DESIGN AND DEVELOPMENT OF A LOW COST AIR COOLER

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Abstract

Air Cooler is one of the appliances that keeping the atmosphere cold. The basic concept of water cooling is to find a medium that can handle and transport heat more efficiently than air. Water has a very good ability to retain heat, in the mean time stay in a liquid form. This project is to design and develop a low cost air cooler which can be used in houses and office

Secondary researches have been carried out to collect data regarding the present design of air cooler. Various types of air cooler available in the market have been identified. Ethnographic study and questionnaire survey has been done for understanding the user product interface. The issues related to current air cooler have been found out. QFD and PDS are prepared based on the data collected.

Concepts are generated according to the PDS prepared. Concepts of a air cooler with additional of a separate fan to spread the water in to the air for cooling. Air cooler with a separate fan is selected as the final concept through weighted ranking method. Colours are chosen according to its applications to make it aesthetically good. A working model of the final concept is made using wood.

Keywords: Blower, Air cooler, Exhaust Fan, Water Pump, Blower Motor

Abbreviations

QFD	Quality Function Deployment
PDS	Product Design Specification

1. INTRODUCTION

Air Cooler is one of the appliances that keeping the atmosphere cold. The basic idea of water cooling is to find a medium that can handle and transport heat more efficiently than air. Water has a good ability to retain heat, in the mean time stay in a liquid form. As long as can circulate cool water to the hot parts. Water can cool it down more efficiently than air.

Method of Air cooling is a dessipating heat. which works by making the object to be cooled have a larger surface area or have an increased flow of air .Evaporative cooling is based on a physical phenomenon in which evaporation of a liquid into surrounding air cools an object or a liquid in contact with it. As the liquid turns to a gas, the phase change absorbs heat. Latent heat of evaporation. Water is an excellent coolant because it is plentiful, non-toxic, and evaporates easily in most climates.

The concept, was refined, became the evaporative coolers which will provide a low-cost, alternative to refrigerated air conditioning. Fresh outside air is pulled through moist pads where it is cooled by evaporation and circulated through a house or building by a large blower. Air Cooler is one of the appliances that keeping the atmosphere cold.

1.1 History of air cooler

Civilizations throughout the ages have found ingenious ways to combat the heat in their region. An earlier form of air cooling, the wind catcher, was invented in Persia (Iran) thousands of years ago in the form of wind shafts on the roof, which caught the wind, passed it over subterranean water in aquanaut and discharged the cooled air into the building. Nowadays Iranians have changed the wind catcher into an evaporative cooler and use it widely. There are 9 million evaporative coolers in central Iran, and in just the first two months of year 1385 in the Persian/Iranian calendar (April–May 2006) 130,000 evaporative coolers were sold in Iran [1].

Fig 1.Air Cooler [5]

The evaporative cooler was the subject of numerous US patents in the 20th century; many of these, starting in 1906, suggested or assumed the use of excelsior (wood wool) pads as the elements to bring a large volume of water in contact with moving air to allow evaporation to occur.

A typical design, as shown in a 1945 patent, includes a water reservoir (usually with level controlled by a float valve), a pump to circulate water over the excelsior pads and a squirrel-cage fan to draw air through the pads and into the house. This design and

this material remain dominant in evaporative coolers in the American Southwest, where they are also used to increase humidity. In the United States, the use of the term swamp cooler may be due to the odor of algae produced by early units.

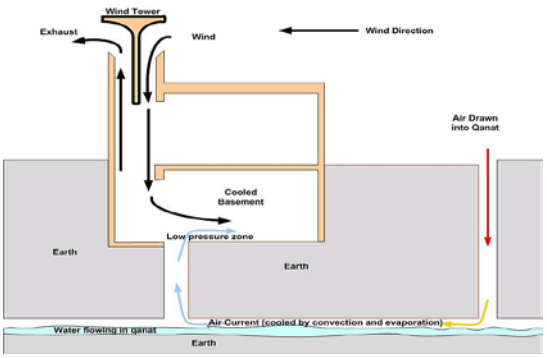

Fig 2. Schematic diagram of an Iranian wind catcher [4]

2 TYPES OF AIR COOLER

Evaporative air coolers also called swamp coolers is one of the most popular types of air coolers in India. Most of the air cooler dealers recommend this type of air coolers for users. The cost effectiveness of the evaporative air coolers makes it easy for common man in India to fight the heat during the summer. The major advantages of evaporative air coolers are easy installation, easy maintenance. There are various types of evaporative air coolers. Here are a few examples and their features.

2.1 Direct and Indirect Evaporative Coolers

These are evaporative air coolers in which the evaporative cooling of the air is carried out directly with the help of pads soaked in water. They are the most efficient and also simple in design .The indirect evaporative air coolers are also same as the direct ones but the only difference is that the latter one is a closed circuit system

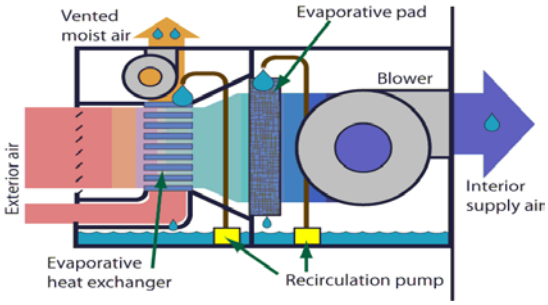

Fig. 3 Direct and Indirect Evaporative Coolers [2]

2.2 Portable Swamp Coolers

- This is the most popular type of evaporative air coolers in India. Most evaporative air coolers are of portable type.
- The evaporative cooling is done only for a small area and can work best for moderate climates.
- Unlike the other kinds of personalized air coolers, you can install these portable swamp coolers anywhere and anytime.

Fig. 3 Portable Swamp Coolers [2]

2.3 Window or Wall Mounted Air Coolers

The window or wall mounted air coolers are evaporative coolers in which the evaporative cooling happens more effectively. The blower is even more powerful as compared to the rest of the swamp coolers. The other advantages of these evaporative coolers are the large tank capacity, easy cleaning options and lower noise levels.

Fig. 4 Window or Wall Mounted Air Coolers [6]

2.4 Add-on Evaporative Coolers

The evaporative coolers are best for the areas that experience a humid climate. It consists of a refrigerated cooling system in which the evaporative cooling is effective. The major advantage of using this type of air coolers is that the cooling costs are reduced. The quality of the air indoors is also better. There is also an alternate cooling system that can take over the evaporative cooling if the main system breaks down. The evaporative or the swamp coolers are greatly beneficial in many ways as compared to the other types of air coolers. You can find the one that suits you best and install it at home or office.

3. PRODUCT STUDY

Product study has been conducted to understand the product in detail. Energy efficient evaporative air coolers help meet the needs of today's world. Evaporative air coolers are engineered to provide the most natural way of creating cool air with significant savings on energy cost compared to using air

conditioners. Coolers are widely range of products offer options for indoor as well as outdoor cooling.

Evaporative air coolers offer an energy efficient option for cooling your home or workplace in the most natural way. Evaporative air coolers do not require power hungry components like compressors. The low power consumption translates into significant savings on energy bills compared to using air conditioners.

Fig. 5 Add-on Evaporative Coolers [5]

Fig. 6 Product Study

3.1 Working Principle

An evaporative cooler is essentially a large fan with water-moistened pads in front of it. The fan draws warm outside air through the pads and blows the now-cooled air throughout the house. The pads can be made of wood shavings, wood from aspen trees is a traditional choice - or other materials that absorb and hold moisture while resisting mildew. Aspen wood pads, also called excelsior, need to be replaced every season or two, and generally cost $20 to $40 for a set. Small distribution lines supply water to the top of the pads. Water soaks the pads and, thanks to gravity, trickles through them to collect in a sump at the bottom of the cooler. A small re-circulating water pump sends the collected water back to the top of the pads.

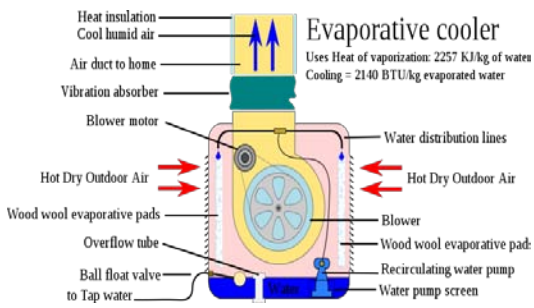

Fig. 7 Working Principle [2]

A large fan draws air through the pads, where evaporation drops the temperature approximately 20 degrees. The fan then blows this cooled air into the house. Small units can be installed in a window, blowing cooled air directly into a room. Larger units can blow air into a central location, or the air can travel through ductwork to individual rooms.

Normal air conditioning is a closed system, taking air from inside a house and recycling it. For air conditioning to function properly, doors and windows should be closed. Evaporative cooling, however, takes air from outside the house. For evaporative cooling to work properly, the cooled outside air must be allowed to escape. By choosing which doors or windows in your home you leave open, we can to help direct the flow of cooled air to areas where it is needed (Figure 7).

3.2 Cooling Pad

Most of the cooling pads are made of either aspen fibre or cellulose. A cellulose pad typically needs more air and water flow than does an aspen pad. More evaporation can take place through a 6-inch pad than a 4-inch pad. Wide Range of Evaporative Cooling Pads is available in the market. Evaporative Cooling is the process in which air is cooled by using the heat in the air to evaporate the water from an adjacent surface. A temperature reduction of 10 to 20^0C (50-68 degree F) can be achieved by passing the hot fresh air through the wetted pads.

Eco Cool Evaporative Cooling Pads that were manufactured using special cellulose material. Top quality material is useful in achieving high cooling efficiency and ensuring degradation resistance. The pads are known for their exceptional wetting properties and airflow to achieve maximum

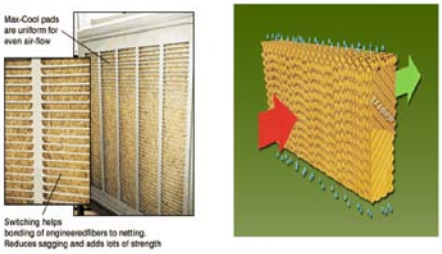

Fig. 8 Cooling Pad [6]

3.3 Blower motor

Forced air is passed through heating or cooling elements and circulated to the desired locations. Blower motors provide that air movement. A blower motor is a term that actually describes a combined unit--an electrical motor and a fan. Most often, a centrifugal fan, which looks like a 6- to 10-inch hamster cage, is used. These fans--mounted in "housings"--are used to force hot or cold air through ducting and vents.

These blower motors are compact in structure and elegant in design, and highly demanded due to their minimum energy consumption and requirement of low maintenance. These Cooler Motors are commonly installed in a variety of coolers.

Fig. 9 Blower motor [6]

3.4 Blower Fan

Air cooling systems in Cooler most commonly rely on forced air. Forced air is passed through cooling elements and circulated to the desired locations. Blower provides this air movement.

Fig. 10 Blower Fan

Fan efficiency is the ratio between the power transferred to the air stream and the power delivered by the motor to the fan. The power of the airflow is the product of the pressure and the flow, corrected for unit consistency. Another term for efficiency that is often used with fans is static efficiency, which uses static pressure instead of total pressure in estimating the efficiency. When evaluating fan performance, it is important to know which efficiency term is being used. The fan efficiency depends on the type of fan and impeller. As the flow rate increases, the efficiency increases to certain height (Figure 10).

3.5 Re-circulating water pump

A re-circulating pump draws water from the basin under the pumps it through a system of sprays (or water distributors) from which the water is directed onto the tube surfaces. Air is induced or forced over the wetted tube surfaces and through the rain of water droplets. By intimate contact of the air with the wetted tube surfaces and water droplets evaporation of part of the water occurs thus cooling both the tube surfaces and the water simultaneously. In this manner evaporation is used to increase the rate of heat transfer from the tubes to the air.

Fig. 11 Re-circulating water pump [6]

3.6 Market Study

Market study has been conducted to know details regarding the current domestic air cooler available in the market. There are wide varieties of Air coolers available in the market. There are lot of companies who manufacture Air Cooler. The following are some of leading companies manufacturing Air Cooler.

4. DESIGN CONSIDERATION

- Giving more importance for the working mechanism of cooling
- Try to avoid the cooling pad
- Material used for the manufacture should be one among wood, aluminum, steel or fiberglass.
- It should be portable and easy to use.
- It should be easy to maintenance and for assembly also
- Safety locks should be there to avoid accidental movements.

Fig. 12 Market Study

4.1 QFD Chart

$ - HIGH RELATIONSHIP - 5
# - MEDIUM RELATIONSHIP - 3
@ - LOW RELATIONSHIP - 1

USER VOICE / TECHNICAL DESCRIPTION	USER IMPORTANCE	DESIGN	SIZE	ERGONOMICS	MATERIAL	MECHANISM	EASY TO MAINTENENCE	ASSEMBLY
LESS COST	5	#	$		#	$	#	#
LESS IN SIZE	4	$	$	#		@		
LONG LIFE	4				$	$	$	$
EASY TO HANDLE	5	#	$	$				
COOLING	5					$	$	$
POWER SAVING	3					$		#
SAFETY	4	#	#	#	@	$	#	#
RATINGS		62	82	49	51	106	72	84

4.2 Product Design Specification (PDS)

Product Design Specification		
Low Cost Air Cooler		
SL. No	Description	Specification
1	Product	Air Cooler
2	Cooler Design	Compact
3	Climatic Condition Suitability	Dry and Humid
4	Mode of usage	Electrical and Mechanical
5	Material	Plastic / Steel Sheet
6	Manufacturing Process	Machining & Assembly
7	Net - Weight	10-12 Kg
8	Water Tank Capacity	20 Liter
9	Cooling Medium	Exhaust Fan
10	Cooling Area	150 (sq.ft.)
11	Blower Motor Speed	1300 Rpm
12	Air Throw Distance	10 Feet
13	Product Life	8 Years
14	Environment	Home / Office
15	Asthestics	Form, Colour, Material & Texture
16	Market	Indian Market
17	Estimsted Cost	Below 2000 Rs

5. CONCEPT GENERATION

5.1 Concept-1

Fig. 13 Concept-1

In this concept the cooling mechanism is entirely different from the current air coolers. For storing water a water storage area is provided at the bottom of the cooler. Water circulating pump is provided inside the water storage area. One water out let tube is connected with circulating pump .Blower is shown at the top of the cooler connected with a motor and an exhaustion fan is provided beneath the blower.

The working principle for this concept is once the water circulating pump is started the water begins to flow through the water outlet tube; the end of this tube is fixed behind the fan as a result the water flows at high pressure through the water out let tube and collapse with leaf of the running fan. As a result the water begins to mix with the air and the air inside the air cooler becomes cool. This cooled air will flow out of the air cooler with the help of the blower.

5.2 Concept – 2

The working principle of this concept is same as in the first concept. In this fan is provided in the back of the blower. For storing water a water storage area is provided at the bottom of the cooler. Water circulating pump is provided inside the water storage area. One water out let tube is connected with circulating pump. Blower is shown at the top of the cooler connected with a motor and a fan with motor is provided beneath the blower. In this concept fan is fixed just behind the blower. The working principle for this concept is once the water circulating pump is started the water begins to flow through the water outlet tube, the end of this tube is fixed behind the fan as a result the water flows at high pressure through the water out let tube and collapse with leaf of the running fan. As a result the water begins to mix with the air and the air inside the air cooler becomes cool. This cooled air will flow out of the air cooler with the help of the blower.

5.3 Concept-3

In this concept copper tube is added. The garbage can is filled with ice water, which is then fed by gravity through the copper tubing coiled along the back of the fan. The hot air passing through the tubing warms the cold water, cooling the air. Waste warm water is then pumped outside. The system will cool an average room to a comfortable level in approximately 15-20 minutes. Depending on flow rate, a full bucket of water will last approximately 1-3 hours. Once the water runs out, the house has cooled off enough that the fan alone provides sufficient cooling.

Fig. 14 Concept – 2

Fig. 15 Concept-3

The main factor affecting the performance is the temperature of incoming water. Cool water will work, but ice water will result in a cooler room, quicker. We can attach the tubing to the front of the fan as well. This will increase performance, just make sure that fan can handle the additional torque of tubing full of water attached to the front.

5.4 Concept-4

An important point is to understand that the temperature of the water does not have any real effect on the cooling produced by the evaporation process.. Imagine being sprayed with water at either of those temperatures on a hot day, as it evaporated off your skin you would feel much cooler.

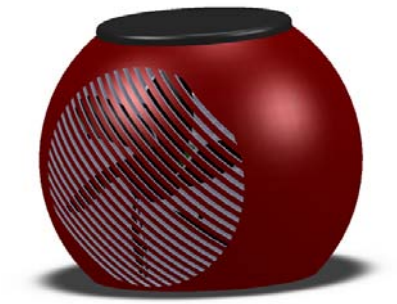

Fig. 16 Concept-4

The construction of an evaporative cooler is such that filter pads are located at the back or sides (or both) of the machine and the surrounding warm air is sucked into the machine through the pads. The pads are kept damp either by water being pumped from an internal reservoir around and through the pads or from an external water source. As the outside warm air moves across the wet pad the water is evaporated removing the heat from the air therefore when that air exits the machine it is in a cooler state than when it entered the machine.

5.5 Concept-5

Fig. 17 Concept-5

The working principle of this concept is same as the second concept. In this fan is provided in the bottom side of the blower. For storing water a water storage area is provided at the bottom of the cooler. Water circulating pump is provided inside the water storage area. One water out let tube is connected with circulating pump .Blower is shown at the top of the cooler connected with a motor and a fan with motor is provided beneath the blower. In this concept fan is fixed just behind the blower.

The working principle for this concept is once the water circulating pump is started the water begins to flow through the water outlet tube; the end of this tube is fixed behind the fan as a result the water flows at high pressure through the water out let tube and collapse with leaf of the running fan. As a result the water begins to mix with the air and the air inside the air cooler becomes cool. This cooled air will flow out of the air cooler with the help of the blower.

6. WORKING MODEL

Fig. 18 Working Model

7. VALIDATION

Fig. 19 Validation

Validation of the Working Model has been carried out with the end users. The model has been taken various houses to get the feedbacks from the users (Figure 19).

8. SUMMARY AND CONCLUSION

The whole work of the project can be summarized as follows.

- Secondary research method like literature review was conducted by referring magazines, journals, manuals, publications, websites etc.
- Data collection was done by product study, user study and market study through ethnography, interviews, images, videos etc at houses, shops and manufacturing units of air cooler
- QFD was prepared using the data collected during the research and the needs identified.
- Then the target PDS is arrived based on the QFD
- Concepts were generated using mind mapping according to the PDS
- The concepts are then digitalized using 3D modelling software Unigraphics NX6 and rendered using Key shot 2.
- A final concept was then selected from those concepts using weighted ranking method
- Detailed drawing of the concept was prepared.
- Working model of the final concept is made in Wood.

A low cost air cooler for residential use has been made to meet the requirements of the customers. All the product design specifications arrived after research has been fulfilled at the end of this project. The project gave an excellent opportunity to go through the end to end life cycle of a product.

9. REFERENCES

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