

EFFECTIVE REDUCTION OF EVAPORATION LOSSES FROM WATER RESERVOIRS

¹Adidi O. David and ²Engr. Solomon Olorunfemi

¹Department of Welding and Fabrication Engineering, Delta State polytechnic, Ogwashi-Uku, Delta State, Nigeria, ²UCDI Training Institute Lafarge Africa Plc, Mfamosing Plant, Calabar, Cross River State, Nigeria

ABSTRACT

Evaporation suppression is the reduction of evaporation by controlling the rate at which water vapor escapes from water surfaces. The need for water saving is greatest in areas of little rainfall and low runoff. Water losses by evaporation from storage reservoirs must be minimized for greatest utility of limited supplies. Using trash of polyethylene with different densities (800, 875 and 900 kg/m³) as floating cover to the water filling cylindrical container with 8 cm diameter led to reduce the evaporation rate. A suitable trash density of 800 kg/m³ gave reduction in evaporation rate of 57% from the theoretical results calculated using equation (4) which is a good result if compared with previous researches.

KEYWORDS: *Evaporation Losses, polyethylene, floating cover.*

INTRODUCTION

Evaporation of water from reservoirs, rivers, and agricultural fields results in major losses of critical water resources, especially in arid regions of the world. In arid regions, evaporation can account for as much as 25 to 30% of the total consumptive use of surface water. Because evaporation is such a large part of the water budget in arid regions, evaporation suppression has been studied for decades. Research has shown that surfactants, which modify the surface tension of the water surface, are very effective in the laboratory in suppressing evaporation. Recent research has shown that environmentally innocuous surfactant monolayers covering water surfaces can reduce the rate of evaporation by as much as 40 to 70%, resulting in substantial water resource savings [1].

Annual loss of water from storages through evaporation can potentially exceed 40 per cent of water stored. Nationally more than 7000 GL is stored in over two million on-farm storages, with a further 80 000 GL held in registered large dams. The loss of water causes lost agricultural production, leading to financial stress for some farmers particularly in times of drought. Low water levels also lead to water restrictions being imposed on urban regions. Reducing the amount of water lost to evaporation would improve water security and lead to increased irrigation production [2]. Hardy [3] was the first to suggest that monolayers were formed from polar molecules consisting of a hydrophobic (water-repelling) and a hydrophilic (water-attracting) part, and hence that the monolayer molecules were orientated with the hydrophilic part (a functional group such as a hydroxyl-OH or carboxyl-COOH) buried in the water, and the hydrophobic part (a hydrocarbon structure) tending to leave the water. Conclusive support for this hypothesis of orientation was provided by Langmuir [4].

Finn and Barnes [5] use a suspended covers which are horizontal sail-like structures that are suspended over water surfaces and are supported externally by steel cables and poles. Suspension systems can be characterized by their span and their cover weight. The cover material can vary from porous shade screens to impermeable plastic [6]. The cover reduces evaporation by blocking incoming solar radiation incident upon the water surface, thus reducing thermal energy input into the reservoir surface waters, which in turn reduces the water surface temperature and the potential for evaporation. The covers also reduce surface wind action by lowering the vapour pressure gradient over the water. The covers can also trap water vapour at the water surface that would otherwise be replaced by dry air.

Howard and Schmidt [7] uses a Floating covers include modular and flat sheet covers that float on the water surface. They reflect a proportion of the incoming solar radiation and act as physical barriers to the passage of water vapour both vertically and horizontally. Unlike suspended covers, the floating covers are supported by the water itself. However, they do need to be fixed on the water surface using some form of anchoring mechanism when used on large dams. While most floating cover products are designed to withstand strong wind forces, it is evident they have been designed predominantly for small storages and have not been rigorously tested on larger reservoirs.

Heymann and Yoffe [8 , 9] studied "the stability of multimolecular films of hydrocarbon oils, containing spreaders, on water surfaces" and found that polymerized spreaders form thick films of oil that are much more stable than other spreaders; some last as long as 18 months if they are kept free from dust. In this paper trash of polyethylene with different densities (800, 875 and 900 kg/m³) used as floated cover to the water filling the container in order to reduce the evaporation rate.

THEORETICAL ANALYSIS

Ficks' Law of Diffusion and Stefan Problem [10]:

Consider a non reacting gas mixture of species A and B. Ficks' Law describes the rate at which one species diffuses through other. For the case of one dimensional binary diffusion, Ficks' Law on a mass basis is:

$$m_A'' = Y_A (m_A'' + m_B'') - \rho D_{AB} \frac{dY_A}{dx} \quad (1)$$

Where $m_A'' = \frac{m_A'}{A}$ is the mass flux of species A (kg / m² .s)

Y_A is the mass fraction

D_{AB} is binary diffusivity (m² / s)

Stefan assumes the following assumptions for equation (1):

1. Gas B is insoluble in liquid A ($m_B'' = 0$)
2. Steady state.
3. Liquid level is constant or interface regresses so slow, that its movement can be neglected.

$$m_A'' = Y_A (m_A'' + m_B'') - \rho D_{AB} \frac{dY_A}{dx}$$

$$m_A'' - Y_A m_A'' = - \rho D_{AB} \frac{dY_A}{dx} \quad (2)$$

Rearrange equation (2) and integrate:

$$\int_{x=0}^x \frac{m''}{\rho D_{AB}} dx = \int_{Y_{A,i}}^{Y_A} \frac{-1}{(1-Y_A)} dY_A$$

$$\frac{m''_{A,x}}{\rho D_{AB}} = \ln \frac{(1-Y_A)}{(1-Y_{A,i})} \quad (3)$$

$$Y_A = 1 - (1 - Y_{A,i}) \exp\left(\frac{m''_x}{\rho D_{AB}}\right)$$

Boundary conditions:

At $x=L$ $Y_A = Y_{A,\infty}$ for equation (3):

$$m''_A = \frac{\rho D_{AB}}{L} \ln \frac{(1-Y_{A,\infty})}{(1-Y_{A,i})} \quad (4)$$

Equation (4) can be used to calculate the theoretical evaporation rate per unit area
 Where m''_A is evaporation rate per unit area
 ρ is the average gas density in the container (Fig.(1)) and can be calculated from:

$$\rho = \frac{P}{(R_u / MW)T}$$

P is the atmospheric pressure

R_u is Universal Gas Constant

L is the interface depth from the top of container

T is Gas Temperature

$$MW = 0.5(MW_{mix,i} + MW_{mix,\infty})$$

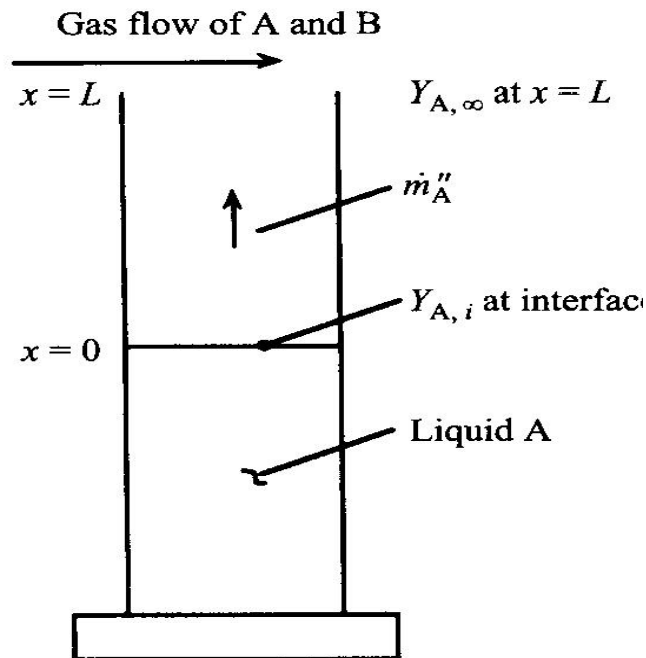


Figure (1) Diffusion of Vapor A through a Stagnant Column of Gas B, i.e., the Stefan Problem

Experimental Part

Figure (1) shows the container (8 cm diameter, filled with water at depth of 3 cm from the top of the container) at which our experiments were take place, using trash of polyethylene for different densities ranged from 800 to 900 kg/m³ putted in a float layout at the interface ($x=0$) to reduce water evaporation from the surface and take the measurements which involve temperature and net weight of the water in the container by using sensitive balance, in each measurement we report the time from starting evaporation in order to divide the net weight on the time to give evaporation time.

RESULTS AND DISCUSSIONS

Calculations of evaporation rate for different trash densities were obtained and compared with theoretical results obtained from equation (4), we can see from figure (2) that it shows the relationship between evaporation rate with temperature , an increase in water temperature led to an increase in evaporation rate, also minimum evaporation rate take place with using trash of lower density (800 kg/m³) and increased with increasing trash density .

Figure(3) shows the relationship between evaporation rate with time , one can observe that an increase in evaporation time will increase the evaporation rate, also minimum evaporation rate take place with trash of low density (800kg/m³) and increase with increasing trash density.

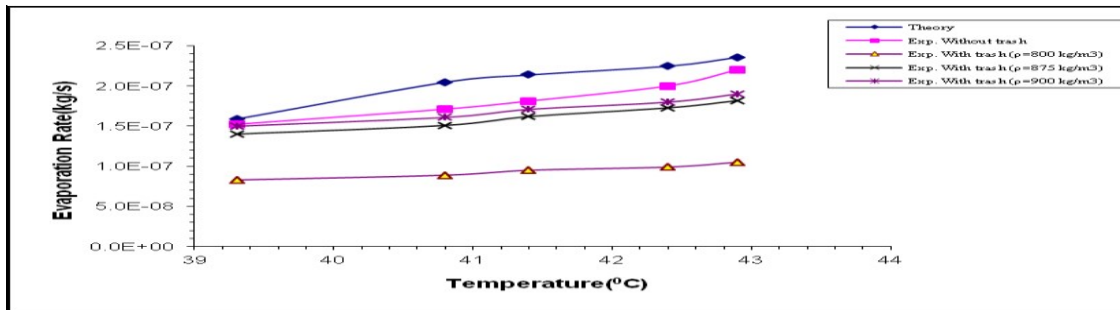


Figure (2) Variation of Evaporation Rate with Temperature

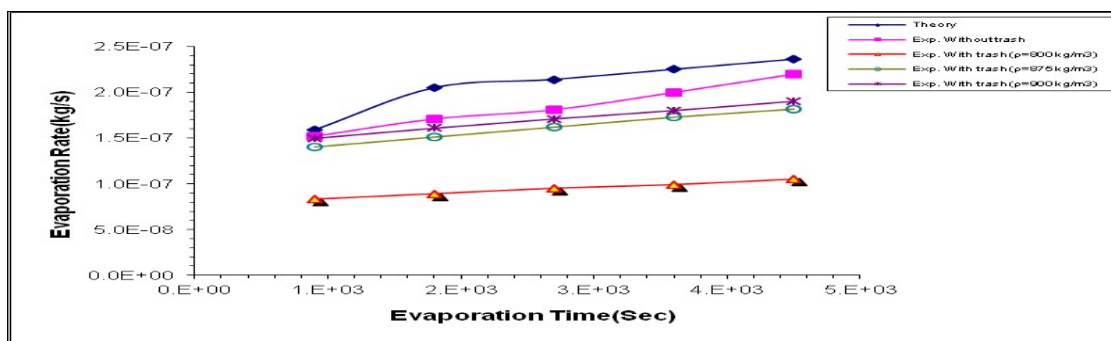


Figure (3) Variation of Evaporation Rate with Time

CONCLUSIONS

From the present work, we can deduce the following conclusions:

1. An increase in evaporation time and temperature will lead to increase in evaporation rate.
2. Reducing the trash density will reduce the evaporation rate.
3. Using trash density of 800 kg/m^3 will reduce evaporation rate 57%

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