

Conflicts Between Eco-design and Usability of Refrigerators

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Introduction

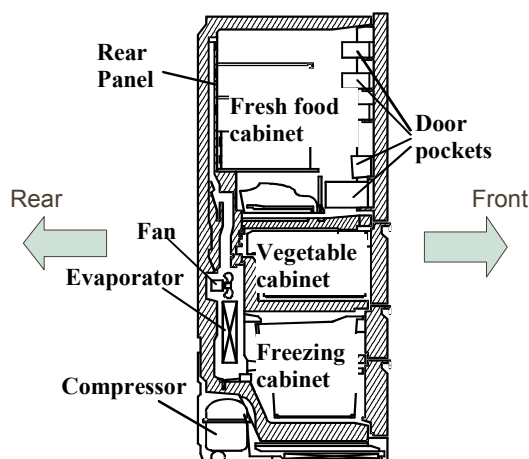
- Design engineers and researchers pay attention to the energy efficiency of the house electric appliances to decrease CO₂ emission.
- Manufacturers should try to change the shape of the refrigerators to improve the energy efficiency.



Introduction

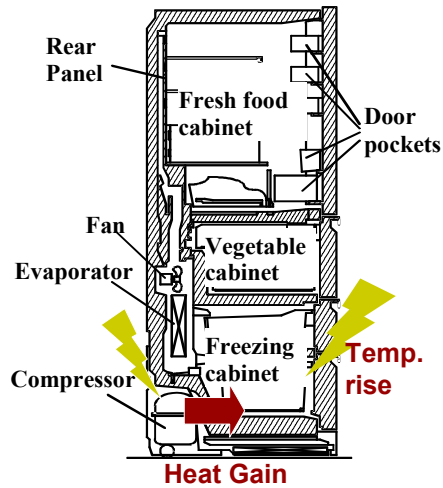
- However, changing the shape may cause the users inconvenience.
- This is the conflicts between eco-design and usability of refrigerators.

A current type of refrigerator



- This layout is decided based on the usability or ergonomics.
- Fresh food cabinet and Vegetable cabinet are located at upper level because they are frequently used.

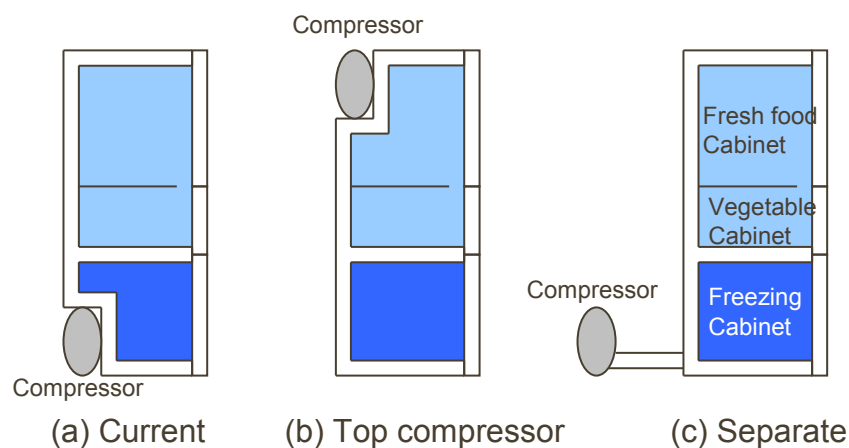
Problems in the thermal engineering



- Nearness of the compressor and freezing cabinet causes temperature rise in the freezing cabinet because of heat gain from the compressor.
- Placing the compressor in the limited space decreases the heat transfer from the compressor.
- These cause a decline of energy efficiency

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Layout of Cabinets and Comps

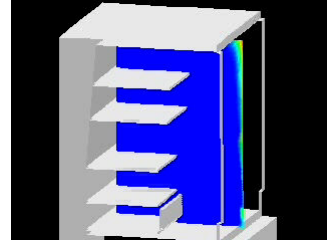


- One of the solutions of these problems is changing the shape of refrigerators

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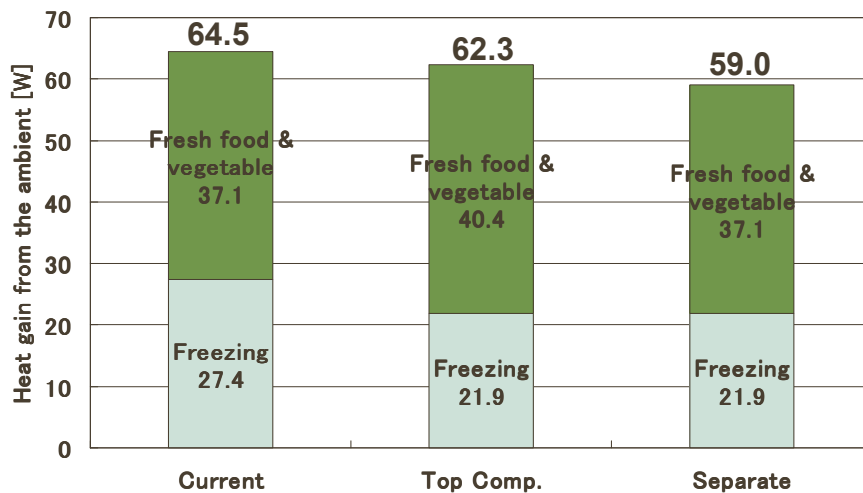
CFD simulations

- To estimate the heat gain of the refrigerators, CFD (Computational fluid dynamics) simulations were carried out



Comparison of heat gain

- The heat gains of the alternatives are smaller than that of the current type



- The energy efficiency of the alternative types will be improved

Dimensions of Quality

Quality dimension	Definition
Performance	A product's primary operating characteristics
Features	The 'bells and whistles' of products and services that supplement their basic functioning
Reliability	The probability of a product malfunctioning or failing within a specified time period
Conformance	The degree to which a product's design and operating characteristics meet established standards
Durability	The amount of use one gets from a product before it deteriorates
Serviceability	The speed, courtesy, competence, and ease of repair
Aesthetics	How a product looks, feels, sounds, tastes, or smells
Perceived quality	Reputation

D. A. Garvin: Harvard Business Review Vol.65 No.6, 1987

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Quality evaluation of refrigerators

Quality dimension	Type of refrigerator		
	Current	Top comp.	Separate
Performance	Medium	Good	Good
Features	Medium	Medium	Medium
Reliability	High	Medium	Medium
Conformance	Medium	Medium	Medium
Durability	Medium	Medium	Medium
Serviceability	Medium	Bad	Bad
Aesthetics	Good	Good	Bad
Perceived quality	Medium	Good	Good

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Quality evaluation of refrigerators

Quality dimension	Type of refrigerator		
	Current	Top comp.	Separate
Performance	Medium	Good	Good
Features	Medium	Medium	Medium
Reliability	Medium	Medium	Medium
Convenience	Medium	Medium	Medium
Durability	Medium	Medium	Medium
Serviceability	Medium	Bad	Bad
Aesthetics	Good	Good	Bad
Perceived quality	Medium	Good	Good

The alternative types are highly evaluated because of their energy efficiency

Quality evaluation of refrigerators

Quality dimension	Type of refrigerator		
	Current	Top comp.	Separate
Performance	Medium	Good	Good
Features	Medium	Medium	Medium
Reliability	Medium	Medium	Medium
Convenience	Medium	Medium	Medium
Durability	Medium	Medium	Medium
Serviceability	Medium	Bad	Bad
Aesthetics	Good	Good	Bad
Perceived quality	Medium	Good	Good

The alternative types are also respected because they are environmentally conscious design

Quality evaluation of refrigerators

Quality dimension	Type of refrigerator		
	Current	Top comp.	Separate
Performance	Medium	Good	Good
Features	Medium	Medium	Medium
Reliability	<div style="border: 1px solid black; background-color: yellow; padding: 5px; text-align: center;"> The separate type gets a low evaluation because it is not compact </div>		Medium
Conformance			Medium
Durability			Medium
Serviceability			Bad
Aesthetics	Good	Good	Bad
Perceived quality	Medium	Good	Good

Quality evaluation of refrigerators

Quality dimension	Type of refrigerator		
	Current	Top comp.	Separate
Performance	Medium	Good	Good
Features	Medium	Medium	Medium
Reliability	<div style="border: 1px solid black; background-color: yellow; padding: 5px; text-align: center;"> The alternative types get a low evaluation because their maintenances are difficult </div>		Medium
Conformance			Medium
Durability			Medium
Serviceability			Bad
Aesthetics	Good	Good	Bad
Perceived quality	Medium	Good	Good

Conclusion

- The energy efficiency of the alternative types of refrigerators is better than that of the current one.
- However, unless the usability of the alternative types is improved, they may not be accepted in the appliance market even though they are eco-designed.



Thank you

