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Effect of heat resistance paints (HRP) on closed-chamber temperature distribution

Pipatpaiboon, N and Thondaeng, T.

Department of Mechanical Engineering, Faculty of industry and technology, Rajamangala University of Technology Isan, Sakon Nakhon Campus, Sakon Nakhon 47160, Thailand.

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A B S T R A C T

Global warming and climate change directly impact on temperature decreasing and temperature of residential temperature especially tropical regions. And present has developed heat resistance paints (HRP) to prevent residential temperature increase. HRP is a type of paints for reflex heat emitted from sun, paint components comprising special mixer substance and there are plenty to choose. Such as this research aims to study the effect of heat resistance paints (HRP) on closed-chamber temperature distribution. The closed-chambers were made from smart board of 3.5 mm thickness and dimensions of 0.5 m. x 0.5 m. x 0.5 m. (W x H x L). The temperature distribution and thermal resistance were compared between three closed-chambers painted with HRPs with differing properties, as well as an unpainted closed-chamber. The experiment measured temperatures at 3 points of the closed-chambers: outer surface temperature (WTO), inner surface temperature (WTI), and centre point temperature (CT). Experiment was conducted between the times of 6.00 AM and 6.00 PM. A solar power meter was also employed to measure the solar power storage. Results of the experiment showed the highest WTO temperature was 48.1˚C, and highest CT temperature was 45.9˚C, both of which were observed where the closed-chamber was unpainted. The lowest temperatures that were tested at 12PM, the hottest part of the day, showed WTO and CT of 39.2 ˚C and 36.8 ˚C respectively. Both temperatures were observed where the closed-chamber was painted with (UV shield) resistance paint. From the study concluded that the application of HRP impacts directly on the inner temperature distributions of the closed-chamber, and also helps to reflect heat away from the closed-chamber surface.

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INTRODUCTION

The effects of world issues such as global warming and climate change are impacting on people's lives through the introduction of unseasonal heat, amongst other unusual weather patterns (Jeremy, G. Carter *et al*., 2015). Obviously people would rather live comfortably inside their own homes, and therefore there is a need to prevent the effects of these issues from being experienced where possible. In particular, there is a need to contain internal house temperatures to a normal level, but how can this be done? One popular method is the use of heat resistance paints (HRP) aiming to: reflect heat away from walls or any materials, increase heat resistance of walls, and decrease inner temperature in housing. Recent studies concluded that different wall materials impact on the amount of solar heat conducted internally (Fang, Z.H *et al*., 2010; Thorat, P.V. *et al*., 2013). Other research conducted on various paints in cone calorimeter tests, determined that it was not possible to distinguish a difference in flame spread propensity based on the number of coats (Mowrer, F.W. and J.R. McGraw, 1999). Another study on temperature impacts on car coated substrate was performed using 54 rectangular shapes of car coated substrate samples acquired from three types of car models: A, B and C. Samples A and B were acquired from two national car models made in the years 2008 and 2000, with a coating of orange metallic acrylic and black metallic acrylic paints, whereas sample C was obtained from an imported car model made in 1992 with its original coating of green solid (non-metallic) acrylic paint. This study concluded that changing the coated substrate temperature, ΔT (˚C) is depending on thermal diffusivity of the painted material directly (Mohammad, K.A., *et al*., 2014). A further study on the mechanical properties of heat and humidity transfer through AAC (autoclaved aerated concrete)

Corresponding Author: Pipatpaiboon, N, Department of Mechanical Engineering, Faculty of industry and technology, Rajamangala University of Technology Isan Sakon Nakhon Campus, Sakon Nakhon 47160, Thailand.
Phone; +6642771391, Fax; +6642771392. E-mail; pipatpaiboon@hotmail.com.

mixed with PP (polypropylene fiber) demonstrated a reducing effect on the inner temperature of a house (Borvorn, I, and D. Peerapol, 2013). Another study into the effects of outdoor colors on indoor conditions of a model house under the hot humid climate of Bangkok demonstrated that light gray thermal protection was better than lily white, This shows that colors affect the internal temperature of a structure (Chantawong, P., *et al*., 2007).

In accordance with these studies, this research aims to investigate the effect of paints, or heat resistance paints, on temperature distribution of a closed-chamber. Experiment results are to be compared and presented, so as to form an introduction into the usage of HRP, as well as providing a basis for selecting an appropriate HRP for practical purposes.

Experiment Details:

The four closed-chambers were each made from smart board 3.5 mm thick with dimensions of 0.5 m. x 0.5 m. x 0.5 m. (W x H x L), as shown in fig.1. Three thermocouples were installed on each chamber to measure the following: outer surface temperature (WTO), inner surface temperature (WTI), and centre point temperature (CT). The undersides of each closed-chamber were covered with glass wool insulation so as to negate any heat transfer on this side. Experiment was performed between 6.00 AM - 6.00 PM. A 3 channel Extech Data Logger was connected to each chamber to track temperature movements caused by the phenomena of heat transfer from the sun to the smart board. This phenomena includes: heat radiation to the outer surface (determining heat absorption and heat reflection levels); heat passing through the smart board (determining heat conduction levels); and finally heat transfer to the centre of the closed-chambers as shown in fig 2.

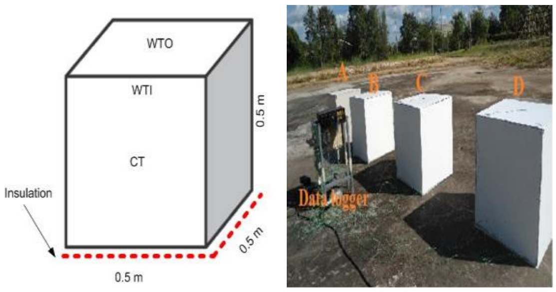


Fig.1: Schematic diagram and experimental set up.

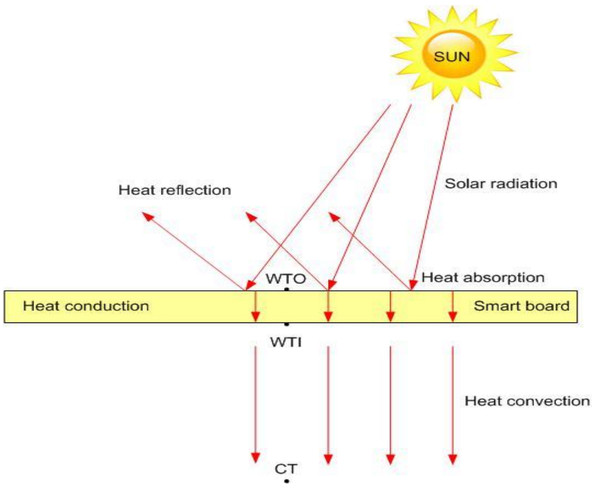


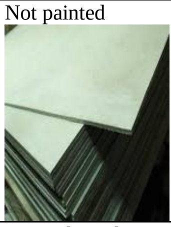
Fig. 2: Heat transfer phenomena.

Table 1 identifies the naming convention used for the purposes of the experiment, with the four closed-chambers identified as A, B, C, and D. The four letter-coded chambers are listed in table 2 with the paint details for each chamber. For the purposes of the experiment chamber A was treated as a control box and was unpainted, chamber B was painted with General acrylic water color, chamber C painted with Weathershield, and chamber D painted with UV Shield. All painted chambers were applied with two coats. The experiment was conducted on 11/11/2014 at Rajamangala University of Technology Isan Skon Nakhon Campus, Thailand (N 17 °21'49.2", E 103°42'45.9") as show in fig.3

Table 1: Letter symbols

Expemental /Sample	Outer surface temperature (WTO)	Inner surface temperature (WTI)	Centre temperature of closed-chamber (CT)	Differnce temperature or DeltaT (WTO-WTI)
A (without paint)	AWTO	AWTI	ACT	DeltaT,A
B (painted)	BWTO	BWTI	BCT	DeltaT,B
C (painted)	CWTO	CWTI	CCT	DeltaT,C
D (painted)	DWTO	DWTI	CCT	DeltaT,D

Table 2: Experimental details

Sample	Items	Color	Details
A	Not painted 	Not painted	Without paint
B	General acrylic water color 	White Base A	General acrylic water color
C	Weather shield 	White Base A	Keep cool, Colour lock technology UV protect, ΔT_{wall} Maxumum 5˚C.
D	UV Shield 	White Base A	3X Solar heat reflective technology, 3X UV protection technology,

RESULTS AND DISCUSSION

This research presents the effects of different HRP paints on temperatures of a closed-chamber with respect to WTO,WTI and CT. These temperatures are compared in fig 4,5 and 6 respectively.

3.1 Outer surface temperature of closed-chamber (WTO):

The phenomena occurring when the closed-chamber receives heat directly from the sun are heat absorption and heat reflection. Under normal conditions smart board will absorb heat better than if it were painted. We can see this clearly in fig.4 where the unpainted closed-chamber recorded by far the highest WTO temperature for the experiment of 46.5˚C at 12:00 PM. With respect to acrylic water color (BWTO), weather shield (CWTO) and UV shield (DWTO), we found that, between 6:00 AM and 12:00 PM, while each temperature was increasing, it was at a far slower rate. The only difference being that BWTO showed a slightly quicker temperature increase than the other painted chambers, however from 12:30 PM onwards the WTO of each painted chamber became relatively even.

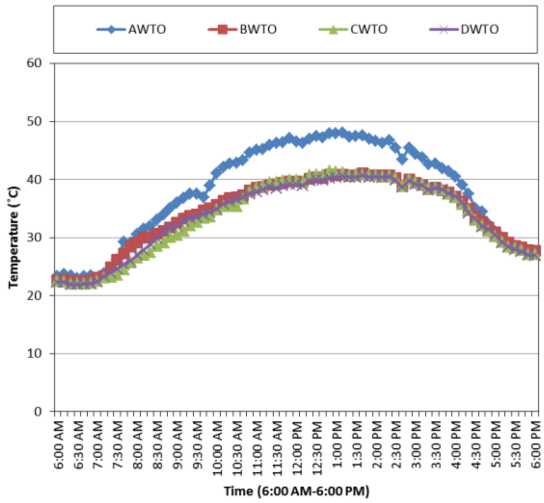


Fig. 4: Effect of HRP on outer surface temperature of closed-chamber (WTO).

3.2 Inner surface temperature of closed-chamber (WTI):

WTI will increase as a result of heat conduction from the outer surface through the smart board to the inner surface of the closed-chamber. At the start of the experiment WTI was recorded as slightly lower than WTO, however after 7:30 AM WTI rose to be higher, as a result of heat accumulation within the closed-chambers. Despite the heat accumulation, fig.5 demonstrates the effects of HRP on WTI as AWTI was recorded as higher than BWTI, CWTI and DWTI throughout the entire experiment, with a maximum temperature of 49.1˚C at 1:00 PM. BWTI and CWTI recorded similar temperatures because the properties of neither BWTI paint (General acrylic water color), nor CWTI paint (Weathershield), focus on heat reflection and heat resistance. Alternatively DWTI, that includes heat resistance of 3X Solar heat reflection technology and 3X UV protection technology demonstrated greater protection from heat and recorded the minimum temperature for WTI. At 12.00 PM temperatures for AWTI, BWTI, CWTI and DWTI were recorded as 47.4 ˚C, 37.6 ˚C, 39.0 ˚C and 36.8˚C respectively.

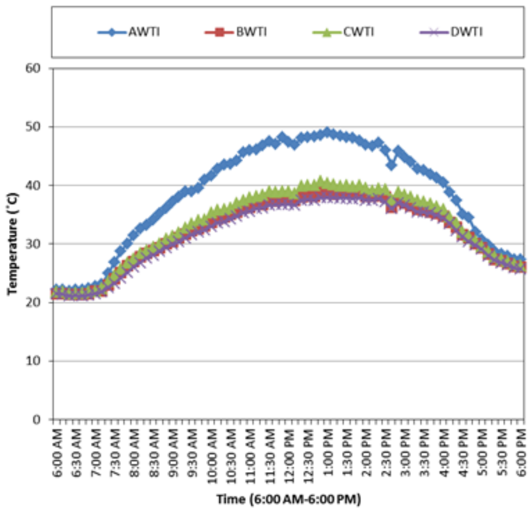


Fig. 5: Effect of HRP on inner surface temperature of closed-chamber (WTI).

3.3 Center temperature of closed-chamber (CT):

CT temperatures were recorded at the center of each closed-chamber. These temperatures determine the amount of heat conduction from the outer surface through the wall thickness, and heat convection to the center of the chamber, as shown previously in fig.2. By measuring CT temperatures we can determine the effect of HRP on temperature distribution within the closed-chambers. CT was recorded at the center of each chamber as this is the last point to feel the effects of solar radiation through the paint layers and smart board.

ACT (centre temperature of unpainted chamber) recorded the highest CT temperature during the experiment, which was expected as smart boards without paint do not qualify as heat resistant. BCT and CCT paints are generally regarded as appropriate for all weather, (as well as easy to clean), but little has been discussed on heat protection of the CCT paint in particular. Temperatures at 12:00 PM for BCT, CCT and DCT were recorded as 37.3˚C, 37.5 ˚C and 36.8˚C respectively, lower than ACT. DCT recorded the lowest temperature as a direct result of the paint, being consistent with the properties on table 2, with strong heat reflective technology.

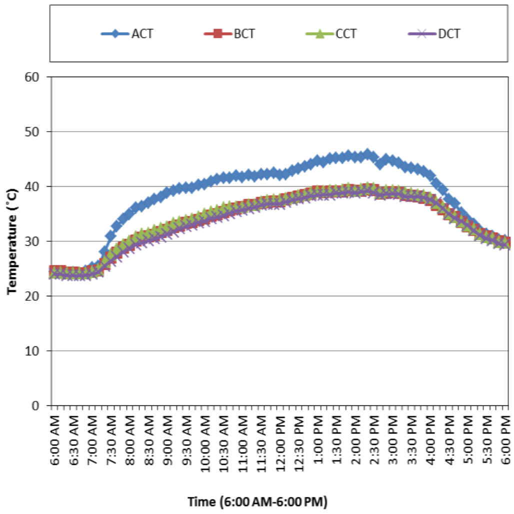


Fig. 6: Effect of HRP on inner surface temperature of closed-chamber (CT).

3.4 Difference temperature of wall (DeltaT):

DeltaT measures the effectiveness of heat resistance paint using the formula (WTO-WTI) as shown in table 1. If the calculation of DeltaT is negative this indicates the ability to resist heat is poor. However if DeltaT is positive this indicates the ability to resist heat is good. The DeltaT,A result in Fig.7 clearly shows the unpainted smart board is poor at reflecting and resisting heat. The DeltaT,C result shows the closed-chamber painted with Weathershield provided enough protection to restrict heat during the high outside temperatures between 11:30 AM and 4:00 PM. Interestingly though, DeltaT,B and DeltaT,D were also able to restrict heat, DeltaT,D in particular showed heat restriction is clearly better between 12:00 PM and 3:30 PM, with a temperature difference of about 3˚C

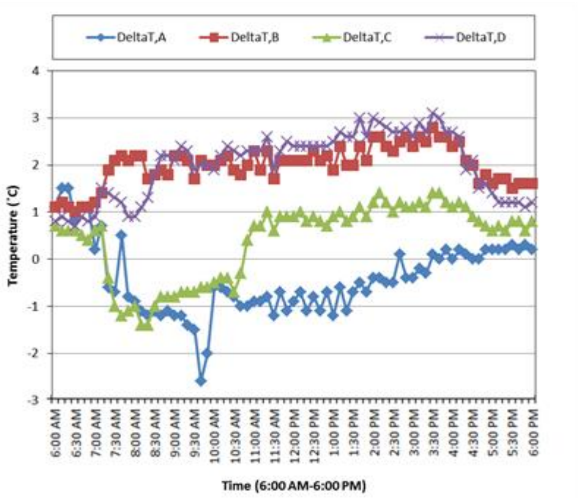


Fig. 7: Effect of HRP on temperature difference of closed-chambers (DeltaT).

Conclusion:

The results clearly demonstrate that strong heat resistance paints (HRP) assist in the prevention of heat when compared to unpainted surfaces, general acrylic paint and Weathershield paint. Results can be summarized as follows:

●HRP can reflect heat off outer surfaces.

●HRP can reduce temperature distribution within closed-chambers, and in particular, the CT results recorded at 12:00 PM (for BCT, CCT and

DCT indicated temperatures of 37.3˚C, 37.5 ˚C and 36.8˚C respectively), show that the HRP used on chamber D, with high heat and UV protection (as per table 2), offered the best resistance to temperature increases.

●The appropriate selection of HRP for practical purposes can reduce the temperature in a residential dwelling, which in turn has the potential to reduce energy consumption through air conditioning.

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