This problem corresponds to METSPE2 problem 32.

Return to Questions (/admin/questions/0?sfield=magento_id&stext=0000004727&sdka=&stype=&sdiff=)

Test Bank Question preview

Question

A 3 in diameter steel sphere achieves a terminal velocity of 122 in/sec when dropping through a tall column of liquid. The density of the liquid is 87 lbm/ft^3. The density of steel is 488 lbm/ft^3. The final drag coefficient of the sphere is most nearly

Answers

(A) 0.22

(B) 0.34

(C) 0.40

(D) 0.48

The answer is (D).

Solution

Content in blue refers to the NCEES Handbook.

When buoyancy effects are taken into account, an object falling through a fluid under its own weight will reach a terminal velocity (settling velocity) if the net force acting on the object becomes zero. When the terminal velocity is reached, the weight of the object, W, is exactly balanced by the upward buoyancy force, $F_{buoyant}$, and the drag force, F_D.

$$W = F_{\text{buoyant}} + F_D$$

If the falling object is spherical in shape, the three forces are as follows. v_t is the terminal velocity. $\pi D^3/6$ is the volume of a sphere, and $\pi D^2/4$ is the projected area of the sphere in the direction of flow. [Mensuration of Areas and Volumes: Nomenclature]

Density, Specific Weight, and Specific Gravity

$$\begin{aligned} W &= \rho g V \\ &= \rho_{\text{sphere}} g \left(\frac{\pi D^3}{6}\right) \end{aligned}$$

Archimedes' Principle and Buoyancy

$$\begin{aligned} F_{\text{buoyant}} &= \gamma V_{\text{displaced}} \\ &= \rho g V_{\text{displaced}} \\ &= \rho_{\text{fluid}} g \left(\frac{\pi D^3}{6}\right) \end{aligned}$$

Drag Force

QUESTION DATA

Vendor

0000004727

Solving Time

Difficulty

easy

Quantitative?

Yes

Status

Archived

Created On

02/12/2018 10:12:43 PM

Published On

02/12/2018 10:12:43 PM

Modified On

05/12/2020 05:10:01 PM

OTHER VERSIONS

05/18/2020 04:59:17 PM **(Active)** (/admin/questions/preview/49804)

DISCIPLINES

FE Chemical (/admin/questions/index?sfield=discipline stext=FE Chemical)

FE Mechanical (/admin/questions/index?sfield=discipline stext=FE Mechanical)

PE Mechanical: Therm and Fluid Systems

$$F_D = \frac{C_D \rho \mathrm{v}^2 A}{2} = \frac{C_D \rho_{\text{fluid}} \mathrm{v}_t^2 \left(\frac{\pi D^2}{4}\right)}{2} = \frac{C_D \rho_{\text{fluid}} \mathrm{v}_t^2 \pi D^2}{8}$$

Substituting the equations for W, F_{buoyant}, and F_D in the force balance equation above, the final drag coefficient of the sphere is

$$C_D = \left(\frac{4Dg}{3\mathrm{v}_t^2}\right)\left(\frac{\rho_{\text{sphere}} - \rho_{\text{fluid}}}{\rho_{\text{fluid}}}\right) = \left(\frac{(4)(3\ \text{in})\left(\left(32.2\ \frac{\text{ft}}{\text{sec}^2}\right)\left(12\ \frac{\text{in}}{\text{ft}}\right)\right)}{(3)\left(122\ \frac{\text{in}}{\text{sec}}\right)^2}\right)\left(\frac{488\ \frac{\text{lbm}}{\text{ft}^3} - 87\ \frac{\text{lbm}}{\text{ft}^3}}{87\ \frac{\text{lbm}}{\text{ft}^3}}\right) = 0.4786 \quad (0.48)$$

(/admin/questions/index?sfield=discipline&stext=PE Mechanical: Thermal and Fluid Systems)

PE Mechanical: HVAC and Refrigeration (/admin/questions/index?sfield=discipline&stext=PE Mechanical: HVAC and Refrigeration)

KNOWLEDGE AREAS

Fluid Mechanics/Dynamics (/admin/questions/index?sfield=area&stext=Fluid Mechanics/Dynamics)

Fluid Mechanics (/admin/questions/index?sfield=area&stext=Fluid Mechanics)

PRODUCTS USED IN

This problem corresponds to METSPE2 problem 53.

Return to Questions (/admin/questions/0?sfield=magento_id&stext=0000004755&sdka=&stype=&sdiff=)

Test Bank Question preview

Question

Steam at 200 psia enters an isentropic turbine operating in a Rankine cycle. The steam exits the turbine at 100°F. The moisture content of the steam in the turbine is not to exceed 8%. The minimum temperature to which the high-pressure steam must be heated is most nearly

Answers

(A) 170°R

(B) 530°R

(C) 980°R

(D) 1300°R

The answer is (C).

Solution

Content in blue refers to the NCEES Handbook.

The following diagrams apply to this problem. [Internal Combustion Engines]

QUESTION DATA

Vendor

0000004755

Solving Time

Difficulty

easy

Quantitative?

Yes

Status

Active

Created On

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05/05/2020 08:21:11 PM

OTHER VERSIONS

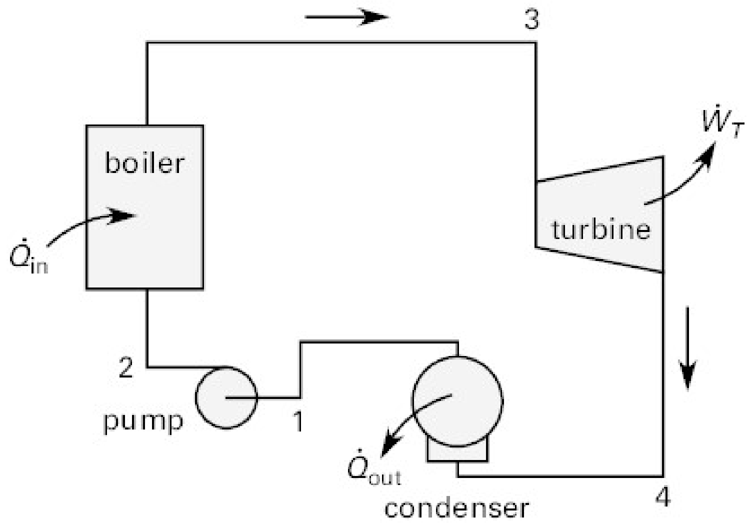
10/23/2019 08:04:57 PM (/admin/questions/preview/25180)

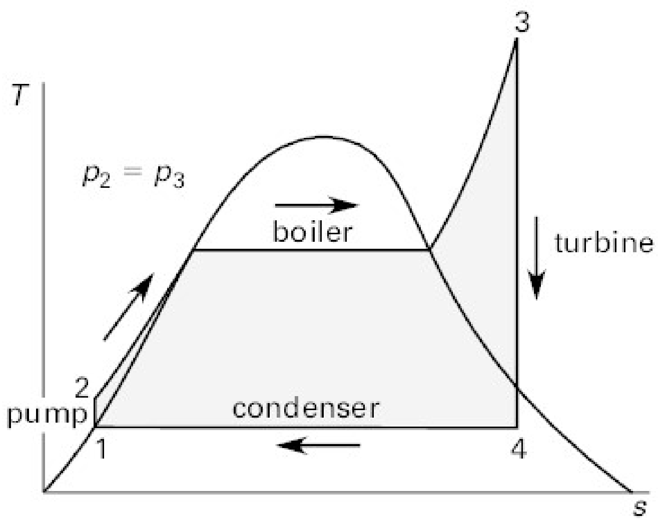
DISCIPLINES

FE Chemical (/admin/questions/index?sfield=discipline stext=FE Chemical)

PE Mechanical: Therm and Fluid Systems (/admin/questions/index?sfield=discipline stext=PE Mechanical: Thermal and Fluid Systems)

KNOWLEDGE AREAS





State 4 is at the output of the turbine where the temperature and steam quality are known. Since turbine expansion is an isentropic process, once the entropy at state 4 is found, the entropy at state 3 is also known. With this and the given pressure, the temperature of the steam entering the turbine can be found.

The entropy at state 4 can be found using

Properties for Two-Phase (Vapor-Liquid) Systems

$$s_4 = s_f + x s_{fg}$$

Using the saturated steam tables at 100°F, [Properties of Saturated Water and Steam (Temperature) - I-P Units]

$$\begin{aligned} &= 0.1296\ \frac{\text{Btu}}{\text{lbm-}^\circ\text{R}} + (0.92)\left(1.8523\ \frac{\text{Btu}}{\text{lbm-}^\circ\text{R}}\right) \\ &= 1.834\ \text{Btu/lbm-}^\circ\text{R} \end{aligned}$$

Since $s_3 = s_4$ and the pressure is 200 psia, using the superheated steam tables, the entering steam temperature is between 950°F and 1000°F. This temperature can be found by linear interpolation between the 950°F and 1000°F temperatures.

Fluid Mechanics/Dynamics (/admin/questions/index?sfield=area&stext=Fluid Mechanics/Dynamics)

Energy/Power Equipment (/admin/questions/index?sfield=area&stext=Energy/Power Equipment)

PRODUCTS USED IN
PEMETS2EX
PEMETSQB

$$\begin{aligned} \frac{T_{1000^\circ\text{F}} - T_{950^\circ\text{F}}}{s_{1000^\circ\text{F}} - s_{950^\circ\text{F}}} &= \frac{T_3 - T_{950^\circ\text{F}}}{s_3 - s_{950^\circ\text{F}}} \\ T_3 &= \left(\frac{T_{1000^\circ\text{F}} - T_{950^\circ\text{F}}}{s_{1000^\circ\text{F}} - s_{950^\circ\text{F}}}\right)(s_3 - s_{950^\circ\text{F}}) + T_{950^\circ\text{F}} \\ &= \left(\frac{T_3 - 950^\circ\text{F}}{1.834\ \frac{\text{Btu}}{\text{lbm-}^\circ\text{F}} - 1.825\ \frac{\text{Btu}}{\text{lbm-}^\circ\text{F}}}\right)\left(1.843\ \frac{\text{Btu}}{\text{lbm-}^\circ\text{F}} - 1.825\ \frac{\text{Btu}}{\text{lbm-}^\circ\text{F}}\right) + 950^\circ\text{F} \\ &= 975^\circ\text{F} \quad (980^\circ\text{F}) \end{aligned}$$