# On Passive thermal regulation for application to closed solar photobioreactor Algofilm©: An experimental approach

Kashif Hussain MANGI, Jack LEGRAND, Jeremy PRUVOST, El-Khider SI-AHMED\*

University of Nantes, CNRS, ONIRIS, GEPEA, UMR-6144, 37 Bd de l’université, BP406, 44602 Saint-Nazaire, France

\*Corresponding author: el-khider.si-ahmed@univ-nantes.fr

**Highlights**

* Passive thermal regulation technique for Algofilm Photobioreactor
* Experimental Study for Quantification of Condensation for estimation of Condensate Film thickness
* Droplet size evolution as a function of inclination

**1. Introduction**

Thermal regulations in Solar Photobioreactors has been a major problem specifically for overheating of microalgae culture due to variable weather factors such as year-round operation, and day/night cycles (Pruvost *et al.*, 2017). In Algofilm Photobioreactor, the phenomenon of evaporation-condensation has been observed (Goetz *et al.*, 2011), which allows a thin film of condensate to be developed on the inner surface of optical cover. It can absorb some amount of infrared radiations which results reduction in energy requirement to regulate the temperature of Microalgae culture inside the Algofilm. Subsequently water (condensate) has an ability of transmitting the visible light spectrum which is essentially required for microalgae. So, an autoregulation technique of the AlgoFilm temperature through a condensate film on the inner surface of reactor has been hypothesized. In first step the experiments for quantification of condensation have been conducted on lab-scale Algofilm© by optimizing the water flowing film temperature, inclination angle and the flowing film thickness, because absorption of solar radiation (Infrared range) is the function of condensate film thickness.

**2. Methods**

Experimental study on Lab-scale Algofilm for quantification of condensation is carried out by varying the fluid temperature and inclination angle to investigate their effect on the condensate and dripping volume. Temperature measurementswere obtained through LabVIEW software and (ICP.CON Data Acquisition Model i-7019R), thermocouples were installed at glass, condensate film, humid air medium, flowing liquid and bottom surface. Flowing liquid thickness measurement was carried out for each inclination angle, and inclination angle was measured with digital inclinometer (Sensorex ALPHA 4000). Condensed volume of water was collected in a container placed under the Algofilm PBR.

**3. Results and discussion**

The thickness of the flowing water was measured at every inclination angle and it remained under the suggested limit of 2mm by (Goetz *et al.*, 2011; Pruvost *et al.*, 2017)**.** Experimental results have shown encouraging condensation which indicated the possibility to develop considerable condensate film thickness, which will filter some amount of the Infrared radiations.



 Figure 1:Film thickness as function the inclination angle



Figure 2. Droplets size evolution as a function of Slope after 4 hours at Different Angles

It is also observed during experiments that decreasing the inclination angle resulted a notable increase on the overall film thickness (figure 1), by increasing the droplet size as shown in figure 2 which will ultimately increase the absorption of Infrared radiations. However, the operational inclination angle for Algofilm is around 2° as per previous study on Algofilm by (Le Borgne, 2014),

|  |  |
| --- | --- |
| **Figure 3 Dripping percentage as function of the inclination angle** | where condensate flowrate was almost equal to zero, so it is assumed that the condensed volume will be remained at glass cover and bigger droplets will be formed. Moreover, experiments for hourly condensation mass flux at different temperatures were also conducted and the percentage of the dripping flow could be deduced as shown in figure 3. This data will be of interest in the modelling aspect. |

**4. Conclusions**

The optimum objective of current study is to develop a passive thermal regulation for microalgae production in solar conditions through condensate film which will absorb the Infrared radiations. Results of experimental study for the condensation and dripping with variations of flowing liquid temperature and inclination angles of Algofilm Photobioreactor have shown that inclination angle is in direct relationship with the condensate flowrate and inversely with the dripping volume. Results are very favourable on lower inclination angle to achieve higher film thickness of condensate in which higher amount of infrared radiations would be absorbed. Furthermore, the simulation study is undergoing to validate these experiments and further experimental study is being conducted on the estimation of Infrared radiation absorption on the basis of these condensation rate results. This thermal regulation technique can be effective for Algofilm type photobioreactors to reduce the energy requirements to regulate the inside temperature.

**References**

1. Le Borgne, F. (2014) *Development of an Intensified Solar Photobioreactor for Large Scale Production of Microalgae Biomass*. PhD Thesis, University of Nantes.
2. Goetz, V. *et al.* (2011) ‘A generic temperature model for solar photobioreactors’, *Chemical Engineering Journal*. Elsevier B.V., 175, pp. 443–449. doi: 10.1016/j.cej.2011.09.052.
3. Pruvost, J. *et al.* (2017) ‘Development of a thin-film solar photobioreactor with high biomass volumetric productivity (AlgoFilm©) based on process intensification principles’, *Algal Research*. Elsevier B.V., 21, pp. 120–137. doi: 10.1016/j.algal.2016.10.012.