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Natural Draught Cooling Towers to minimise Adverse Environment Effects

Réfrigérants à tirage naturel pour réduire la charge sur l'environnement

Naturzugkühltürme zur Reduktion der Umweltbelastung

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SUMMARY
Thermal and nuclear power plants employ condensers for cooling the steam used for running the turbines and the condensers require large quantities of circulating water for effecting the cooling. Cooling towers are employed for recycling the hot water for repeated usage. The natural draught cooling towers (NDCT) have a lesser effect on the environment than the induced draught cooling tower.

RÉSUMÉ
Les centrales thermiques et nucléaires utilisent des condenseurs pour refroidir la vapeur qui entraîne les turbines; de ce fait, une énorme quantité d'eau en circulation s'avère indispensable pour refroidir les condenseurs. Les tours de réfrigération servent à recycler l'eau chaude et il est possible pouvoir ainsi la réutiliser maintes fois. Les aéroréfrigérants à tirage naturel exercent un moindre effect néfaste sur l'environnement que les réfrigérants à tirage induit.

ZUSAMMENFASSUNG
Konventionelle wie nukleare, thermische Kraftwerke benötigen zur Kondensation des abgearbeiteten Dampfes grosse Mengen Frischwasser. Kühltürme dienen der Wiederverwendung des aufgeheizten Kühlwassers in mehreren Durchläufen. Naturzugkühltürme haben geringere Auswirkungen auf die Umwelt als solche mit künstlicher Ventilation.

1. INTRODUCTION

Condensers in thermal and nuclear power plants require large quantities of water for cooling. If water is available nearby, it is used for cooling, otherwise cooling towers are used for recycling the hot water. For a typical 210 MW plant cooling about 33000 cu.m. of water per hour from 42.5 deg C to 32.5 deg C, the heat content discharged is about 3x10 to the power of 8 Kilo Cal/hour which will result in a thermal shock to the aquatic system of the water body.With increasing awareness of the damage caused to aquatic life by discharge of hot and possibly contaminated water into aquatic eco-systems and to minimise the requirement of water which would otherwise be required for human consumption/irrigation/aquiculture purposes, the cooling towers are becoming more common features of thermal and nuclear power plants in India. Of the two types of cooling towers normally used, the Natural Draught Cooling Tower (NDCT) has a lesser effect on the environment than the Induced Draught Cooling Tower (IDCT).

2. FEATURES OF NDCTs

2.1 Thermal Features

NDCTs have a tall hyperboloid-shaped tower on the outside and are majestic structures forming a landmark in any major power plant. They have a good aesthetic appeal and blend well with the other tall structures. There is some interrelation between the functional/thermal requirements and the structural form of the outer tower. For dissipation of heat the NDCT employs a simple process of evaporative cooling. Indian NDCTs are invariably of counterflow type wherein the water and cooling air move in parallel streams opposite to each other. Hot water from the condenser is sprinkled over a heat exchange medium or packing' or 'fill' arranged in the lower reaches of the tower. Cool air is drawn into the tower because of the difference in density between the hotter air inside and the cooler air outside and while passing upwards through the packing the air cools the water which is flowing down. Energy is required only for pumping the water into the condenser system after recooling and such energy expenditure is also required for the 'once-through' system .

The packing is of two types-film type employing PVC (or AC)corrugated sheets, or splash type employing PVC splash bars or concrete splash bars. The PVC film type packing of recent origin is more expensive and generally requires the use of treated water to avoid clogging of the finer pores of the packing. On the other hand the traditionally used splash packing in India employs a rugged system consisting of prestressed concrete splash bars called laths. This packing can handle practically any type of water and being of prestressed concrete, has a reasonably long life. In India so far the NDCTs were provided with splash type of packing.The concrete lath suits the Indian environment better in that it's production is labour-oriented and labour is inexpensive in India and needs employment opportunities. In a typical tower about 250,000 numbers of these laths of about 2.6M length may be required.

2.2 Functional Features

In the Indian towers hot water enters the tower at about 10M to 11M height above ground level, through mild steel headers and is then distributed throughout the area through concrete ducts and small diameter AC distribution pipes. Nozzles located below the orifices in the distribution pipes spray the water on top of the packing. Water cascades down through the layers of the packing in the form of fine droplets which interact with the upward stream of air, transferring the heat. The recooled water collects in a pond after it exits from the packing and is then pumped back into the condenser system. Various accessories provided for proper functioning of the tall NDCTs include inspection platforms and walkways,aviation warning lights,lightning conductor system, access staircase and ladders upto tower top, control gates and screens in the recooled water outlet, drainage system for the recooled water pond, etc.

2.3 Structural System

2.3.1 Outer Tower

The outer tower generally has a hyperbolic shape though nowadays other curvilinear forms are also used. This results in a highly efficient structural scheme for the outer tower. It is claimed that the outer tower has lesser material over the enclosed volume than an egg-shell over its volume. The minimum thickness of a 125 M tall tower can be as little as 175 mm. The outer shell is supported on a number of small diameter columns normally arranged in a diagonal manner. This open system of support columns forms the air inlet opening. These columns either rest directly on a foundation or rest on pedestals integral with the wall enclosing the pond of recooled water.

2.3.2 Internal System

Inside the tower the packing is supported independently over a grid of beams resting on a series of columns which rise up from the pond floor. These beams and columns generally are of precast reinforced concrete. Within the packing, the pear-shaped concrete laths are supported on bearer blocks or beams having serrations on the top face to hold the laths.

2.4 Construction Scheme

The outer concrete shell is constructed in a number of lifts of the order of 0.9m to 1.5m height, using a 'jump-form' system with a scaffolding system climbing on the already concreted shell in stages supporting the forms and working platforms. The climbing scaffolding is either moved up manually lift by lift or is hydraulically moved up in a mechanical system. In the lower regions where the diameter is large and shell thickness is more, the circumference is cast in a number of segments and higher up, where the concrete volume involved is small, concreting is done in two segments. To save on construction time the internal fill structure is precast and erected, generally after the shell construction is over. Current practice with the safer hydraulically climbing system is to start the erection of the fill structure simultaneously with the outer tower to save on time, adopting proper safety measures. The columns and beams of the fill-supporting structure are precast in a site casting yard and the laths are precast and prestressed by a long-line pretensioning method.

3. COMPARISON BETWEEN NDCT AND IDCT

As opposed to the NDCT, the IDCT employs mechanical means- a topside fan driven by a motor through a reduction gear box - to induce a draught of air to cool the circulating water.The primary advantage of NDCT is that its energy consumption is much smaller than that of an IDCT. Typically for a 210 MW thermal power plant about 1500 KWH of energy per hour is saved in the case of an NDCT. The NDCT has no moving or mechanical components and hence requires lesser maintenance. On the other hand the IDCT has a number of moving parts-motors, gear boxes,fans,etc. Regarding noise produced by the cooling tower, the NDCTs have a low noise level on account of falling water and the IDCTs have higher noise levels mainly on account of fan operation. Another important aspect affecting the environment is the drift. There is a tendency for the air passing through the tower to carry with it a 'drift' consisting of fine droplets of water. The moisture-laden exit plume is released by the tall NDCTs at a much higher elevation than the IDCTs and hence undesirable ground level condensation is minimised. The exit plume in an IDCT is discharged at lower levels and the consequent condensation on the structures around can cause a number of problems, especially for electrical installations. There are also problems of recirculation of the hot air back into the tower and resultant loss in efficiency.Under the Indian context the ambient air temperature is fairly high and hence the driving force on air movement for a NDCT is small and consequently the air velocity through the tower is small. The maximum loss of circulating water through such drift is less than 0.2% of the volume of circulating water. Hence drift loss is not significant and drift eliminators which trap the water drops in the exit plume are not required. On the other hand drift eliminators are a must for IDCTs. Drift eliminators account for a significant part of the pressure drop for the air moving through the tower. Since pressure drop directly affects the tower size or fan size, not having to provide drift eliminators results in savings. Since there are no moving parts in a NDCT, there is no need for any oil, grease or other lubricants which have a risk of contamination or pollution of the environment. The only two disadvantages of the NDCT are the high initial cost and the relative lack of flexibility for differential operation during various seasons. These disadvantages are far outweighed by the advantages.

4. POSITIVE INFLUENCES OF THE NDCT

4.1 Basic Features

The main positive feature of the NDCT is that it helps conserve water for purposes other than mere cooling, and there is no danger to the ecosystem by the discharge of large volumes of hot water into water bodies. The water requirement is limited to make-up water to compensate for drift loss or evaporation loss or blowdown to keep the concentrations of suspended/dissolved solids to acceptable levels. This requirement of make-up water is only of the order of 4% of the volume of circulating water. Since there is no consumption of extra energy, the use of NDCT promotes energy conservation. With the use of NDCT there is no noise pollution either. As mentioned earlier, the NDCT is an energy-saving and eco-sympathetic system.

4.2 Steps to Improve NDCT Performance

4.2.1 General

With further development of technology in India in the field of NDCTs, the performance of the NDCT is being improved with regard to three basic areas: thermal,functional and structural fields.

4.2.2 Thermal Aspects

In the field of thermal performance high-efficiency film-type packings are being introduced. The use of this type of packing results in smaller-sized towers and lesser energy for pumping the water into the tower/condenser system. The drawbacks of this type are that it generally requires treated quality water, it is relatively more expensive and its life has not yet been established in practice. The developing use of high-performance nozzles also results in better performance through better distribution of water over the

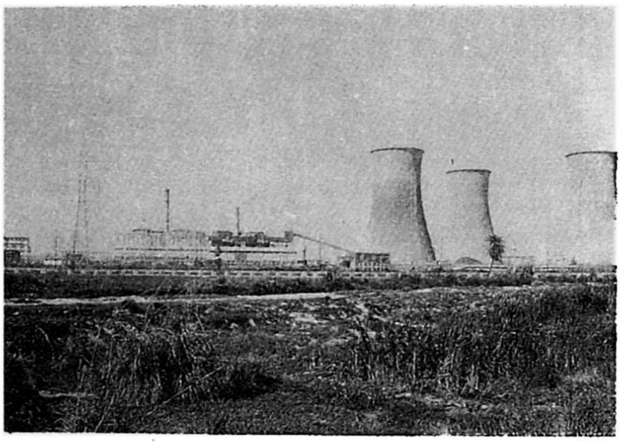

Fig. 1 NDCTs in a power plant

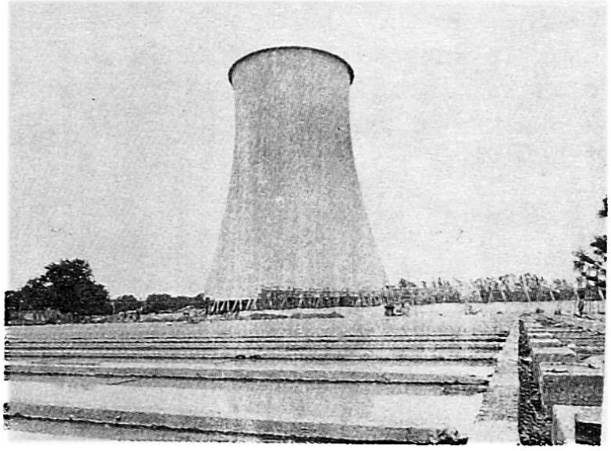

Fig. 2 An NDCT with a lath casting yard in the foreground.

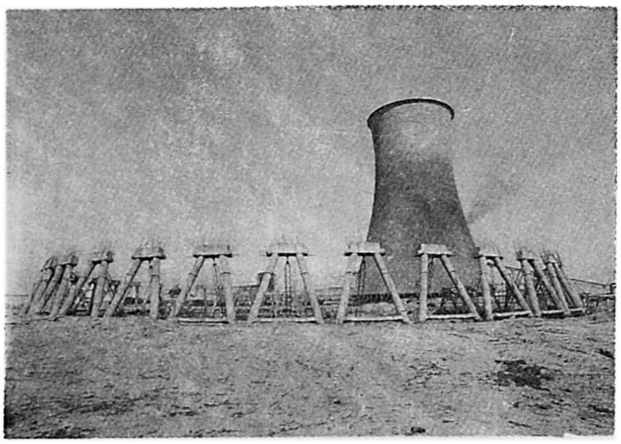

Fig. 3 Precast diagonal column systems under erection

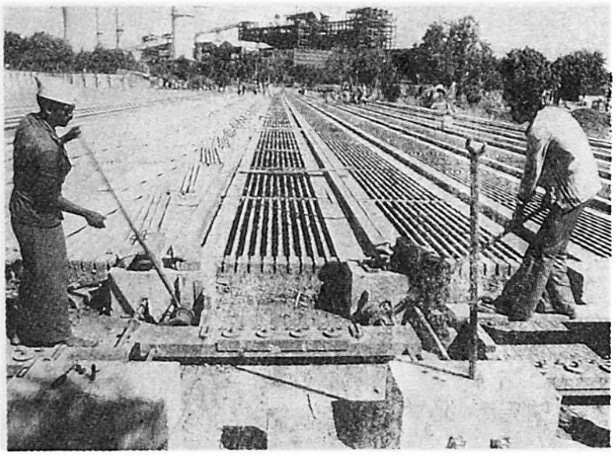

Fig. 4 A typical lath-casting yard

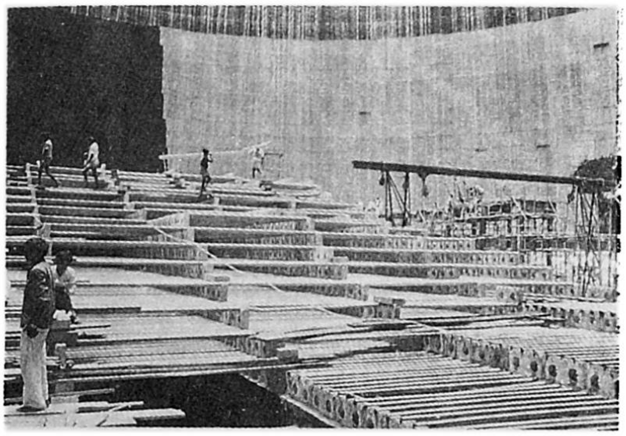

Fig. 5 Assembly of laths for the packing in progress

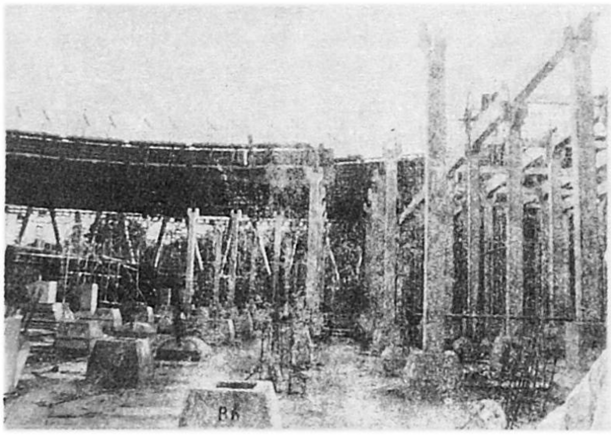

Fig. 6 Hydraulically climbing form in position.

packing and finer atomisation of water to promote heat transfer. The recent development of 'dry' type of NDCT has not yet found an application in Indian power plants because of the high cost. In this type the circulating water is fully enclosed in heat exchanger pipes and there is least loss of water. The impact on the environment in this case is even less than that of the 'wet' type of NDCTs.

4.2.3 Functional Aspects

A number of measures are being taken to improve the functional performance and efficiency of NDCTs with reference to operations and maintenance. The various accessories mentioned earlier are being improved upon. Maintenance is being planned for in the design stage itself. In France water collecting systems have been recently developed to collect the recooled water just below the packing itself and thus saving on precious pumping head. This system has been installed in the world's tallest NDCT at Golfech. In some NDCTs in Germany flue gas is being vented through NDCTs thus obviating the need for a separate chimney. Such systems have not yet found an application in India.

4.2.4 Structural Aspects

Better understanding of the behaviour of the outer hyperbolic shell,development of better analysis and design techniques-particularly with reference to buckling phenomena,response to dynamic loads and thermal loads and soil-structure interaction- and development of better structural forms for the internal fill-supporting structure are some of the developments in the structural field in India.On the construction side, indigenous adaptation of the hydraulically-climbing form and more efficient assembly of the internal precast fill-supporting structure are some of the developments. Construction periods are getting reduced and construction is being more streamlined.Better quality control measures and Quality Assurance Schemes are being implemented.In France vertical columns have been recently introduced for supporting the shell instead of diagonal columns, as for instance in the NDCT at Golfech, to simplify construction and to improve the thermal performance.

5. CONCLUSION

Given the requirement of power generation and consequent requirement of cooling of condenser steam, the Natural Draught Cooling Tower is the most suitable system from the point of view of least adverse effect on the environment. There are a large number of such towers in India which are operating well and these towers are being continually improved. The Indian industry has now geared itself up to meet the future challenges of power production by building up an indigenous base for the design and construction of the NDCTs.

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