DESIGN AND PERFORMANCE OF A NEW ROOM COOLER

by

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ABSTRACT

A new design of room cooler, working on capillary action has been described with relevant performance data, and compared with an existing type. Its cooling efficiency, volume output efficiency and overall efficiency are about 63%, 85%, and 54% respectively. The necessity of periodic wetting of the cooling fabric surfaces has been avoided. Apart from its cheapness, simplicity and low running expenditure, it has been made reasonably free from risks, personal or otherwise. Detailed instructions and precautions for its proper use have also been included.

Introduction

Use of khus-khus screens in improving the thermal environments of living and working places during the dry, hot summer months has been quite a common practice in north Indian areas. A scientific investigation of the merits of the method was undertaken during the summer of 1951 by Majumdar and Das Gupta,[1] and the results were found to be far from satisfactory. It was, however, recognised that if properly used in a closed room provided with a powerful exhaust fan located in a suitable position, khus-khus screens, wetted frequently and thoroughly, can be definitely regarded as a most reliable means of maintaining a steady and comfortable environment throughout the working day. One cannot, however, lose sight of the attendant botherations and the huge recurring expenditure involved especially in the offices located in the hutments. The need was, therefore, urgently felt of replacing khus-khus screens with some suitable and cheap form of mechanical cooling arrangements. Subsequently the desert cooler and certain types of cooling boxes were introduced which also made use of cooling by evaporation of water.

One of the existing types of cooling-boxes, which was used for a number of years in many offices under the Ministry of Defence is shown in Fig. 1, as used in the normal position. A study on the efficiency of this type of cooling-box was carried out by the present authors[2] during the summer months of 1956. One of its major drawbacks was found to be the arrangement for wetting the cooling fabrics (gunny cloth) requiring almost hourly filling of the upper tray. Moreover, the holes in the upper tray got blocked very soon, and had frequently to be opened up with a pin or a similar device. The fan was placed at the back of the box, and the air was forced against an appreciable resistance resulting in a low volume output per minute. In short, this cooling box was found to be rather unsatisfactory.

EXISTING TYPE COOLING-BOX IN NORMAL POSITION

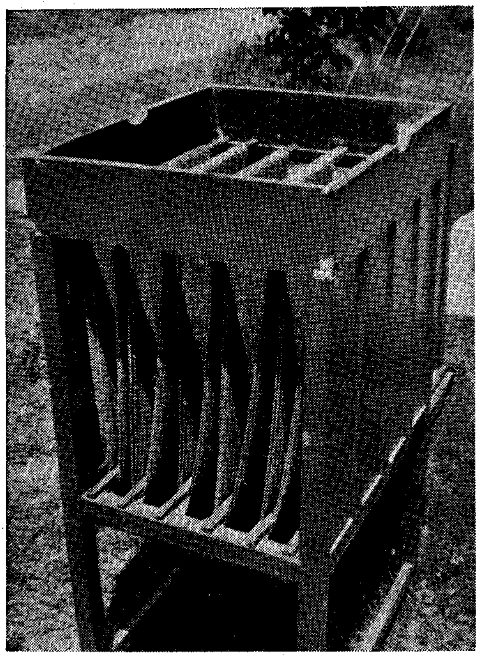


FIG. 1—Front view showing folds of gunny-cloth. Upper tray is removed. Fan in back-chamber, and directed inside the box.

It was thus considered worthwhile to direct further studies at developing an improved wetting device with provision of adequate protection and insulation of the fan.

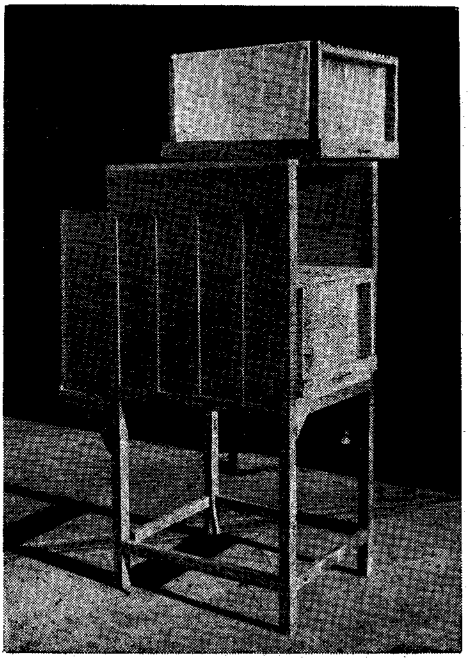
The investigation resulted in the development of a new room cooler, named as the D.S.L. Room-Cooler (Figs. 2 & 3).

Design of Room Cooler

It has three compartments in all. Behind the fan chamber, there are two chambers, one above the other, each measuring 26″ in length, 19″ in breadth and 13″ in height. Care is taken so that little air can get into the box from outside, except through the opening at the back, measuring $19'' \times 26\frac{1}{2}''$.

There are two trays of galvanized sheet, measuring $23'' \times 18\frac{3}{4}'' \times 2''$ each, which can go easily into either compartment, leaving very little gap on the sides. A brass handle has been fixed on each tray to facilitate its introduction and removal. A small hole fitted with a suitable stopper may be provided at one corner of each tray for draining out water whenever necessary.

Each tray holds a wooden frame, $21\frac{1}{2}'' \times 18\frac{1}{2}'' \times 12\frac{1}{2}''$, carrying the cooling fabric. The gap between successive layers is about $\frac{1}{2}''$ on the average, neglecting the thickness of the fabric. Only brass nails and screws have been used



D. S. L. Room-Cooler.

Fig. 2.— Back view, showing the trays containing the frames carrying the cooling fabric.

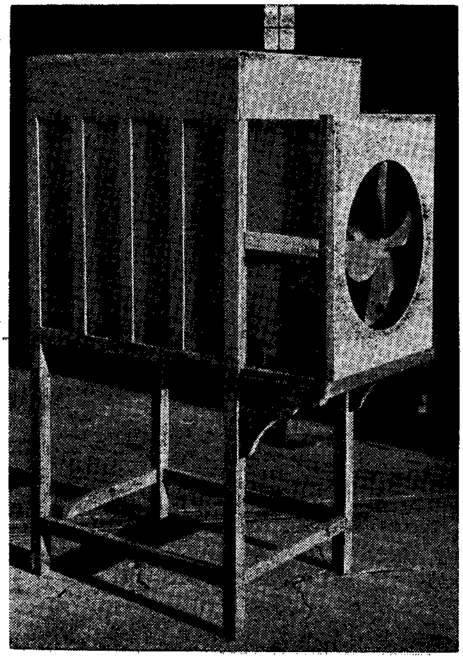


Fig. 3—Front view, showing fan in position.

in making the frame to avoid rusting. The total cooling surface, considering both sides of the fabric works out to be about 114 sq. ft.

The table fan (16″ sweep) is used as a suction fan, its face being directed outward from the box. The fan chamber in the front is covered with a door of plywood, having a circular hole about 16″ in diameter, the centre of the hole being practically at the same level as the centre of the fan. This cover is essential for effective performance of the cooler. The fan has to be placed with the plane of its blades about ½″ to 1″ behind the door.

For the cooling fabric, absorbent lint (18″ width) has so far been found to be the best material available for the most effective capillary action. One cooler requires about 4½ lbs of lint. When the dry fabric was suspended with its lower end dipping in water in a shallow tray placed in front of a running table fan, water was found to rise to a vertical height of more than 18″ above the free surface of water in the case of absorbent lint.

Distinguishing Features

The principal features of the D.S.L. Room-Cooler, distinguishing it from the existing types are:—

(*i*) It works on capillary action, thereby avoiding the necessity of periodic wetting of the cooling fabric surfaces. The trays, once filled in the morning, keep the surfaces wet throughout the working day.

(*ii*) Unlike most of the cooling-boxes (including the desert cooler) in current use, there is no water dripping through the air stream sucked by the fan. As such, no water particles are likely to be carried into the air stream, thereby eliminating all attendant risks of damage or short circuit of the armature and hence any possible fire. The running armature, by virtue of its high temperature sets up a convective air current outward, and there is no chance of any water vapour condensing on the armature surface.

(*iii*) The optimum width and spacing of the cooling fabric surfaces have been worked out in relation to the air delivery of the fan, which has considerably improved the overall efficiency of performance.

Performance Details

The experimental methods have been described in detail in a previous report.[2] Air velocity was measured with a 4″ vane-anemometer, air temperature and relative humidity with a sling psychrometer in conjunction with a psychrometric chart.[3] The air-delivery of the table fan was computed according to the method laid down in Appendix D of IS: 555—1955.[4] The various terms[2] used in this paper are briefly defined as under—

(*a*) *Cooling efficiency* $= \left(\dfrac{T_{D_1} - T_{D_2}}{T_{D_1} - T_{W_1}} \right) \times 100$ per cent.

where, T_{D_1} Dry bulb temperature of incoming air.

T_{W_1} = Wet bulb temperature of incoming air.

T_{D_2} = Dry bulb temperature of outgoing air.

From a knowledge of this cooling efficiency one can easily work out the amount of cooling that will be produced in the cooler under any given ambient conditions.

(b) *Volume Output efficiency* $= \dfrac{\textit{Volume output}}{\text{Air delivery of fan}} \times$ 100 per cent.

From this value, one can find out the volume output with any fan (16″ sweep) of known air delivery.

(c) *Over-all efficiency* $= \dfrac{\textit{Cooling efficiency}\%}{100} \times \dfrac{\textit{Vol. Output efficiency per cent}}{}$

(d) *Drying time*—is defined arbitrarily as the time in which the cooling efficiency drops by 33% of its maximum value.

The cooling efficiency, volume output efficiency and the overall efficiency of the D.S.L. Room-Cooler have been found to be about 63%, 85% and 54% respectively, so that with a standard 16″ table fan of normal air delivery of about 1400 cft per minute, when ambient air is at 110°F with 10% relative humidity, the cooler will deliver air at 84°F with 46% relative humidity, at the volume rate of about 1200 cft/min. Theoretical calculations show that the average water requirement per working day of 7 hrs (1000 hrs to 1700 hrs) should be about 14·7 gallons per cooler on typical dry, hot days of May in the hutments, assuming a mean day temperature of 95°F with relative humidity 25% inside the room. The method of calculation has been indicated in a D.S.O. report [2]. In general, water requirement will be appreciably less than the calculated amount in closed rooms with open ventilators.

Comparison with the existing type

Comparative data of performance for the D.S.L. Room-Cooler and the existing type of cooling box[2] are presented in table 1.

TABLE 1

Performance data of the D.S.L. Room-Cooler and the existing type of Cooling-box

	D.S.L. Room-Cooler	Existing Cooling-box (in normal position)	Remarks
Cooling efficiency	63%	50%	
Vol. Output efficiency	85%	58%	
Over-all efficiency	54%	29%	
Drying time (hrs)	24	1	
Delivery air-temp. °F.	78·0	81·5	Values calculated for standard fan(16″), with normal air delivery 1400 cft/min, ambient air being at 95°F with 25% R.H.
Delivery air Relative Humidity ..	60%	51%	
Delivery air Vol. output (cft/min.)	1200	800	
Theoretical water requirement per cooler per working day of 7 hrs. (gallons).	14·7	8·0	

Instructions Regarding Use of the D.S.L. Room-Cooler

(*i*) In the morning, if the cooling fabrics are found to be sufficiently dry, the two trays along with the frames should be taken out from the respective chambers, and the fabric layers thoroughly wetted by pouring water gradually from above with a tumbler. This requires about half a bucketful of water for each frame. The trays should then be replaced inside the compartments, carefully avoiding undue friction against the fabric surfaces. *In case the fabrics are already wet, operation (i) is altogether unnecessary,* and one should proceed from operation (*ii*).

(*ii*) The trays should now be nearly filled with water, avoiding unnecessary spilling. *Both the operations (i) and (ii) should be carried out before placing the fan in position.*

(*iii*) The table fan (16″ sweep) should now be installed in position, with its face directed outward from the cooler, and the door should be tightly closed, with the cable placed in the groove on the front-bottom edge close to the hinge. The height of the fan should be so adjusted that its centre lies practically at the same level as the centre of the circular hole on the door. The cooler is now ready for use for the whole day.

(*iv*) At the end of the working day, the fan should be taken out and kept on a dry base (preferably not on the floor). It is desirable to have some water left in the trays, so that the lower edge of the frame may remain in water, about $\frac{1}{4}$″ deep. This will render operation (*i*) unnecessary on the next morning.

Caution

The entire length of the cable and its connection to the plug and the fan should be thoroughly checked, and no portion of it should be allowed to touch any wet object. Every fan, before it is issued with a cooler, must be checked and passed by a competent authority.

The fan issued with the cooler should be sufficiently powerful so as to meet the minimum standard of air delivery of 1400 cft/min., as laid down by ISI.[4]

The life of the fan can be considerably increased if it is kept outside the cooler when not in use.

Conclusions

The D.S.L. Room-Cooler appears to be quite satisfactory so far as the results of laboratory trials are concerned. As this work was not carried out in summer, complete assessment of its merits as a practical room-cooler can only be made under actual summer conditions, in one of the uncomfortable rooms in the hutments. The working life of absorbent lint, used as a cooling fabric, has yet to be ascertained and a search for a more suitable material should also be made.

Acknowledgements

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