HVAC management for the alleviation of the heat shock

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Heat shock

❖Heating, ventilating, and air-conditioning (HVAC) systems make discontinuous temperature gaps between temperature-controlled and uncontrolled spaces

❖People exposed to the temperature gaps will suffer thermal stress called "**heat shock**".

❖**Heat shock** sometimes causes cardiac and cerebrovascular diseases, especially to older people

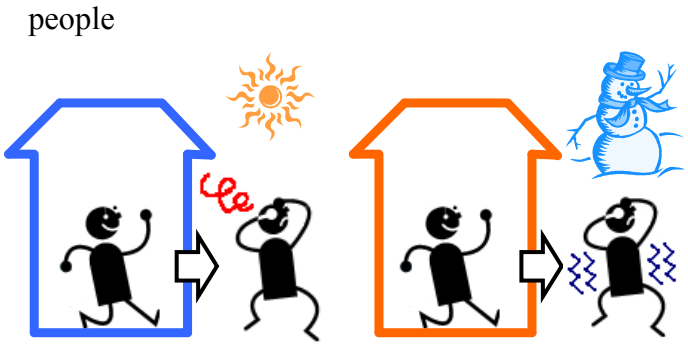


Fig. 1 Heat shock (it includes cold shock)

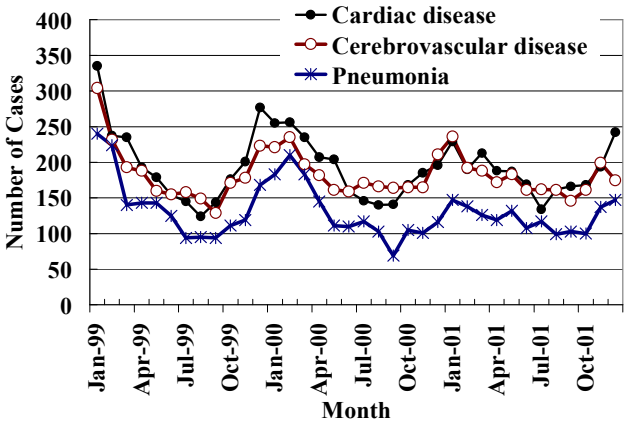


Fig. 2 Number of disease cases in each month (Yamaguchi, Japan)

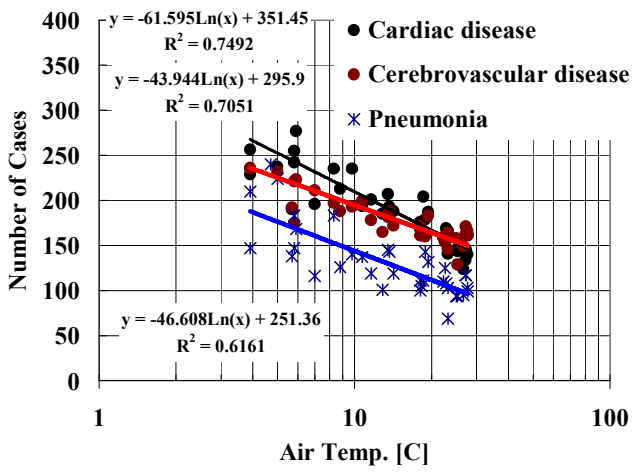


Fig. 3 Relationship between air temperature and number of cases (Yamaguchi, Japan)

Prevention of heat shock

❖We should take a more advanced management policy, under which the discontinuous temperature changes are controlled or moderated

❖We thus examined adequate HVAC technologies and evaluation methods for preventing the heat shock

HVAC technology

❖Using a patent database which covers US and European patents, we reviewed the current HVAC technologies for preventing the heat shock

❖ However, there were few solutions to the problem, such as the auxiliary air-conditioning

❖To find various alternatives or variations, we applied **TRIZ** (Theory of Inventive Problem Solving, which was created by Genrich Altshuller and improved by Darrell Mann) tools, for example, "contradiction matrix", "trends of evolution", "knowledge/effects", "trimming", etc. to the heat shock problem

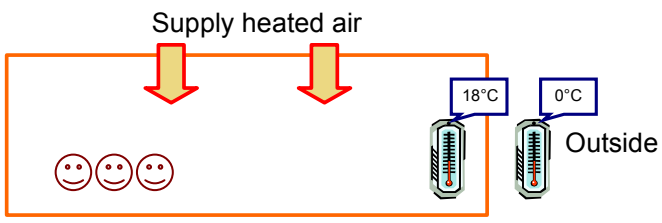
❖Then we found the following HVAC systems as practical and effective solutions to the problem:

- Auxiliary air-conditioning system driven by renewable natural energy
- **Task-ambient air-conditioning system**

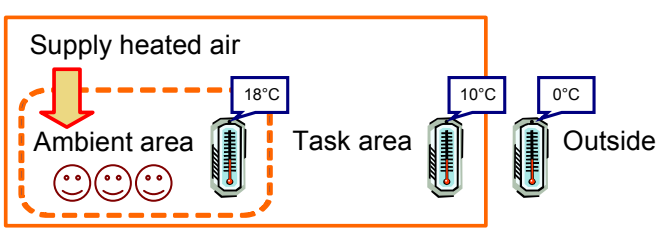
Task-ambient AC

❖Task-ambient air-conditioning (TAAC) systems

- Selectively control microclimate in "task" area
- Loosely control microclimate in "ambient" area
- Decrease air-conditioning loads
- Alleviate temperature gaps

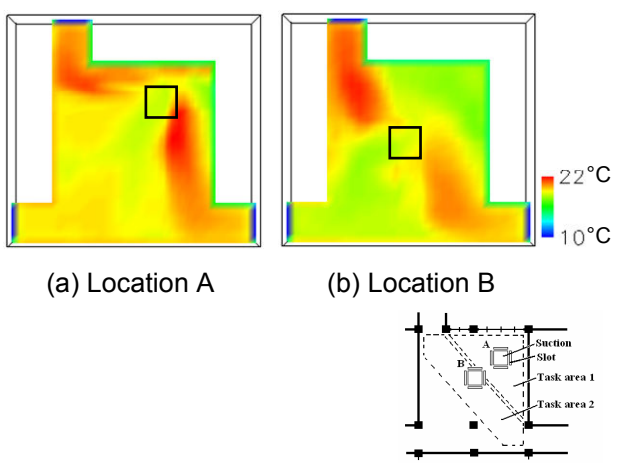


(a) Ordinary air-conditioning system



(b) Task-ambient air-conditioning system

Fig. 4 Comparison between two types



(a) Location A (b) Location B

(c) Location of task area and air-conditioners

Fig. 5 Temperature distributions at a height of 1.2 m when TAAC system was applied

Evaluation methods

❖Some indices for thermal stress are necessary for evaluating how much people suffer the heat shock and controlling HVAC systems based on the evaluated values

❖We proposed two thermal stress ind e x for people exposed discontinuous temperature changes

❖The proposed index is:

- **Integral of squared PMV changes**

PMV

❖Predicted mean vote (PMV) is a thermal comfort index

- Proposed by P. O. Fanger (1967)
- PMV describes the imbalance between the actual heat flow from the human body in a given environment and the heat flow required for optimum comfort at the specified activity
- PMV is a function of air temperature, velocity, humidity, metabolic activity, insulation provided by the clothing, etc
- PMV gives thermal-sensation scale shown in Table 1

Table 1 Thermal-sensation Scale

+3 hot
+2 warm
+1 slightly warm
0 neutral
-1 slightly cool
-2 cool
-3 cold

Integral of squared PMV changes

❖PMV can be used as a scale of thermal stress

❖Rete of PMV change will indicate heat shock

❖By integrating squared PMV change, we can indicate accumulation of heat shock

❖We name this value heat shock evaluation value and use a symbol E

❖Fig. 6 shows that the value of E is small when the PMV change is moderate

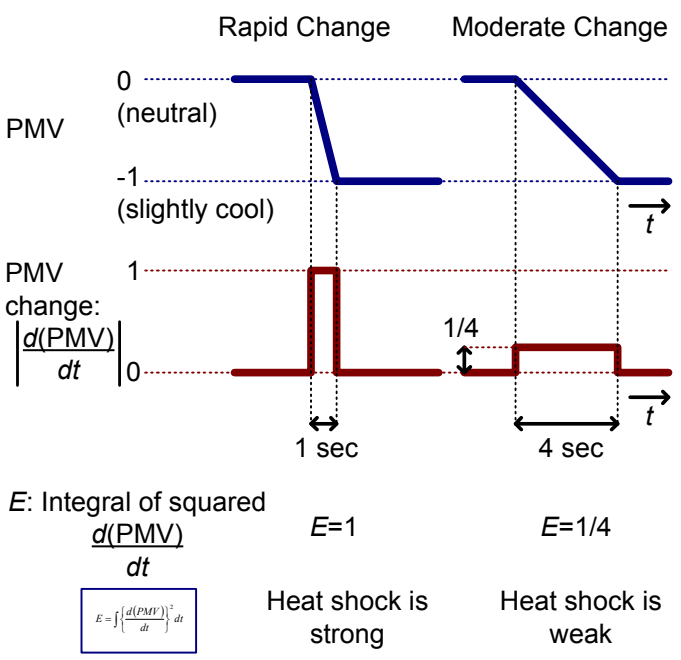


Fig. 6 Task-ambient air-conditioning system