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# **References:**

- A) For Phase Change from Vapour to Liquid:
- 1- Mainly Refer to the Related Articles
- 2 One-Dimentional Two-Phase Flow
  - WALLIS B. GRAHAM

McGRAW - HILL BOOK COMPANY, 1969

3 – Two-Phase Steam Flow In Turbines And Seperators Theory, Instrumentation, Engineering

> M.J.MOORE C. H. SIEVERDING

HEMISPHERE PUBLISHING CORPORATION. 1976

**B)** For Phase Change from Liquid to Vapour

#### 1 - Fundamentals of Heat and Mass Transfor

Frank P. Incropera David P. Dewitt

John Wiley & Sons, 1996, 2002, 2007, 2010 (6th edition)

### 2 – Converctive Boiling and condensation

#### JOHN G. COLLIER

(Atomic Energy Research Establishment, Harwell)

McGRAW-HILL BOOK COMPANY, 1972, 1996 (3rd edition)

#### 3 - Enhanced boiling heat transfer

#### JOHN R. Thome

Engineering Consultant Rome. Italy

#### HEMISPHERE PUBLISHING CORPORATION, 1990

#### 4 - Boiling Phenomena

Physicochemical and Engineering Fundamentals and Applications

#### Sjoerd Van Stralen

Eindhoven University of Technology

#### Robert Cole

Clarkson College of Technology

HEMISPHERE PUBLISHING CORPORATION, 1979

#### 5 – Enhanced boiling heat transfer

Hector A. Ayala, University of Houston, 1996

#### 6 - Liquid-Vapour place change phenomena

Carey, Taylor and Francis, 2008

#### 7 – Two-Phase Flow, Boiling and Condensation Seyyeal Mostafa Ghiaasiaan.

Cambridge University Press, 2007