COOLING TOWER CONSIDERATIONS FOR ENERGY OPTIMIZATIONS

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ABSTRACT

Energy conservation strategies and production economies involve more than examining the cooling tower fan consumption of horse power.

Colder water provides vast potentials for savings. Ask yourself, "What is the dollar and energy utilization value if I can obtain 1°F colder water off my cooling tower than I am now getting?" Therefore, let us first examine the elements of the cooling tower to determine the areas of greatest potential improvement to generate that colder water.

The air flow generated by the fan should first be looked at in both counterflow or crossflow towers to determine that maximum flow is available through pitching fans up to within the motor plate amperage limitations and fan stall point calculations. If applicable, new fiberglass state of the art fans can be installed and additional motor horse power added.

However, the most dramatic improvement that can be obtained in producing colder water is to retrofit modern film fill to replace the old fashioned wood splash bar slats.

CASE I: - CROSSFLOW TOWER

In this case history of a Gulf Coast Chemical Plant producing sulphuric acid, the large crossflow tower (Figure 1) had typical heat transfer surfaces of the old style and narrow 1/4 inch thick wood splash bar slats (Figure 2).

This wood is relatively thin and maintenance personnel had registered complaints concerning the excessive amount of wood chips accumulating in the strainers and tubes. The California Redwood Institute states that the service life of thin section Redwood used in cooling towers is approximately 15 to 20 years. Therefore, in these older-type towers the fill is usually deteriorated to the point where a change out would be required to maintain any semblance of heat transfer. Consequently, it is economically prudent at this time to install state of the art fill bars to take advantage of the labor intensive operation required to take out the old deteriorated wood and also gain a higher level of heat transfer in the tower.

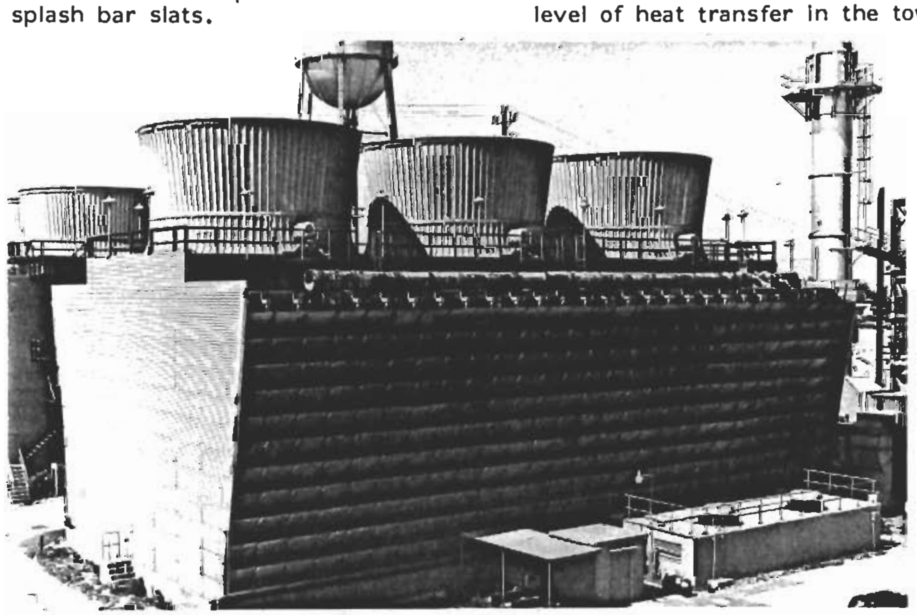

Figure 1. Industrial cross-flow cooling tower modernized and optimized by state of the art retrofit.

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A very professional analysis of the performance of many configurations of crossflow fill is investigated and calculated by Neil W. Kelly in his publication "Kelly's Handbook of Crossflow Cooling Tower Performance". This handbook is the accepted standard in the cooling tower industry for crossflow thermal performance analysis.

This publication provides heat transfer curves and methods of predicting the performance of various materials. It also includes illustrations and the procedures for calculating and projecting performance values of various types of fill configurations together with static pressure drop calculations for the fill, drift eliminators, structure, and air intake louvers. The companion book for counterflow tower analysis is the Blue Book published by the Cooling Tower Institute.

Because the PVC self-extinguishing plastic bars are a combination splash and film cooling surface, they are highly efficient. The cooling tower in this case has produced 4°F colder water after conversion (Figure 3).

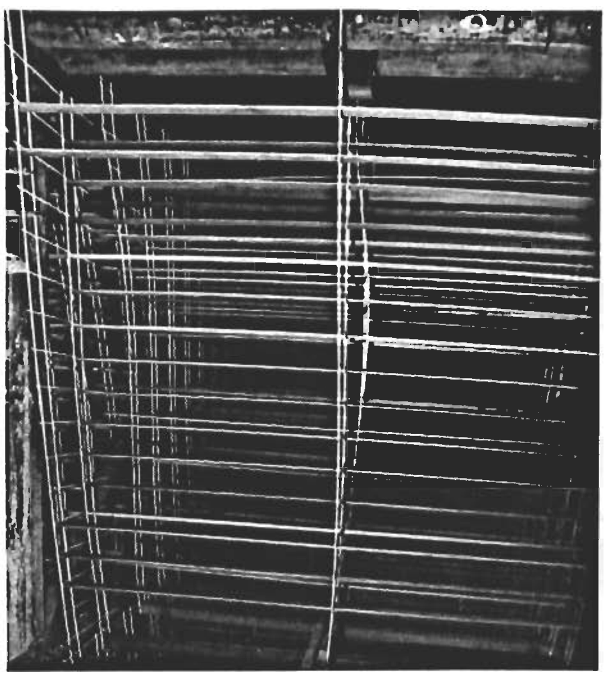


Figure 2. Old fashioned wood splash bars designed over 30 years ago to be replaced by new PVC units.

To convert wood to the more efficient PVC, the old existing fill must be taken out and disposed of from the premises, along with their hanging supports. New supports to fit the configuration of the plastic bars are then installed. The new materials are properly "threaded in" as indicated in Figure 3.

It should be noted that water quality and temperature parameters indicated, in this case, that the least expensive PVC material was utilized. PVC is capable of withstanding up to about 130°F, CPVC up to 160°F, and Polypropylene up to 185°F. These criteria should be verified by the manufacturer for any particular installation. High sustained temperatures and severe chemical service might require stainless steel. A further selection decision, in either crossflow or counterflow configuration is the quality of the circulating water, make-up water, and possible chemical upset which could effect the performance of the fill packing.

This increase in colder water, according to the Plant Project Engineer in this case history, produced approximately 16 percent more sulphuric acid at less condensing energy costs and probably saved about $200,000.00 the first nine months of operation which paid back the cost of retrofit.

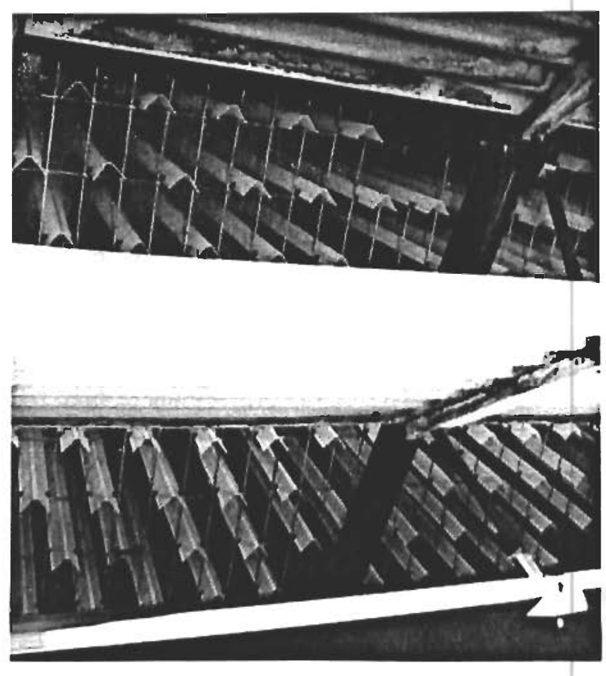


Figure 3. New splash-film fill installed parallel to air movement produces up to 5°F colder water.

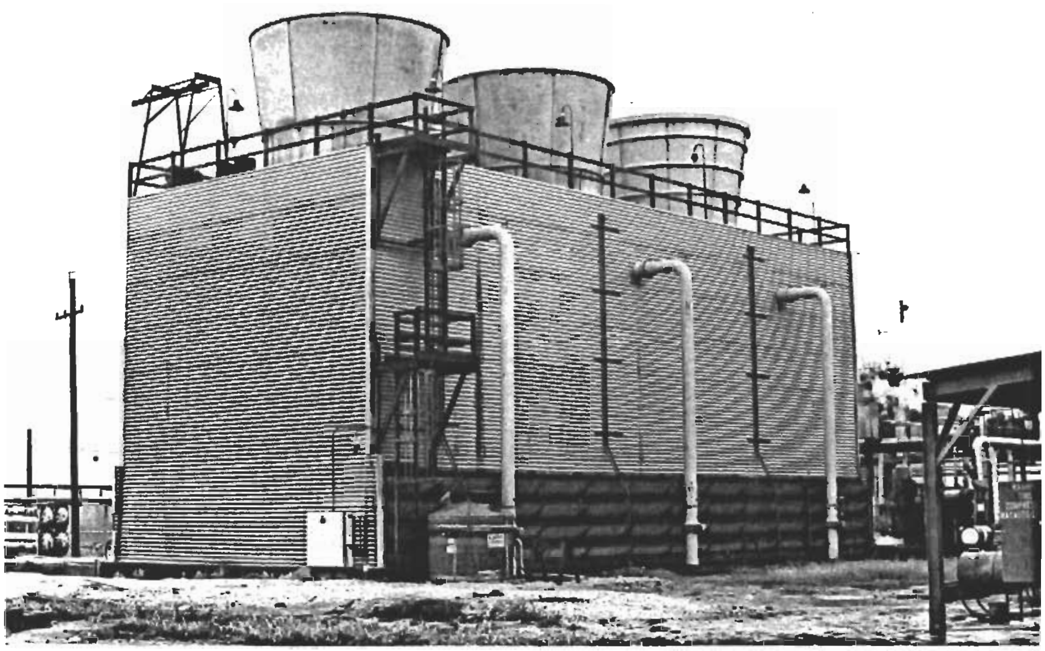


Figure 4. Gulf Coast Refinery Cooling Tower was tested by the Cooling Tower Institute in accordance with ATC-105. The results, certified by CTI showed improvement from 74% to 123% of Capability.*

CASE II: - COUNTERFLOW TOWERS

In the counterflow configuration, there are two important opportunities for improving the performance of the tower: water distribution and cellular fill installation.

In this Refinery cooling tower (Figure 4) 25,000 gallons per minute of circulating water required a design of 105°F entering water and 88°F discharge water at an 80°F inlet ambient temperature. The tower consisted of three cells with six 50 horse power motors. A CTI-105 Test in July of 1978 produced a 74.2 percent of capability of the old configuration.

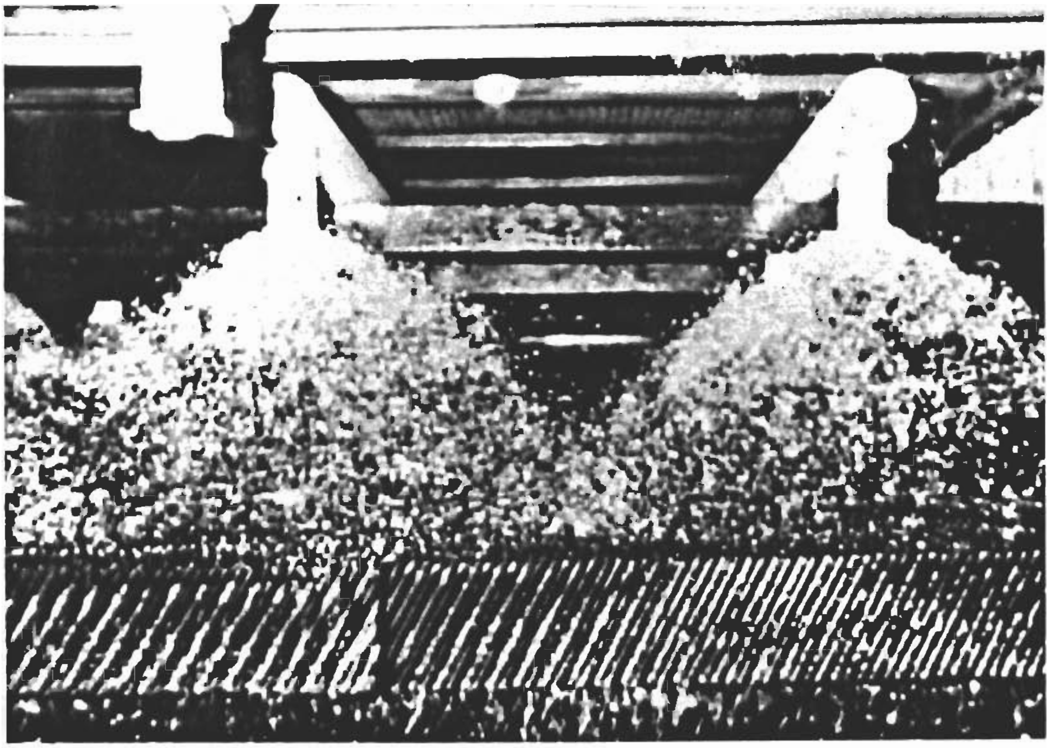
The wood fill and water distribution system were designed approximately 20 years ago and apparently could never produce a sufficient level of cooling.

The retrofit consisted of installing square spray ABS nonclogging nozzles and a five foot depth of cellular fill (Figure 5) having a large flute width of 1.90 inches and separation between layers for possible cleaning due to occasional "greasy" water exposure.

After retesting by the CTI in November, 1983 of the rebuilt tower it produced 123.9 percent of the original design performance.

This improvement more than paid for the retrofit costs within 6 months by reducing power costs to the condensers.

* Location and name of Project Engineer available upon application.



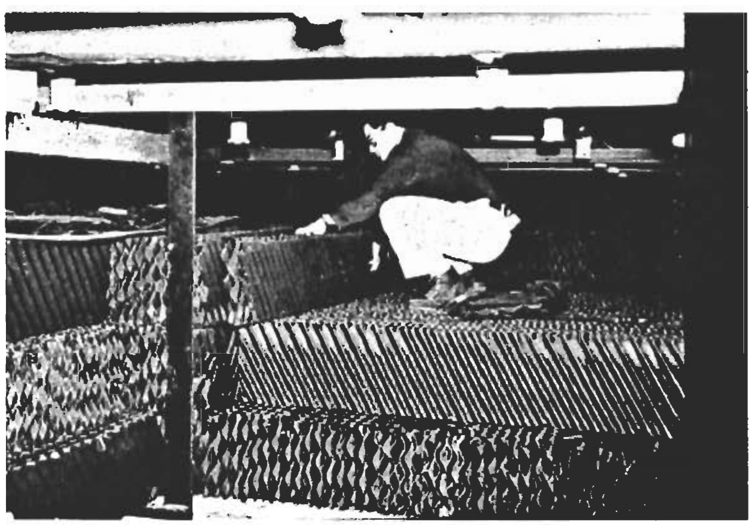


Figure 5. Rebuilt elements of the refinery cooling tower showing highly efficient square spray water distribution pattern and state of the art cellular film fill packing.

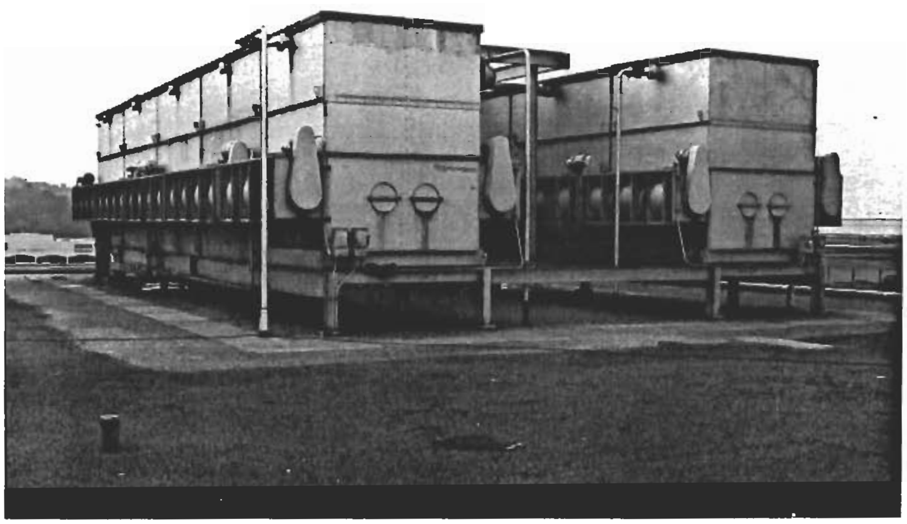


Figure 6. Eight cell blow-thru tower where rebuilding lowered the water temperature 4°F greatly reducing compressor head pressures and temperatures thereby lowering energy consumption throughout the system.

CASE III: - Blow-through Squirrel Cage Tower

The subject eight cell metal tower had a water distribution system of 960 small orifice nozzles on 1½" piping per cell (Figure 6) and the air conditioning machinery it had to cool was operating at high head temperatures and pressures as a result of not providing a sufficient level of cold water. The clogged and corroded water distribution system was removed from the tower and the rusted, clogged, steel plate corrugated wet decking fill was also disposed of. After sandblasting and coating with coal tar epoxy, the new spray system consisting of 12 nozzles per cell on 3" diameter PVC pipes was installed together with new PVC cellular fill (Figure 7).

Enthalpy charts for Freon indicate that 3½ percent of the electrical energy to the compressors and condensers can be saved for every 1°F colder water. The subject cooling tower was tested in accordance with the Cooling Tower Institute Acceptance Test Code 105 and indicated a 5°F colder water was obtained after retrofit. Since the rebuilding for colder water cost $113,100.00, the return on the investment was realized in approximately 14 months with a projected ten year savings of more than $500,000.00. This payback estimate was generated on the basis of 100 percent air conditioning utilization per year. If it is realistically cut back 50 percent, the savings of $250,000.00 still are well worth the rebuilding and upgrading investment.

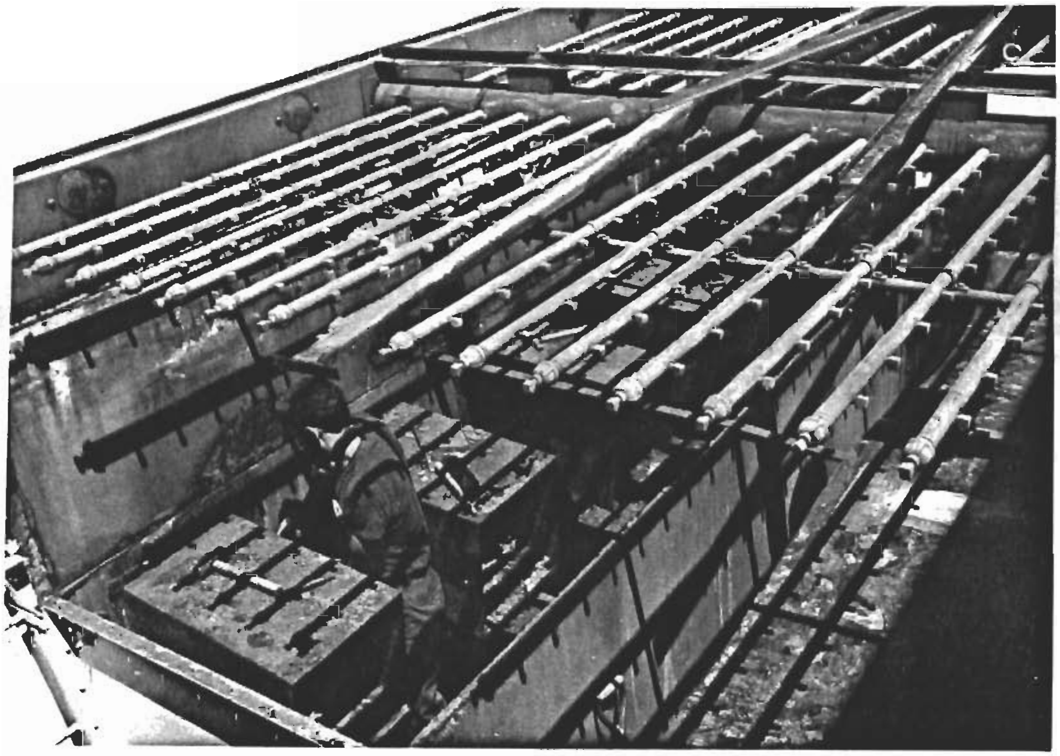
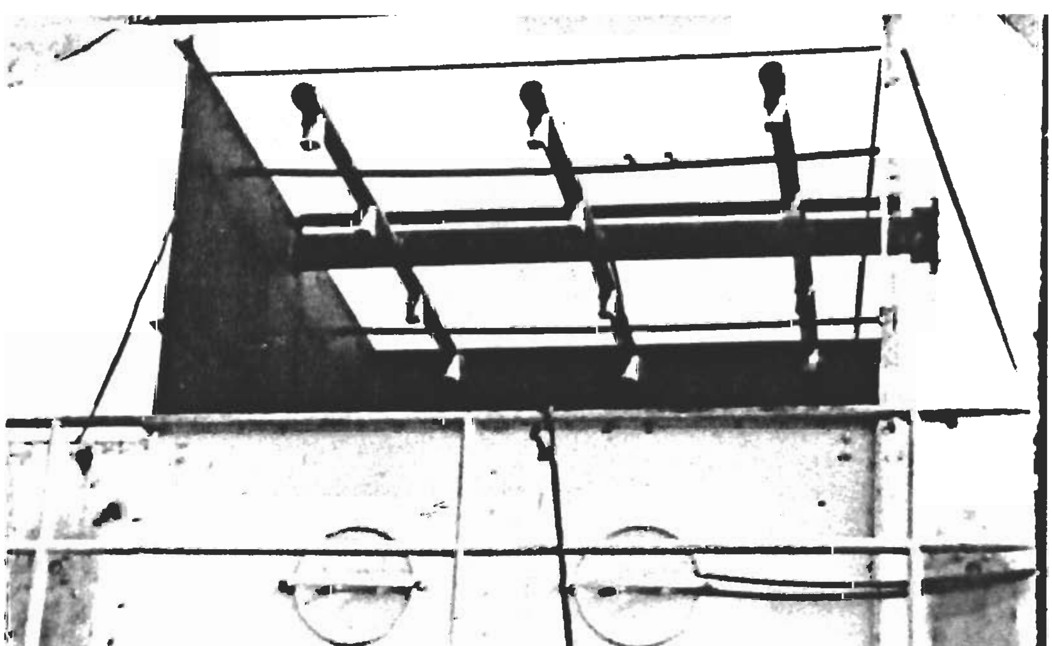


Figure 7. The original 280 small orifice (1/8") nozzles per cell on 1½" piping replaced by large (1¼") practically non-clog ABS nozzle on 3" diameter non-corroding PVC pipe arms Cellular fill, illustrated on Figure 5, was installed.



CONCLUSION

If a refrigeration/air-conditioning system chemical process plant or electric generation station is operating marginally due to high head temperatures, it behooves the owners and operators to investigate the possibility of upgrading the existing cooling tower rather than installing another O.E.M. unit which may or may not solve the problem of requiring colder water. It should be well understood that colder water can save energy and create an operating profit. Cooling towers are hidden bonanzas for energy conservation and dollar savings when properly engineered and maintained. In many cases, the limiting factor is the quality and quantity of cold water coming off the cooling tower.

The thermal upgrading and structural retrofit technology of all types of cooling towers is the same, only the size is different, as illustrated on Figure 8.

It would be prudent for the engineer with responsibility for the efficient operation of the refrigeration/air conditioning system to have a professional inspection of the cooling tower by a consultant who can analyze the energy savings potential of his installation. In these days of high energy costs, the savings accrued from a well engineered and retrofitted cooling tower bringing it into the 1980's can make a significant impact on a company's profit and loss statement.

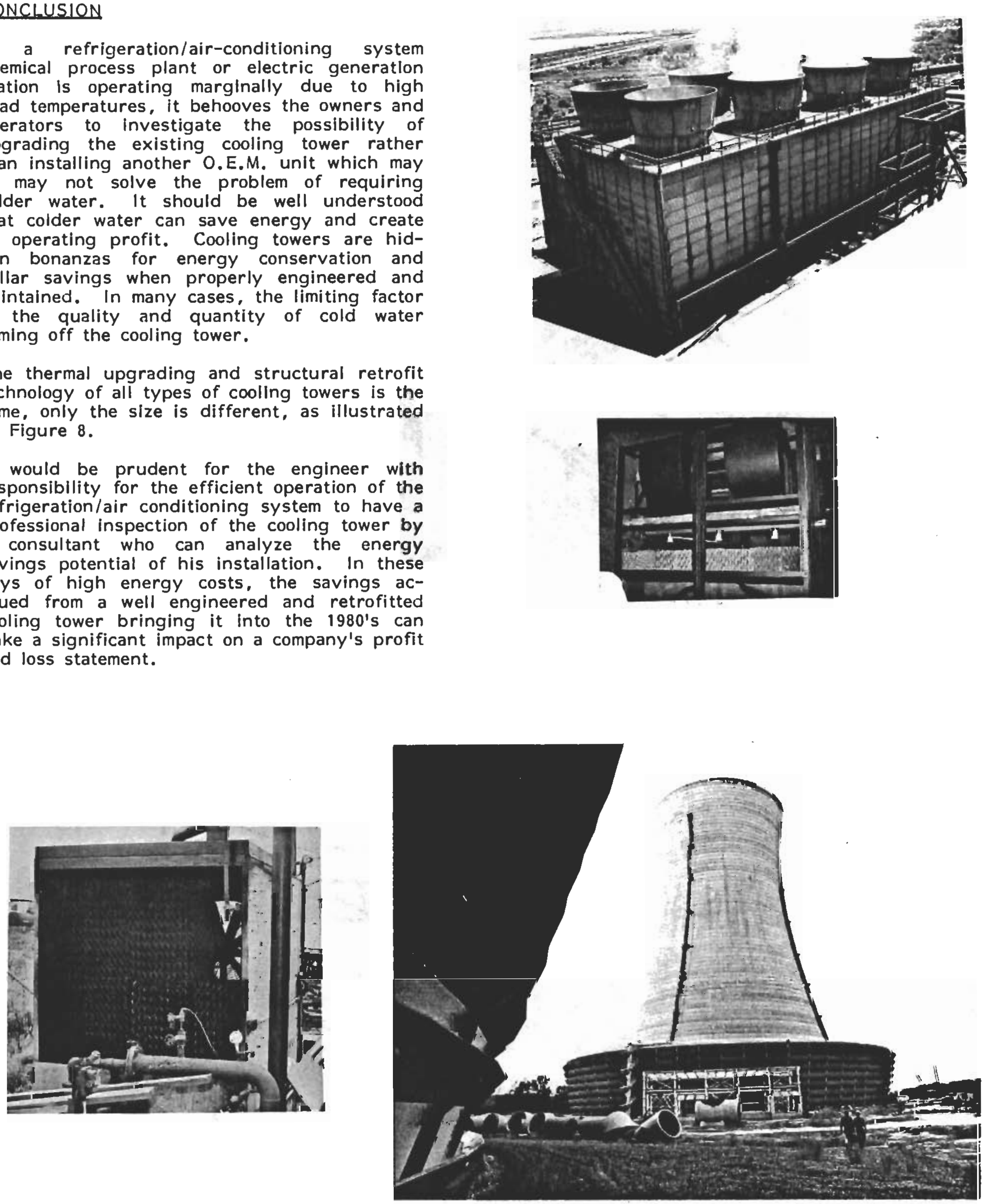


Figure 8. The size of the cooling tower is relative. Energy conservation techniques are the same for large or small counter-flow or crossflow configurations.