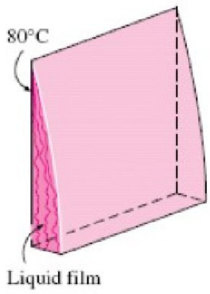
Topic - Types of condensation-film wise and drop wise condensation

Condensation: Physical Mechanisms

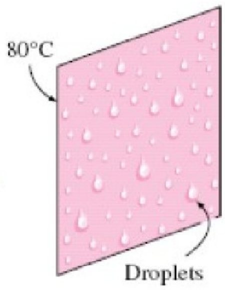
Film condensation

- The condensate wets the surface and forms a liquid film.
- The surface is blanketed by a liquid film which serves as a *resistance* to heat transfer.



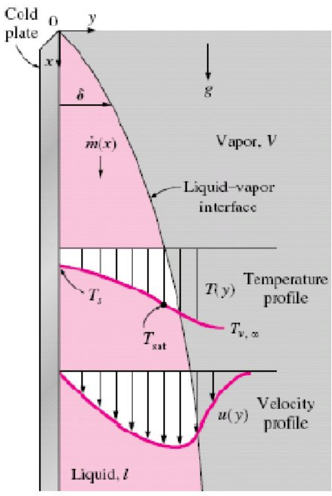
Dropwise condensation

- The condensed vapor forms droplets on the surface.
- The droplets slide down when they reach a certain size.
- No liquid film to resist heat transfer.
- As a result, heat transfer rates that are more than 10 times larger than with film condensation can be achieved.



Film Condensation on a Vertical Plate

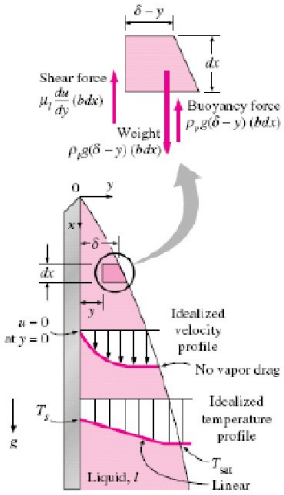
- liquid film starts forming at the top of the plate and flows downward under the influence of gravity.
- d *increases* in the flow direction x
- Heat in the amount h_{fg} is released during condensation and is *transferred* through the film to the plate surface.
- T_s must be below the saturation temperature for condensation.
- The *temperature* of the condensate is T_{sat} at the interface and decreases gradually to T_s at the wall.



Heat Transfer Correlations for Film Condensation — Vertical wall

Assumptions:

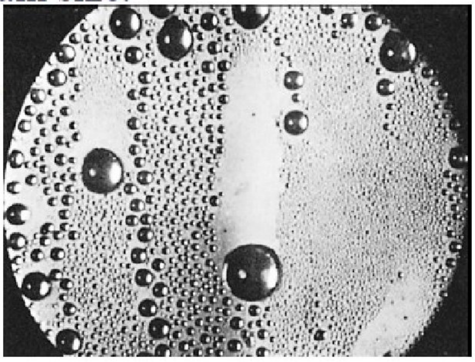
1. Both the plate and the vapor are maintained at *constant temperatures* of T_s and T_{sat}, respectively, and the temperature across the liquid film varies *linearly*.
2. Heat transfer across the liquid film is by pure *conduction*.
3. The velocity of the vapor is low (or zero) so that it exerts *no drag* on the condensate (no viscous shear on the liquid–vapor interface).
4. The flow of the condensate is *laminar* (Re<30) and the properties of the liquid are constant.
5. The acceleration of the condensate layer is negligible.



Height L and width b

Dropwise Condensation

- One of the most effective mechanisms of heat transfer, and extremely large heat transfer coefficients can be achieved.
- Small droplets grow as a result of continued condensation, coalesce into large droplets, and slide down when they reach a certain size.
- Large heat transfer coefficients enable designers to achieve a specified heat transfer rate with a smaller surface area.



Dropwise Condensation

- The challenge in dropwise condensation is not to achieve it, but rather, to *sustain* it for prolonged periods of time.
- Dropwise condensation has been studied experimentally for a number of surface–fluid combinations.
- Griffith (1983) recommends these simple correlations for dropwise condensation of *steam* on *copper surfaces:*

$$h_{dropwise} = \begin{cases} 51{,}104 + 2044T_{sat} & 22^0C < T_{sat} < 100\ ^0C \\ 255{,}310 & T_{sat} > 100^0C \end{cases}$$

References:

1. Kothandaraman C.P "Fundamentals of Heat and Mass Transfer" New Age International, New Delhi,4th Edition 2012 (Unit I, II, III, IV, V).
2. Frank P. Incropera and David P. DeWitt, "Fundamentals of Heat and Mass Transfer", John Wiley and Sons, New Jersey,6th Edition1998(Unit I,II,III,IV, V)
3. MIT open courseware – https://ocw.mit.edu/courses/mechanical-engineering

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