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EFFECT OF USING INTERNAL PACKAGING MATERIALS FOR NEW BUILDING WALLS ON HEATING LOAD

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Abstract: Experimental and theoretical investigation of three types of internal packaging materials(PVC, MDF, Gypsum board) for the residential building was carried out in the present work, to reduce heating load in winter. Experiments were carried out at the university of Wasit (Al-Kut city, late 32.5N), winter season by building small room from sandwich panel. The room's dimensions were 2m width, 2m length and 2.4m height.On the south wall, made two slots, the slot dimensions are 0.3m width and 1m height. Two types of walls built in the two slots. The first wall was built from common bricks. The second wall was built from bricks covered with packaging material. The radiant time series (RTS) method was used for calculating the experimental heat losses through the walls.ESP-R used to calculate the theoretical result. The results of the experimental work show that. The maximum values of percentage energy saving as follows: Internal packaging materials; 22.87% MDF, 20.48% PVC and 16.45% Gypsum board

Keywords:*packaging material, interinal packing material, heat loss, RTS*

دراسة تاثير استخدام مواد التغليف للجدران الداخلية في الابنية الحديثة على حمل التدفئة

الخلاصة: أجريت دراسة عملية ونظرية لثلاثة انواع من مواد التغليف لجدران الداخلية (حشب و بلاستيك مجوف و الواح جبسية) للابنية السكنية الحديثة لتقليل حمل التدفئة. أجريت التجارب في جامعة واسط (مدينة الكوت خط عرض 32.5 شمال)، في فصل الشتاء ببناء غرفة صغيرة بقياس 2م * 2م * 2.4م من السندويج بنل. شق في الجدار الجنوبي فتحتيين. ابعادها هي 1م x 0.3م في كل فتحة بني جدار. الجدار الاول بني من الطابوق. الجدار الثاني بني من الطابوق تم تغليفة بأنواع مختلفة من مواد التغليف. حسب فقدان الحرارة عمليا باستخدام السلاسل الزمنية (RTS). اظهرت نتائج العمل التجريبي ان القيم القصوى من نسبة توفير الطاقة على النحو التالي: مواد التغليف الداخلي :22.87% الواح الخشب و 20.48% بلاستيك مجوف و 16.45% الواح جبسية.

1. Introduction

Many buildings constructed in the present, most are far from the principles of energy conservation, as the main reason for the lack of controls and regulations which oblige a designer to observe this building controls during the design process.

The thermal performance of buildings during the design or implementation of choosing construction materials and building systems that reduce heat loss from buildings must be studied, especially when using modern construction or non-traditional materials. Methods , new types of decoration materials and new building materials have appeared in the current time. The thermal properties, its effect on convection and energy consumed for air conditioning equipment must be known[2] .

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Outdoor temperature in winter reaches down to 5°C in Al-kut[3] . It is necessary to use heating equipment. The main aim of the present work is to reduce heating load of the building. By investigation the performance of used packaging material (PVC, MDF, Gypsum board)in building on the walls.

2. Experimental Work

The experimental work consists of preparing a packaging material and then building an experimental room to investigate the effect of packaging material on heat loss from the space to the outside of the room.Experiments were carried out at the university of Wasit (Al Kut city, lat 32.5N) by building a room to be in direct contact with solar radiation, in the winter season, especially for the coldest monthly (February 2016).
The study concentrated on the south wall of the experimental room. Many kinds of packaging materials were used to minimize the heat loss transmission through the wall from the inside room to outside.The packaging was fixed on the south wall at internal side; PVC, MDF and Gypsum board.

2.1. *Room Models*

The model consists of one room, the walls and roof of the room built from the sandwich panel of polyurethane foam (0.029 W/(mK)) 5 cm thickness to reduce the heat transmission to the minimum valueof all wall's direction: north, west, east and south except a slot in the south wall which was under this study. The room's dimensions were 2 m width, 2 m length and 2.4 m height as shown in fig. 1. In the south wall made two slots, the slot dimensions are 0.3 m width and 1 m height.All the walls were exposed directly to the outdoor conditions.Building a room walls facing the four directions North, South, East and West.The floor is made from wooden pallet 17 mm thickness.

Fig. 1: Room model

The two slot walls built from bricks one of them covered with different type of packaging material.as shown in Fig. 2.Theresults will be compared with the first wall (with packing) to show the heat transmission saved by packaging.

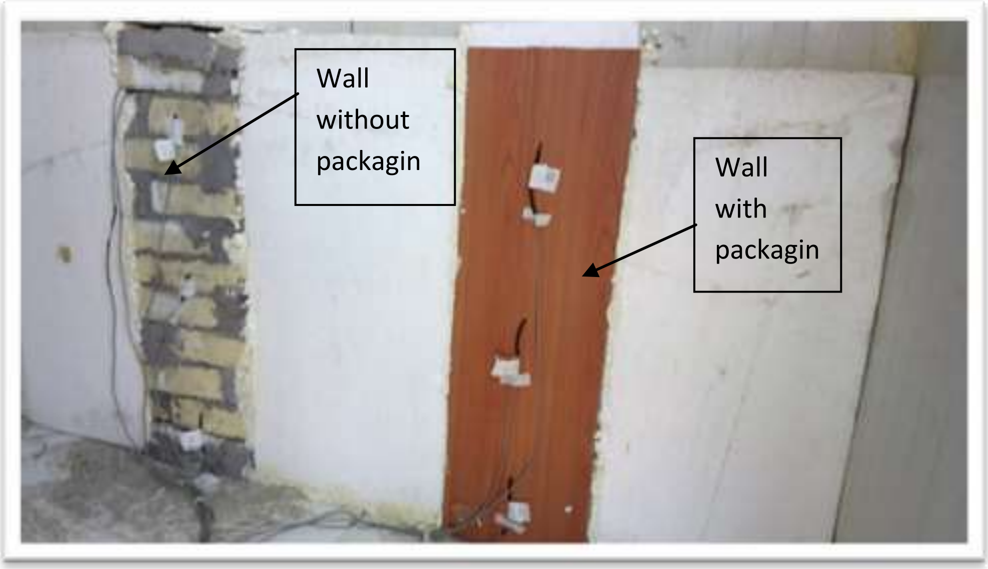

Fig. 2: Brick wall with and without packaging

2.2. *Packaging Materials*

Three types of packaging material were tested: PVC, MDF and Gypsum board, packaging fixed oninternal walls, as shown in fig. 3. It can be described as following

Fig. 3: Wall with internal packaging

2.3. *Measurement Apparatus*

2.3.1. *Temperature Data Logger (LabjackWith Thermistors) LabJack*
In this study, a LabJack model, U3-LV, data logger was used. This data logger has 16 inputs channel with labjack extension as show in fig.4, which were used to measure the temperature data.

2.3.2. *Solar Power Meter*

Solar radiation measured by solar power meter type (TES-1333R) in W/m², made in china the device was used for measuring the solar radiation intensity during all day at experimental times as show in fig.4.

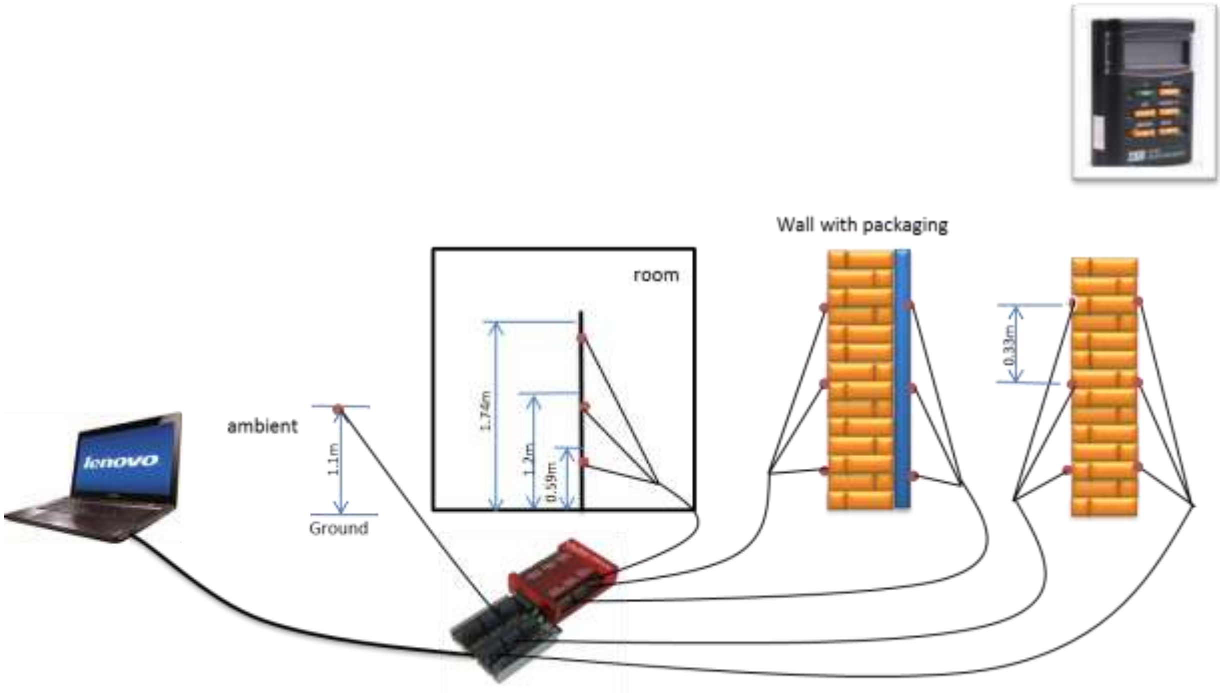

Fig. 4: Connection of the temperature measurement

2.4. *Heating Equipment*

The room model heated by a heating unit (model no.: KPT-2000B 5207L) maintain at constant temperature about 25°C by using the heating unit (Ceramic fan heater). The unit consists of two electric heaters (1000 watt) with fan and thermostat to control the room temperature. This unit work during day and nigh-time continually. The device has proven in the northern wall,1.5m above the floor**.**

2.5. *Types of Tests*

2.5.1. PVC

A wall composed of bricks added PVC panel hollow sheet of 0.3m x 1m. The probationary period of 2-Feb-2016 at 8a.m. to 3-Feb-2016 at 7a.m.

PVC Wall Panels are designed for interior walls and ceiling. Wall panels made of this material deservedly enjoy great popularity among the customers for several reasons: Low cost, excellent insulation, resistance to environmental factors (high and low temperature, moisture), high resistance to aggressive media: acids, alkalis, chemical reagents.

2.5.2. MDF

A wall composed of bricks added MDF panel hollow sheet of 0.3m x 1m. The probationary period of 3-Feb-2016 at 8a.m. to 4-Feb-2016 at 7a.m., comparing the results wi MDF (Medium Density Fibreboard) is a type of hardboard, which is made from wood fibres glued under heat and pressure.th a second wall of bricks only.

2.5.3. Gypsum Board PVC

A wall composed of bricks added Gypsum board sheet of 0.3m x 1m. The probationary period of 8-Feb-2016 at 8a.m. to 9-Feb-2016 at 7a.m., comparing the results with a second wall of bricks only.

Gypsum board is a panel made of gypsum plaster pressed between two thick sheets of paper. It is used to make interior walls and ceilings. Advantages of Gypsum Board Construction: Fire Resistive, Sound Attenuating, Durable, Economical and Versatile**.**

3. Method of calculation

3.1. *Theoretical calculation*

The ESP-R program from Energy Systems Research Unit (ESRU) - University of Strathclyde used to calculate the theoretical results. It is the intensity of the radiation and temperature on the walls[4].
The theoretical results were calculated by using the program ESP-R.
Three steps required for using the program
1-Model creation, 2-Simulation, 3-Results analysis

3.2. *Experimental calculation*

Heat Loss**:** using Radiant Time Series (RTS) Method to calculate heat loss**:**
The radiant time series (RTS) method is a new simplified method for performing design heat load calculations that was derived from the heat balance (HB)[5].

Conductive Heat loss Using Conduction Time Series.

$$Q_{i,\theta-n} = UA(T_{e,\theta-n} - T_{r,\theta-n}) \tag{1}$$

Where
$Q_{i,\theta-n}$: Conductive heat input for the surface n hours ago, W.
U : Overall heat transfer coefficient for the surface, W/(m^2K).
A : Surface area, m^2.
$T_{e,\theta-n}$: Sol-air temperature n hours ago, °C.
$T_{r,\theta-n}$: Presumed room air temperature n hours ago, °C,

Conductive heat loss through walls or roofs can be calculated using conductive heat inputs for the current hours and past 23 h and conduction time series

$$Q_\theta = C_0 Q_{i,\theta} + C_1 Q_{i,\theta-1} + C_2 Q_{i,\theta-2} + C_3 Q_{i,\theta-3} + \cdots + C_{23} Q_{i,\theta-23} \tag{2}$$

Where

Q_θ: Hourly conductive heat loss for the surface, W.

$Q_{i,\theta}$: Heat input for the current hour, W.

$Q_{i,\theta-n}$: Heat input n hours ago, W.

C_0, C_1, etc. : Conduction time factors.

4. Results andDiscussion

4.1. *Experimental Results*

4.1.1. *Temperature Distribution*

Figures 5, 6, 7show the temperature gradient of a brick wall and packaging wall; ambient temperature (T_a), room air temperature (T_r), temperature on the inner surface of a brick wall (T_{bi}), temperature on the outer surface of a brick wall (T_{bo}),temperature on the inner surface of packaging wall (PVC, MDF and Gypsum board) (T_{pi}), temperature on the outer surface of packaging wall (T_{po}) and solar radiation (I_r).

Fig.5 show the compare between brick and PVC wall, Maximum value of $\Delta T_{p_{i-o}}$(10.3°C) at 7 a.m., and maximum value of $\Delta T_{b_{i-o}}$(6°C) at same time, so the maximum save percent (for temperature difference) is 41.73% for heating load during night-time (coldest time at 7 a.m.).The value of $\Delta T_{p_{i-o}}$is higher than of the $\Delta T_{b_{i-o}}$ because the increase in the thermal resistance of the packaging wall.

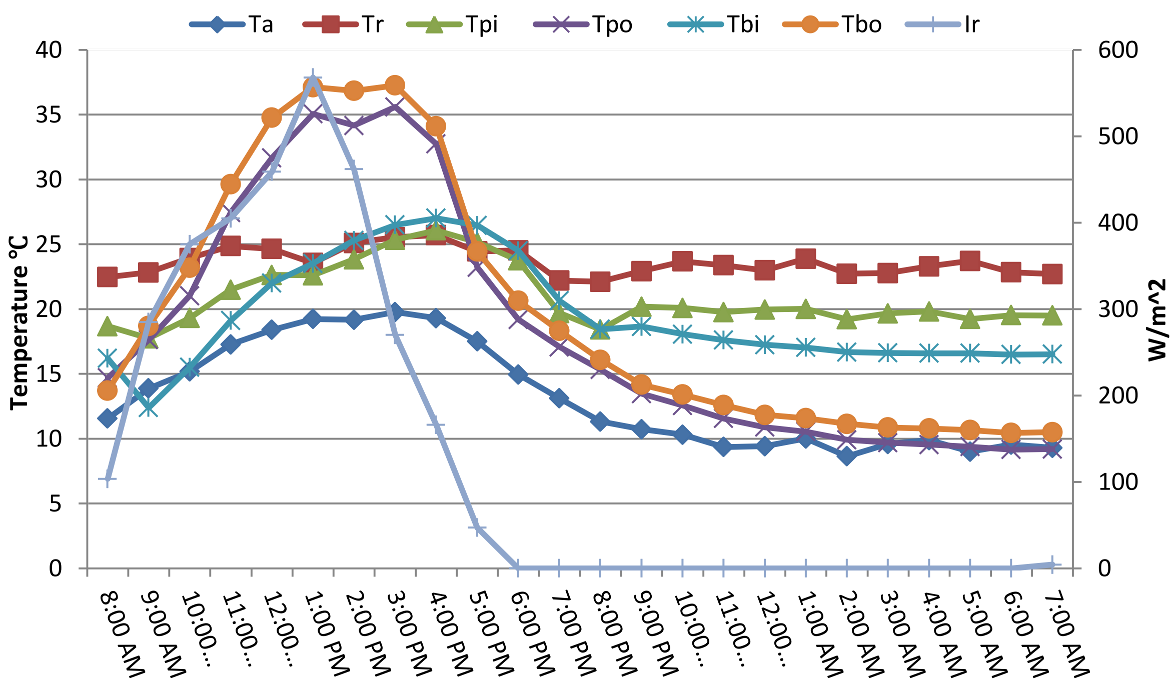

Fig. 5: Temperature gradient & solar radiation ofPVCwall compare with brick wall at 2-Feb-2016.

Fig. 6 show a compare between brick and MDFwall, Maximum value of $\Delta T_{p_{i-o}}$(9.7°C) at 7 a.m., and maximum value of $\Delta T_{b_{i-o}}$ is (6.9°C) at same time, so the maximum save percent is 29.18% for heating load during night-time (coldest time at 7 a.m.).

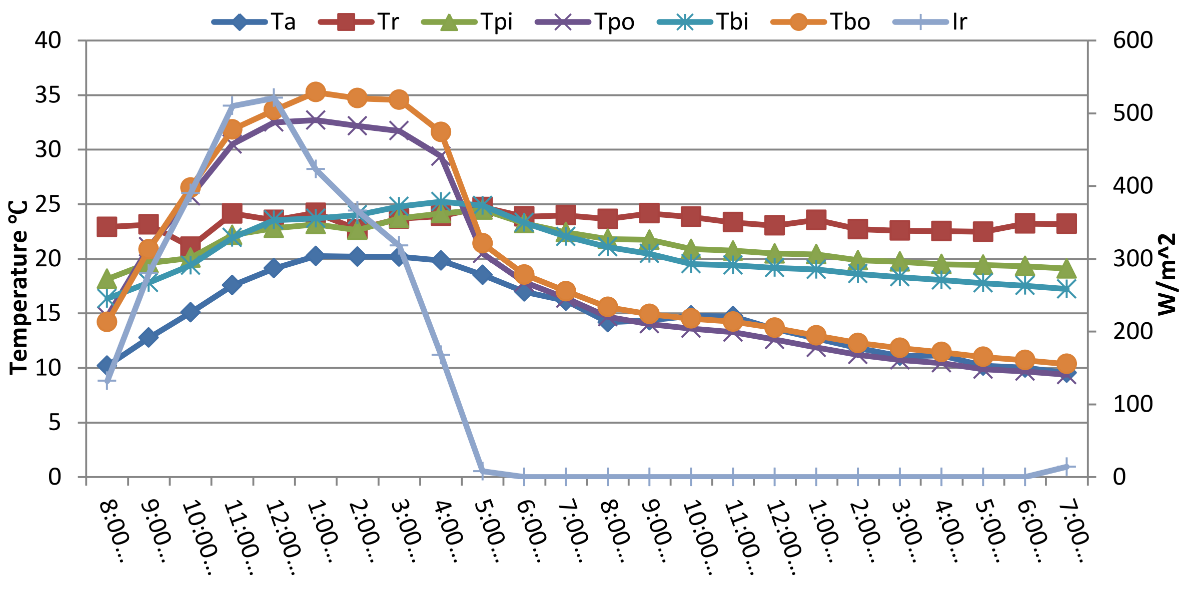

Fig. 6: Temperature gradient & solar radiation of MDFwall compare with brick wall at 3-Feb-2016.

Fig. 7 show a compare between brick and Gypsum boardwall. In the daytime the difference minus because of the high temperature of the outer surface of the walls as a result of solar radiation falling on it, and this leads to reduce the heating load. Either at night-time this difference would be plus, starts increasing at night-time up to the maximum after dawn, the value of $\Delta T_{p_{i-o}}$is higher than of the $\Delta T_{b_{i-o}}$ because the increase in the thermal resistance of the packaging wall. Maximum value of $\Delta T_{p_{i-o}}$is (10.5°C) at 5a.m., and maximum value of $\Delta T_{b_{i-o}}$ is (7.2°C) at same time, so the maximum save percent is 31% for heating load during night-time (coldest time at 5 a.m.).

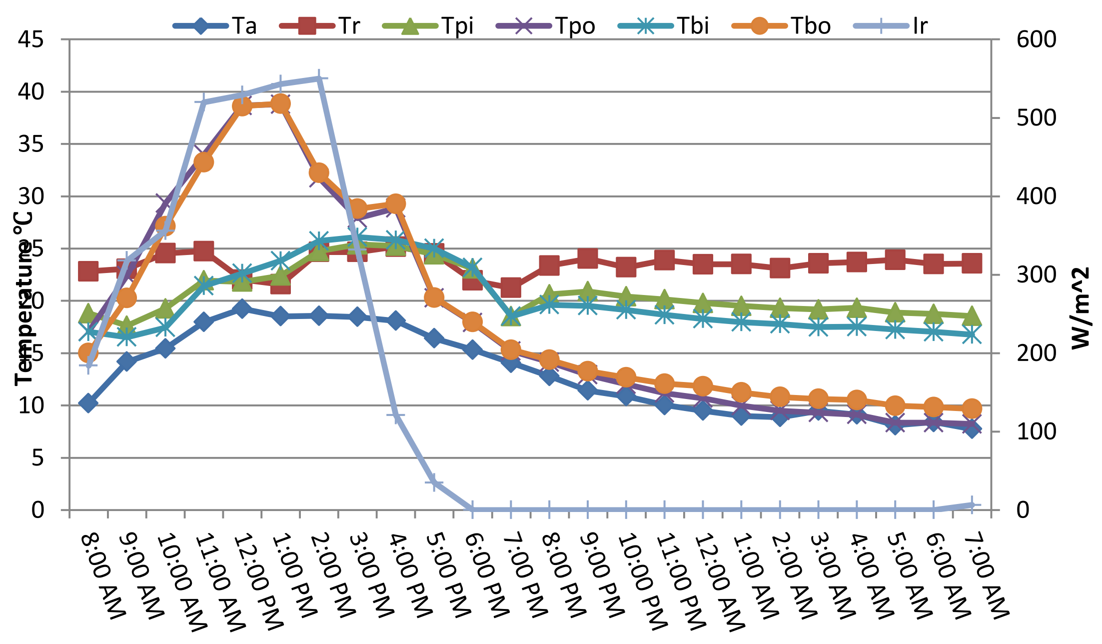

Fig. 7: Temperature gradient & solar radiation of Gypsum boardwall compare with brick wall at 8-Feb-2016.

4.1.2. *Heat Loss From The WallsDistribution*

Figures 8, 9, 10 show the heat loss was start decrease at day-time because increasing Sol-air temperature and solar radiation. At night time heat loss starts increase due to drop in ambient temperature reaches the highest.

Fig. 8 show a compare between brick and PVC wall,The maximum value of heat loss of brick wall without packaging was (-36.95 W/m^2)At 8 a.m., and heat loss of brick wall with packaging of PVC was (-29.38 W/m^2) at 8a.m., so PVC packaging gave saving energy (20.48%) at 8a.m..

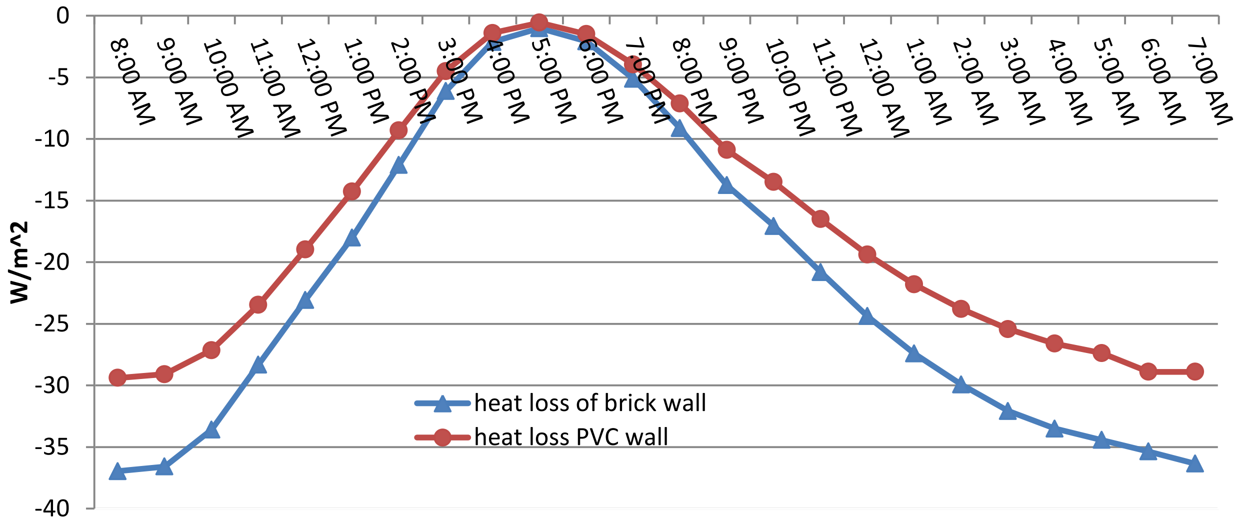

Fig. 8: The comparison of heat loss between brick and PVC wall (2-Feb-2016).

Fig. 9 shows a compare between brick and MDF wall. The maximum value of heat loss of brick wall without packaging was (-32.05W/m^2) at 9 a.m., and heat loss of brick wall with packaging MDF was (-24.72W/m^2) at 9 a.m., so MDF packaging gave saving energy (22.87%) at 9 a.m..

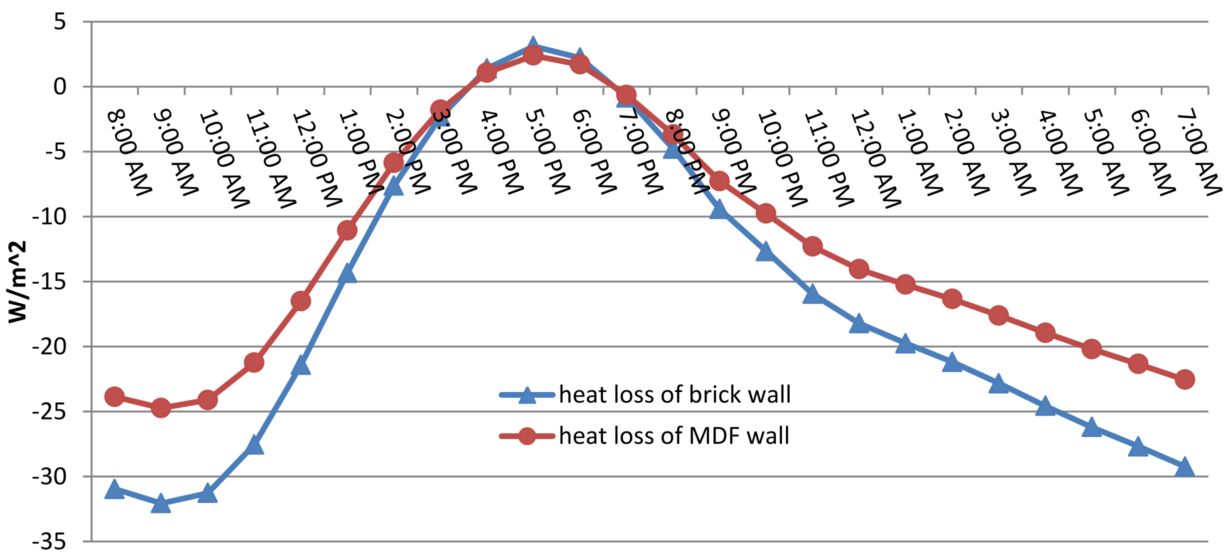

Fig. 9: The comparison of heat loss between brick and MDF wall (3-Feb-2016)

Fig. 10 shows the compare between brick and Gypsum boardwall. The maximum value of heat loss of brick wall without packaging was (-39.52W/m^2) At 9 a.m., and heat loss of brick wall with the packaging Gypsum board was (-33.01W/m^2) at 9 a.m., so Gypsum board packaging gave saving energy (16.45%) at 9 a.m..

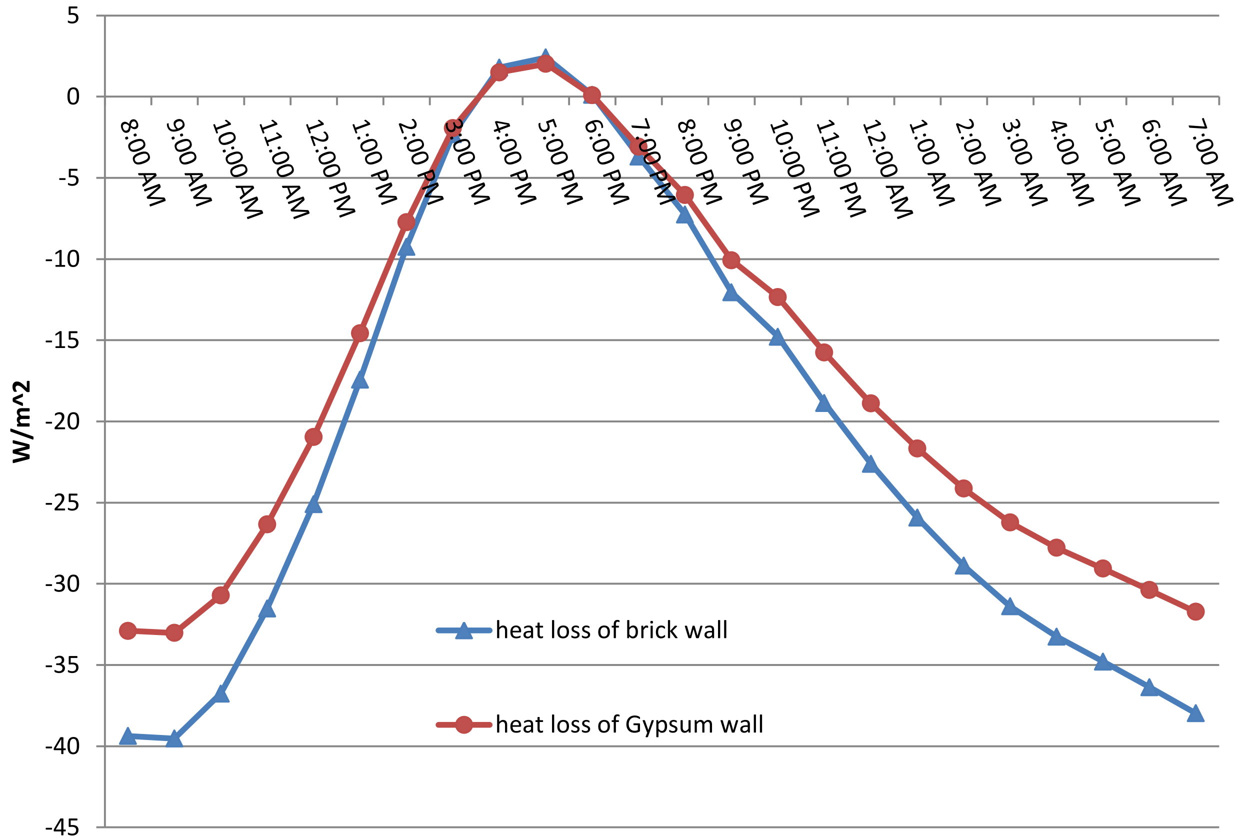

Fig. 10: The comparison of heat loss between brick and Gypsum board wall (8-Feb-2016)

4.2. *Theoretical Results*

4.2.1 *Temperature Distribution*

Using ESP-R program to calculate temperature for surface wall, room (indoor and outdoor) and solar radiation.

Figures 11, 12, 13 show the temperature gradient of a brick wall and packaging wall; ambient temperature (T_a), room air temperature (T_r), temperature on the inner surface of a brick wall (T_{bi}), temperature on the outer surface of a brick wall (T_{bo}), temperature on the inner surface of packaging wall (PVC, MDF and Gypsum board) (T_{pi}), temperature on the outer surface of packaging wall (T_{po}) and solar radiation (I_r).

Fig 11 shows the compare between brick and PVC wall, Maximum value of $\Delta T_{p_{i-o}}$ is (8.6°C) at 7a.m., and maximum value of $\Delta T_{b_{i-o}}$ is (7.96°C) at the same time, so the maximum save percent is 7.46%. The value of $\Delta T_{p_{i-o}}$is lower than of theexperimental resultsbecause Because used the weather file of Baghdad and Weather conditions change every year.

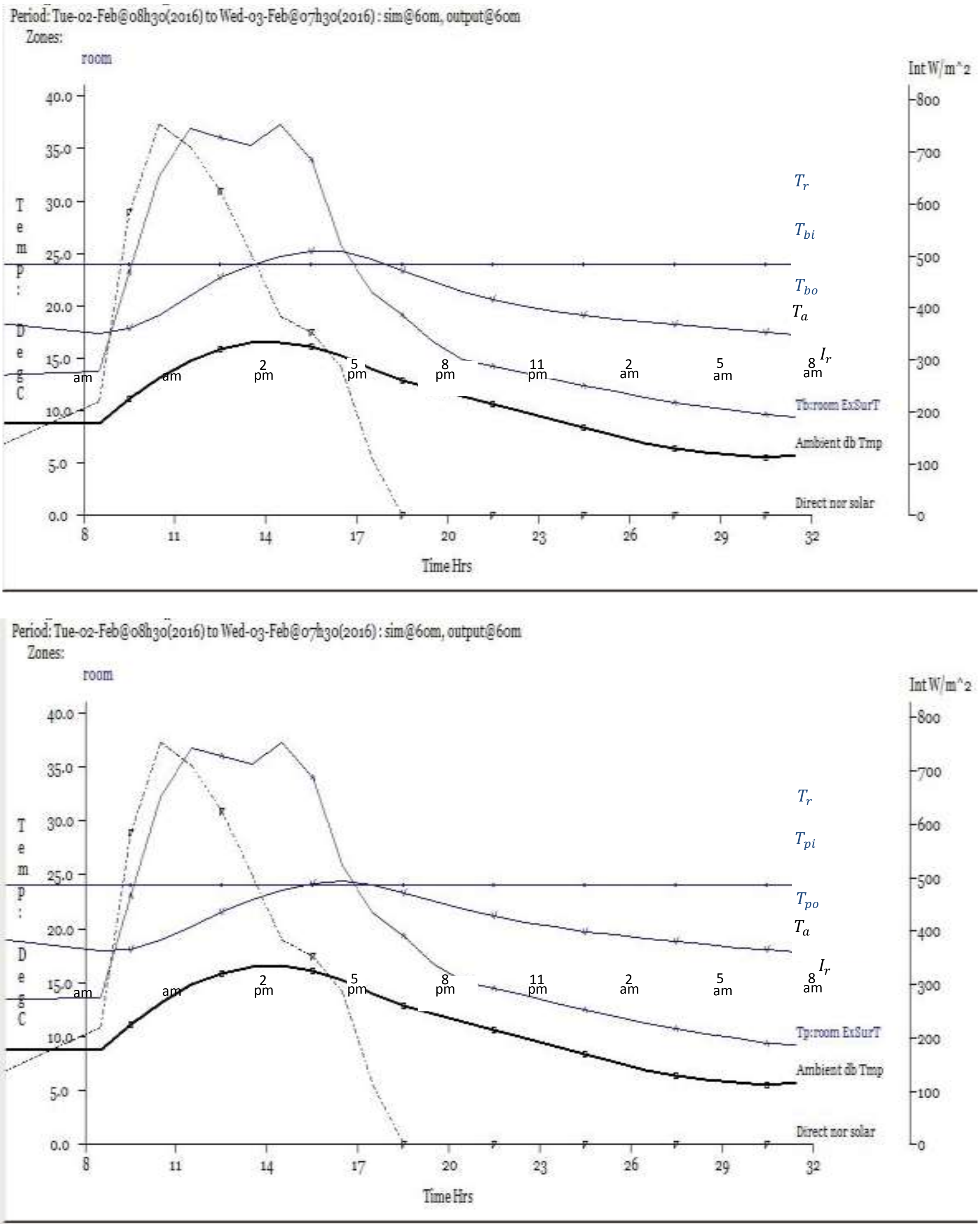

Fig. 11: Temperature gradient & solar radiation of PVC wall compare with brick wall at 2-Feb-2016.

Fig. 12 shows the compare between brick and MDFwall. Maximum value of $\Delta T_{p_{i-o}}$ is (12.27℃) at 5 a.m., and maximum value of $\Delta T_{b_{i-o}}$ is (10.65℃) at 5a.m, so the save percent is 13.15% for heating load during night-time (coldest time at 6a.m.). Convergent results fromexperimental.

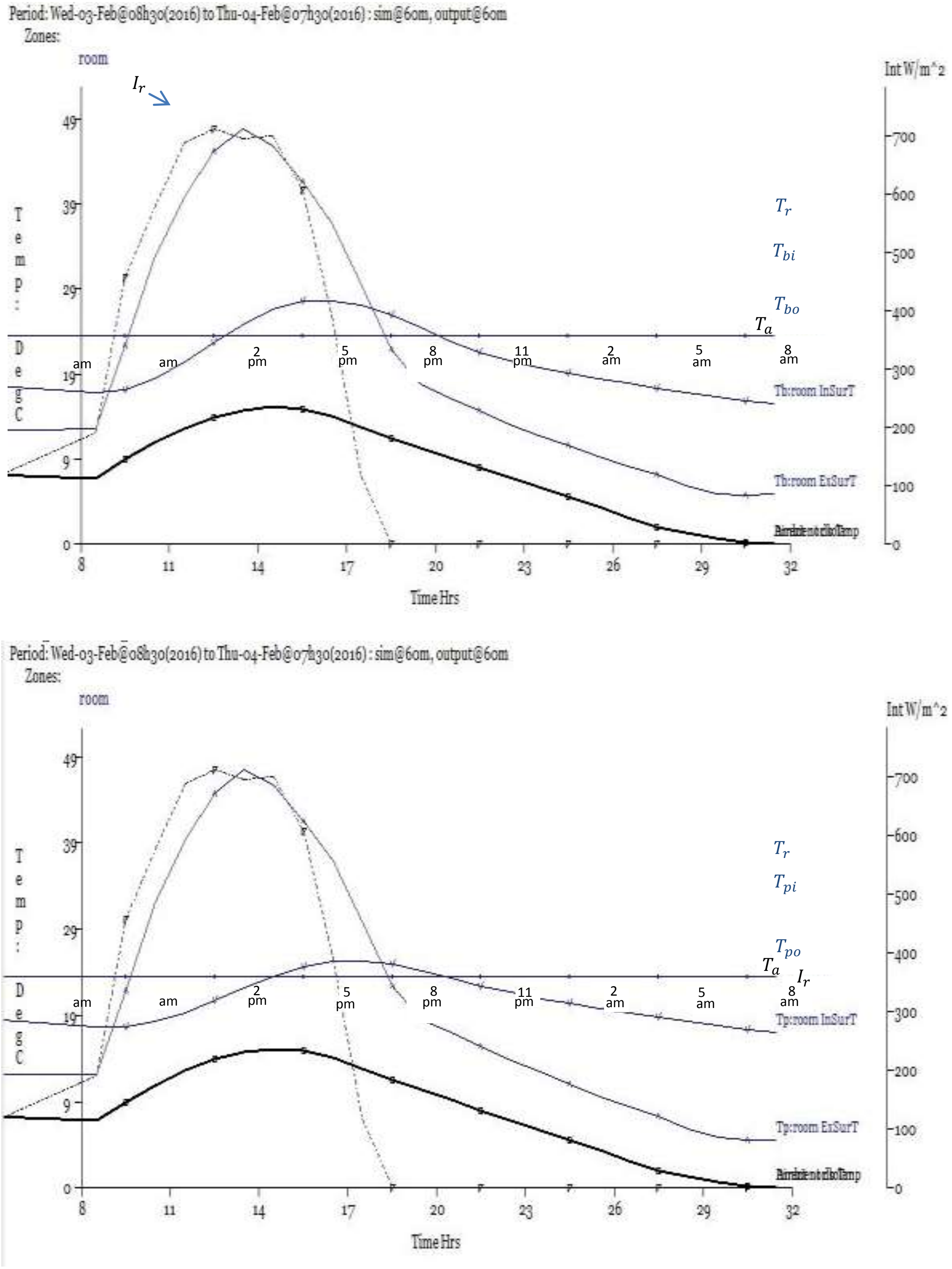

Fig. 12: Temperature gradient & solar radiation of MDF wall compare with brick wall at 3-Feb-2016.

Fig 13.show the compare between brick and Gypsum boardwall. Maximum value of $\Delta T_{p_{i-o}}$ Is (11. ,45°C) at 6a.m., and maximum value of $\Delta T_{b_{i-o}}$ is (10.12°C) at same time, so the save percent is 11.63%.

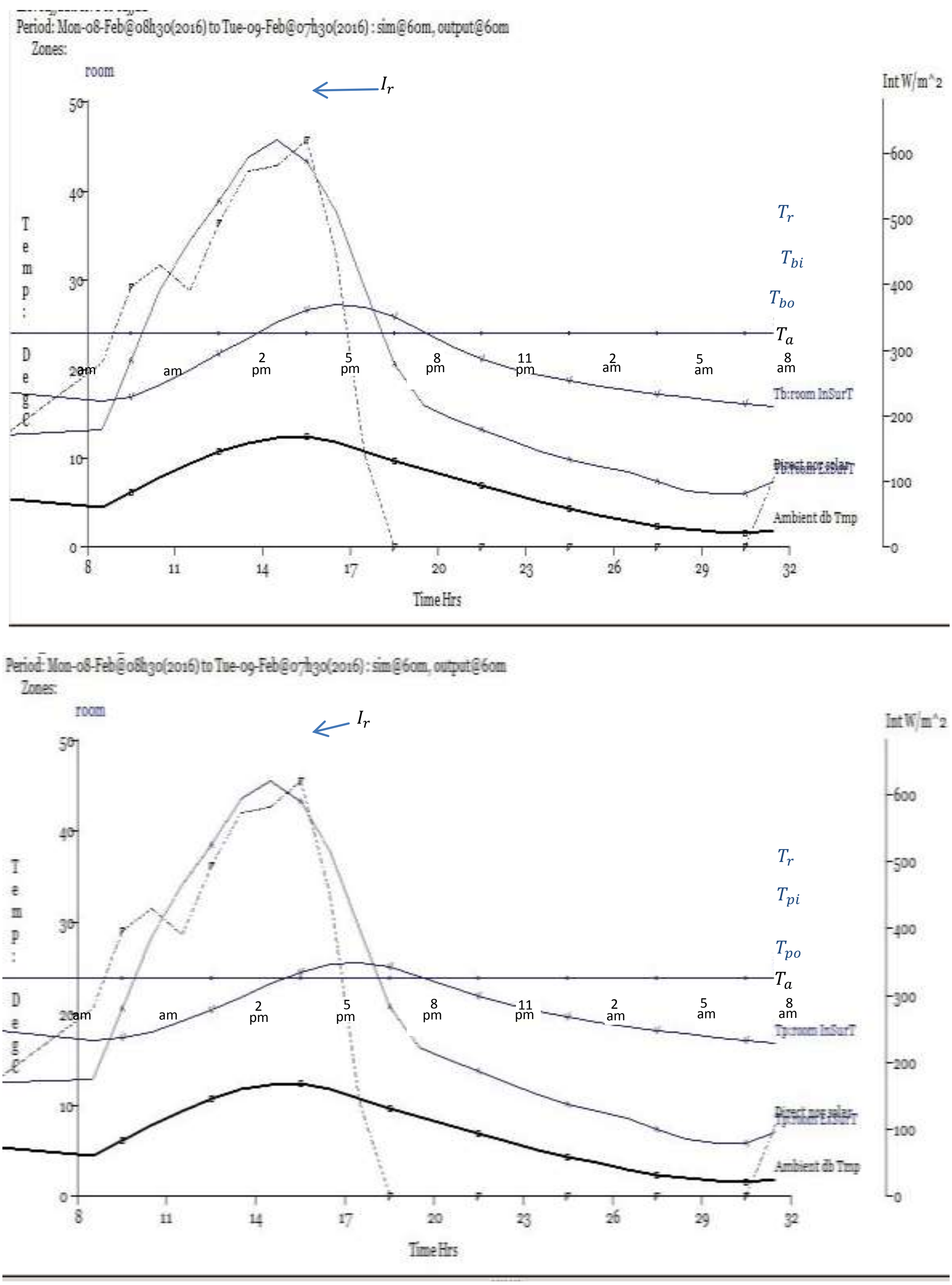

Fig. 13: Temperature gradient & solar radiation of Gypsum board wall compare with brick wall at 8-Feb-2016.

5. Conclusions

The saving energy for experimentally tested, internal packaging material can be arranged from a maximum value of saving as follows: 22.87% MDF, 20.48% PVC and 16.45%

Gypsum board.. The author recommended to use the internal packaging material for new building and also for the old to decrease heat loss, then save electric power save and running cost for heating load.

6. References

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