MEASURED PERFORMANCE OF A PASSIVELY COOLED INDUSTRIAL BUILDING IN MALTA - PRELIMINARY RESULTS

BRIAN FORD
Peake Short & Partners
15 Prescott Place
London SW4 6BS

ABSTRACT. This paper desribes preliminary results from the first few months of monitoring the thermal performance of the passively cooled process building at the Simonds Farsons Cisk Brewery in Malta. Although only limited data is available it can be shown that with daily maximum external air temperatures regularly above 35°C, the process hall air temperature remains below a peak of 27°C for all but extreme days. The process hall floor surface temperature shows a mean of 25.3°C for this period and is very stable, while the 'jacket' air temperature fluctuates more widely between process hall and external air temperature. These results are broadly in line with performance simulations made at design stage with a two zone finite difference model.

1. Introduction

The design of the new process building for Farsons Brewery in Malta has been described previously (1). The building was officially opened on July 12 1990, and the design has been very favourably received (2). The building's performance has been monitored since September 1990. Initial results are very encouraging, and it is anticipated that over the next year analysis will reveal more detail on exactly how night ventilation coupled with internal thermal mass maintains these very stable temperatures.

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2. The Building

The process building was designed to exploit the high thermal capacity of the fabric coupled with night ventilation during the summer to maintain acceptably cool conditions internally and to minimise the cooling load associated with the vessels inside the building. The process hall is surrounded by a 'jacket' of corridor/circulation space (Fig.1 plan). This has a number of functions: reducing solar gain into the process hall; providing a plenum via which the process hall is ventilated; allowing daylight to be reflected into the process hall via high level glazing; providing a major route for piped services as well as an access corridor for workers in the building.

The process area is ventilated via high level openings in the 'towers' above the jacket (Fig.2). The glazed vent openings into and out of the process hall are automatically controlled, regulated to open at night on a temperature differential and to close in the morning according to ambient light level.

3. Evaluation

The objective of this performance evaluation is to test the design intention. This includes:

1) Achievement of satisfactory summer time temperatures within the process hall by means of
 a) Night time ventilation
 b) The 'buffering' effect of the jacket space
 c) The high thermal mass of the building fabric

2) Achievement of satisfactory daylighting of the interior by means of indirect and reflected light via high level clerestorey glazing.

Appropriate methods include both short term (spot checks) and long term (continuous) measurements. Spot checks of air movements through vent openings and within the jacket have been made using a thermal anemometer, providing an indication of air speed and direction. Continuous recording of temperatures (at ten minute intervals) at 12 different locations within the building allow comparison with external air temperature for basic assessment of performance. The data logger used is a 16 channel 'Squirrel' recorder, Type 1206 by Grant Instruments of Cambridge.

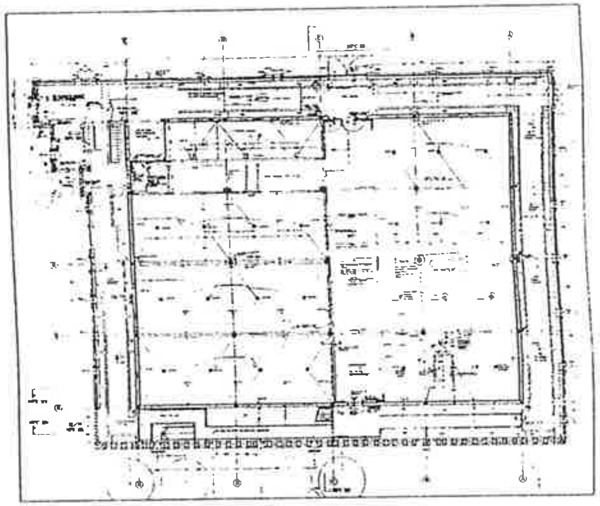

Fig.1. Process Hall Floor Plan

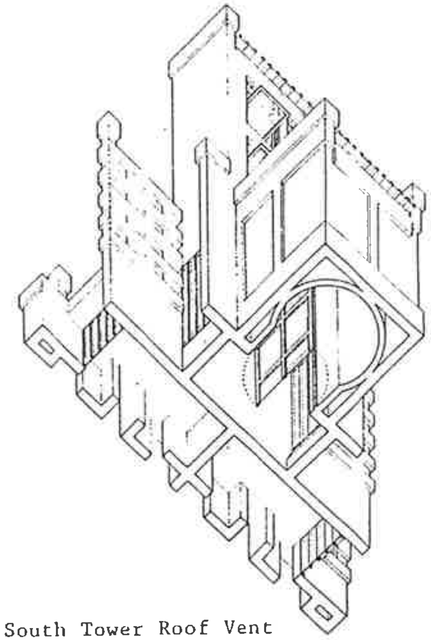

Fig.2. South Tower Roof Vent

4. Preliminary Findings

Data is so far only available for the months of September - November 1990. This is clearly a very limited set of data, but preliminary conclusions can be drawn.

Simulation of performance at the design stage predicted that for all but extreme days in August, the dry resultant temperature within the process hall will stay below 27°C. An 'extreme' August day is characterised by an external air temperature above 40°C. Records indicate that September 1990 was about average (mean monthly external air temperature 23.3°C compared with 24.0°C for the 80 year average). The daily maximum external air temperature was regularly above 35°C, and night time minima were generally above 20°C, with an extreme minimum for the month of 16.8°C.

So, in this context, how does the building perform? For September as a whole the mean air temperature in the process hall was 25.7°C, the minimum 23.1 and the extreme maximum 28.9°C. The stability of the temperatures within the process hall is demonstrated clearly in Fig.3. which shows that for a week (3 - 10 Sept) when daily maximum external air temperatures were regularly above 35°C, the process hall air temperature remained very stable, with a maximum diurnal swing of 2.5°C and a mean of 24.9°C.

The effect of night ventilation can be seen by comparing results for 3 - 10th September with 9 - 15th September (Fig.4). Lower nightime air temperatures coupled with lower daytime solar heat gains result in a considerable drop in the amount of heat stored in the roof slab. It appears that a cool night (minimum below 20°C) has a profound effect on the start temperatures for the following day, and that a succession of cool nights can have a marked effect in depressing surface temperatures within the process hall. This effect is carried through to the following week (15 - 21 September), with process hall temperatures remaining stable around 24.0 C.

For October the monthly mean external air temperature was 23.0°C, with a maximum of 39.8°C and a minimum of 10.2°C. The mean process hall air temperature during this period was 23.1°C, 2.6°C below the previous monthly mean.

It is apparent that cooling associated with night ventilation, the 'buffering' effect of the jacket, and the influence of internal thermally massive floors and walls all contribute to the extremely stable temperatures within the process hall. The building is behaving broadly in line with simulated performance, and it is anticipated that the

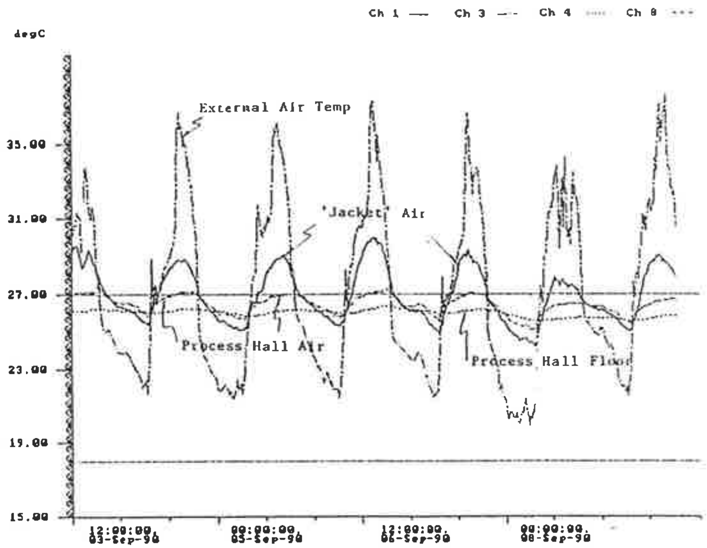

Fig.3. 3 - 9th September 1990 SFC Brewery, Malta.

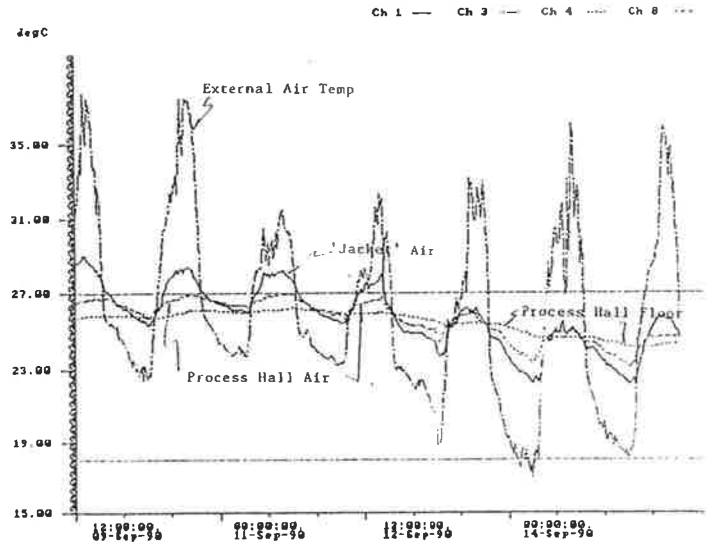

Fig.4 9 - 15th September 1990 SFC Brewery, Malta.

continued programme of measurements will enable disaggregation of the influence of the different elements.

5. Future Measurements

The programme of measurements will continue for at least a further 12 months, and it is intended that additional sensors (to measure relative humidity and solar radiation) will be installed. A series of spot measurements of air movement will be made during the summer of 1991 to obtain information on air change rates. The influence of building geometry on the pattern of air movement will be studied using smoke (to trace movement through vents) and helium filled neutral buoyancy balloons (to trace movement through large spaces). Spot measurements of daylight levels will enable the determination of daylight factors throughout the building.

It is anticipated that the final programme of measurements will enable a detailed investigation of parameters for which little empirical data currently exists, including:

1. Convective heat exchanges to and from the soffit of the roof slab
2. Long term mass effects on the stability of internal temperatures
3. User assessment of the operational success of the building.

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References

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