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## EVAPORATIVE ROOF COOLING - ECONOMY

The article presents information on research on evaporative cooling system for large surfaces conducted by the company Öntözés.hu Ltd in cooperation with the Budapest University of Technology and Economics. It enumerates advantages of employing such solutions on roofs.

**Keywords:** evaporative cooling, roof cooling systems, ASHRAE, economy

### INTRODUCTION

In our climate, on an average summer day, the solar heat load of a roof starts to build up at 4-5 am, reaches  $500\div 600$  W/m<sup>2</sup>/hour by 8 am, it gradually culminates by 12-1 pm with  $800\div 900$  W/m<sup>2</sup>/hour, slowly decreasing to  $500\div 600$  W/m<sup>2</sup>/hour by 4 pm. It means that from 8 am until 4 pm the roof itself absorbs and radiates into the building 6-9 times the heat load of a floor heating system, and the external surface of roofs may reach the temperature of  $60\div 80^{\circ}\text{C}$ . In industrial and commercial buildings, this procedure is responsible for three major problems:

1. The ascending internal heat (produced by machines and hot technologies that normally leaves the buildings mainly through the roof), is trapped inside;
2. The internal heat is even increased by the heat load from the roof: the whole roof acts as a huge solar heat absorption panel and radiator;
3. The continuous dilatation of the roof membrane ( $60\div 80^{\circ}\text{C}$  daytime;  $8\div 10^{\circ}\text{C}$  at night;  $0^{\circ}\text{C}$  or below in a summer shower or hail) creates tears and cut-off points, causing leakage.

Evaporative roof cooling can greatly reduce all three problems. In most cases the effect of roof cooling is enough to reduce the internal heat load under the critical level on machinery and employees as well, thus preventing 80-100% of costly technical and staff problems normally caused by summer heat. At the same time, keeping the roof at an even temperature stops dilatation and leakage, and extends the life cycle of the roof materials and roof-mounted equipment - such as heating, ventilation, and air conditioning - by 30-40% [1].

## 1. "EVAPORATIVE" COOLING IN THE WORLD

At room temperature, 1 litre of water absorbs  $0.65\div 0.68$  kWh ( $2,200\div 2,300$  BTUs) to evaporate. It is about the same order of magnitude as that of the total solar heat-load.

Could we make to evaporate 1 litre of water/hour/m<sup>2</sup>, we would be able to keep the whole solar heat load away from the roof. Roof spray systems were first introduced in the US in 1934. These systems basically sprayed excessive amounts of cool water over the surfaces, using water itself rather than evaporation, for cooling. After World War II, many thousand hectares of roofs in the US were equipped with this method. The introduction of cheap air-conditioning and low energy prices had cut back the technology, but following the energy crisis of 1973-1974 it became widely popular again.

Today there is a large industry with many contractors and wide scientific literature based on "evaporative" roof cooling throughout the US, India, Japan, Korea, Australia, etc. Evaporation is much cheaper (using a small fraction of water compared to the old systems), and much more effective, since evaporating water can carry away  $7\div 10$  times the energy of cooling water. With the use of fine-mist-producing spray heads and microprocessor-based controllers, the modern American systems started to use the effect of evaporation rather than cooling with water itself. But these American "evaporative" cooling technologies have clear limits:

- no American or Far-Eastern technology known to us was able to make evaporate more than  $1\div 1.2$  gallon of water/10 ft<sup>2</sup>/day =  $0,4\div 0,5$  litre/hour/m<sup>2</sup> - which is less than half the amount needed to disperse the total solar energy load;
- these systems are either copper-pipe systems, making them cost  $400,000\div 600,000$  \$/10,000 m<sup>2</sup>, or they utilize UV stabilized PVC, still costing usually  $250,000\div 300,000$  \$/10,000 m<sup>2</sup> (still  $2\div 3$  times the price of ours);
- the American contractors are proud to say that their systems need low maintenance - supervised weekly (or some of them monthly) by authorized personnel;
- all of these systems suffer expensive (5,000-10,000 \$) damages from lightning.

## 2. THE FIRST REALLY EVAPORATIVE ROOF COOLING SYSTEM OF THE WORLD: ÖNTÖZÉS.HU LTD'S "WATER-FILM TECHNOLOGY"™

Our company, Öntözés.hu Ltd, have more than 14 years experience in the field of micro-irrigation (Figs. 1, 2). Since roof-cooling technologies had neither experiments nor predecessors in Europe, we started a fundamentally new research and development on the issue of evaporative cooling of large surfaces, co-operating with the Laboratory of Thermo-Physics of BME (Budapest Polytechnic University).

All of the modern American systems use different methods for monitoring the variations of TEMPERATURE, thus enabling them to EVALUATE the POSSIBLE evaporation. Instead of the method of CALCULATION, we decided to MEASURE

the ACTUAL and momentary evaporation. It is the more important since evaporation is affected much more by factors like relative humidity and wind than by mere temperature.



Fig. 1. Evaporative roof cooling system

Through 6 years of practical research and testing, we succeeded to find the method and the practical materials for the task. It enables us to build roof-cooling systems, that

- can make evaporate  $12 \div 18 \text{ litre/m}^2/\text{day} = 1.2 \div 1.8 \text{ litre/hour/m}^2$  - which is 1.5÷1.8 times more than the amount needed to disperse the total volume of solar energy load, and 3÷4 times more than our competitors can provide;
- thus we are capable not only to prevent all the solar heat load from entering the buildings, but also to actively reduce the internal heat through the roof;
- the construction costs are reduced to about 100,000 € (130,000 \$) /10,000 m<sup>2</sup> (it might be higher on small or fragmented, proportioned roofs);
- practically maintenance-free throughout the harsh conditions on a roof in continental climate (against thunderstorms, -30°C in winter, + 80°C in summer, etc.) - with only 2 scheduled maintenance procedures a year (restarting in spring, and dewatering in autumn);
- lightning-proof: in the past 5 years, instead of the thousands of dollars per each lightning usual in the systems of the competitors, we have never had damages

- more than 200÷300 \$ at a time due to lightnings, though there were storms, when we detected more than 200 (!) strikes on the area of our systems within an hour (e.g. on the roof of GM Hungary - today Opel Szentgotthárd);
- self-controlled, protecting itself, and protecting the roof from being eventually flooded: all possible pressure, leaking or breaking problems are continuously monitored, self-tested and controlled by the central controller (many times in each second);
  - the central controller automatically shuts down any problematic zone - but the rest of the system keeps working, and at the same time, a request is being sent for service, indicating the precise nature of the problem;
  - remote-controllable and remote-manageable;
  - instead of producing a closed surface or ponds of water (except of the rare occasions when the efficiency calculations of the central controller show that closed water cover is more efficient in a given situation), we produce, and continuously re-produce, only a thin layer - a “film” - of water.



Fig. 2. Evaporative roof cooling system

### 3. “WATER-FILM TECHNOLOGY”™ - COSTS, PAYBACKS, ENVIRONMENT PROTECTION

“Since the first energy crisis, where there is a sufficient supply of industrial water available, roof cooling spray systems proved to be the most effective

and economic way of heat-protection in the US and in many other countries.” (ASHRAE - The American Society of Heating, Refrigerating and Air-Conditioning Engineers - data [1])

- Cost of investments usually varies among 90,000÷120,000 €/10.000 m<sup>2</sup> (smaller or more proportioned roofs cost significantly more pro m<sup>2</sup>);
- Operating costs (water consumption: about 10÷18 l/m<sup>2</sup>/day + energy consumption: about 2÷5 W/m<sup>2</sup>/day are incomparably lower (< 1%) than costs of air-conditioning;
- A well-designed roof-cooling system substitutes about 25÷30% of air-conditioning needed - for 5÷6% of the investment and less than 1% of operating costs;
- Return of investment: according to ASHRAE data [1], Roof Cooling Systems, in our climate, when planned in new construction, usually return 1.5÷2 times the investments in the first year, in equipment savings, roof-life extension savings and HVAC operating costs;
- But in many cases, where there are high costs due to technical, labour or productivity losses in hot summer conditions, return of investment - even in cases of retrofitting on existing buildings - can be reached in 1 or 2 DAYS;
- Environment protection:
  - energy consumption is extremely low: 2÷5 W/m<sup>2</sup>/day;
  - the system neither uses nor produces environmentally dangerous materials;
  - by preventing thermal dilatations of the roof, it reduces or stops leaks without the use of further layers of environmentally hazardous plastic or asphalt, and - according to ASHRAE researches - it usually doubles the life expectancy of the roof, and of the expensive roof-mounted - such as heating, ventilation, and air conditioning - equipment.
- Conveniences, ergonomics: With professional autumn drainage + flushing, and inspection when activating the system in the springtime, the system usually needs no maintenance.
  - the interactive central unit provides continuous control and self-correction, it provides full monitoring and remote control/management possibilities for the authorized local personnel and for our service as well.

## CONCLUSION

The company Öntözés.hu Ltd have a large experience in the fields of micro-irrigation. Since roof-cooling technologies had neither experiments nor predecessors in Europe, we started a fundamentally new research and development. The roof-cooling system is characterized by smaller cost pro m<sup>2</sup>, smaller water consumption and extremely low energy consumption. The system neither uses materials which are dangerous for the environment.

## REFERENCES

- [1] ASHRAE - The American Society of Heating, Refrigerating and Air-Conditioning Engineers - data and information.

### DACHY Z CHŁODZENIEM WYPARNYM - EKONOMIA

W artykule przedstawiono informację na temat badań prowadzonych nad wyparnym systemem chłodzenia dla dużych powierzchni przez firmę Öntözés.hu Ltd we współpracy z Uniwersytetem Politechnicznym w Budapeszcie. Omówiono korzyści płynące z zastosowania tego rodzaju rozwiązań na dachach.

**Słowa kluczowe:** chłodzenie wyparne, dachowe systemy chłodzenia wyparnego, ASHRAE, ekonomia