D = F.\frac{\lambda}{\delta}(t^D_{w1} - t^D_{w2})
\]

In indexes “\( w_1 \)” “\( w_2 \)” corresponding to in and out sides. Indexes “\( B \)” “\( T \)” and “\( D \)” correspond with side, up and lower sides.

\( U \) [V], \( I \) [A] – Voltage and current intensity through the light bulb.

\( \lambda \) - heat conducting factor of panel, W/m.K ;

\( \delta \) - thickness of panel, m ;

Inferred:
\[ \lambda = \frac{Q}{F \cdot 4 \cdot \left( t_{w1}^B - t_{w2}^B \right) + \left( t_{w1}^T - t_{w2}^T \right) + \left( t_{w1}^D - t_{w2}^D \right)} \]  

(5)

**Test and calculation result**

Table 1: Heat conducting factor confirming result $\lambda$ of panels, W/m.K

<table>
<thead>
<tr>
<th>No.</th>
<th>Rice husk panel</th>
<th>Bagasse panel</th>
<th>Sawdust panel</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\lambda$, W/m.K</td>
<td>0.085</td>
<td>0.155</td>
<td>0.175</td>
</tr>
<tr>
<td>$\rho$, kg/m$^3$</td>
<td>153</td>
<td>167</td>
<td>195</td>
</tr>
</tbody>
</table>

2 Comparing with heat conducting index and weight of panels with other heatproof materials, we found that its heatproof ability is much better other materials. On weight, it is only heavier than fiber glass.

Table 2: Comparison panel features with other materials

<table>
<thead>
<tr>
<th>Indexes</th>
<th>Ditomite</th>
<th>Fiber glass</th>
<th>Asbestos</th>
<th>Plaster</th>
<th>Fibrolite</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\lambda$, W/m.K</td>
<td>0.11–0.17</td>
<td>0.035–0.174</td>
<td>0.09–0.26</td>
<td>0.25</td>
<td>0.098–0.197</td>
</tr>
<tr>
<td>$\rho$, kg/m$^3$</td>
<td>500–700</td>
<td>95</td>
<td>1000–1300</td>
<td>1650</td>
<td>300–500</td>
</tr>
</tbody>
</table>

3.2. Tests and checks for other features

a- **Fast color:**
To test fast color, it must have time to verify. By checking panel manufactured since 4/2010 we found its color is still kept, not changed. It is because we used dried, endurable material and by special adhesive layer mixed before pressing. By this adhesive layer, mould has no condition to develop.

b- **Absorbent and decay in water:**
Because panels are pressed from agricultural wastes so they have absorbent. However by the adhesive layer, its absorbent ability is limited. On the other hand, by the adhesive layer panels are not decay and soft in water. This is very important nature in using for factory and condition project ceilings.

c- **Testing endurance**
We manufactured panels in special technical process: tightly compressed, adhesive quality, molding time, panel thickness… All these elements tested in many manufactures, changes chemical concentration to get needed endurance, no broken. Product endurance is tested by eyesight and well actual deployed result.

d- **Test firing**
We tested these panels and recognized panels are hard to be fired, no fire concealed because its compressed necessary.

4. **Economic technical effectively assessment**

4.1. **Economic effect**
Based on manufactured materials for panel (material, adhesive, acid, labor cost, equipment amortization), we
confirm cost price of 1m$^2$ panel manufactured by us is **175,000 dongs/m$^2$**. If comparison with other ceiling materials, it is much cheaper than plaster and alum ceiling panels. Plastic ceiling panel is cheap but having a lot of weak points above mentioned.

<table>
<thead>
<tr>
<th>Plaster ceiling panel</th>
<th>Alu ceiling panel</th>
<th>Plastic ceiling panel</th>
</tr>
</thead>
<tbody>
<tr>
<td>220.000 VND/m$^2$</td>
<td>300.000 – 700.000 VND/m$^2$</td>
<td>21.000 VND/m$^2$</td>
</tr>
</tbody>
</table>

4.2. Technical features

With traditional ceiling panels we found it is not suitable for industrial projects.

Our manufactured panels used well for factory, warehouse, restaurant … projects because: they have good heatproof nature, no old under heat radiation from the metal sheet, no damage, no wet, no shake. And it also uses for civil projects such as house, office … with good color and flat smooth.

5. Conclusion

By survey, testing manufacture of heatproof panel from agricultural wastes, we have conclusion as follows:

a. Panels manufactured have good heatproof, satisfied heatproof demand of construction projects in Vietnam.

b. Panels have good appearance, good color, used friendly environment materials, closed to Vietnamese, protecting environment, increasing income for farmers, easy manufacturing.

c. Endurable color, no old under heat, endurance, no wet, no swell and no break in water.

d. Light weight, no catching fire, and reasonable price.

e. Manufacturing heatproof panels from agricultural wastes is a suitable way to settle pollution in rural, and making out a suitable material for industrial projects.

f. In manufacturing we used adhesive glue. This is permitted in usage, mixing rate is small, chemical in use mixed in panels, not scattered to the environment, so it is not impacted to the environment.

References

Reference book


Website