"Turbo HW5"
"Zhaoyi Jiang (.1364)"
"Problem 1"

"Given"
u=250[m/s]
cz=0.6*u
R=0.65
alpha_2=55[degree]

"Normal stage"
phi=cz/u
R=1-0.5*phi*(tan(alpha_2)+tan(alpha_1))
tan(alpha_2)=(1-R+psi/2)/phi

"Velocity triangles"
tan(beta_1)=-(R+psi/2)/phi
tan(beta_2)=-(R-psi/2)/phi
w1=cz/cos(beta_1)
w2=cz/cos(beta_2)
c1=cz/cos(alpha_1)
c2=cz/cos(alpha_2)

"Work"
W=u*(w2*sin(beta_2)-w1*sin(beta_1))*convert(j,kj)

SOLUTION

Unit Settings: SI C kPa kJ mass deg

α_1 = -14.65 [degree]	α_2 = 55 [Degree]
β_1 = -62.59 [degree]	β_2 = -13.42 [degree]
c1 = 155 [m/s]	c2 = 261.5 [m/s]
cz = 150 [m/s]	ϕ = 0.6
ψ = 1.014	R = 0.65
u = 250 [m/s]	W = 63.36 [kj/kg]
w1 = 325.8 [m/s]	w2 = 154.2 [m/s]

No unit problems were detected.

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"Turbo HW5"
"Zhaoyi Jiang (.1364)"
"Problem 2"

"Given"
u=250[m/s]
phi=0.42
psi=0.32
alpha_1=5[degree]
p1=1[bar]
t1=300[k]

"degree of R"
tan(alpha_1)=(1-R-psi/2)/phi

"Velocity triangles"
tan(alpha_2)=(1-R+psi/2)/phi
tan(beta_1)=-(R+psi/2)/phi
tan(beta_2)=-(R-psi/2)/phi
u=cz*(tan(alpha_1)-tan(beta_1))
w1=cz/cos(beta_1)
w2=cz/cos(beta_2)
c1=cz/cos(alpha_1)
c2=cz/cos(alpha_2)
W=u*(c2*sin(alpha_2)-c1*sin(alpha_1))*convert(j,kj)
c3=c1

"zetas"
zeta_r=0.04+0.06*((beta_2-beta_1)/100[deg])^2
zeta_s=0.04+0.06*((alpha_2-alpha_1)/100[deg])^2

"Thermal analysis"
h1=enthalpy(air,t=t1)
s1=entropy(air,t=t1,p=p1)
h01=h1+0.5*c1^2*convert(j,kj)
t01=temperature(air,h=h01)
p01=pressure(air,s=s1,h=h01)
hr1=h1+0.5*w1^2*convert(j,kj)
h2=hr1-0.5*w2^2*convert(j,kj)
h2s=h2-zeta_r*0.5*w2^2*convert(j,kj)
s2s=s1
p2=pressure(air,s=s2s,h=h2s)
t2=temperature(air,h=h2)
s2=entropy(air,p=p2,t=t2)
s3s=s2
h02=h2+0.5*c2^2*convert(j,kj)
h02=h03
h3=h03-0.5*c3^2*convert(j,kj)
h3s=h3-0.5*zeta_s*c3^2*convert(j,kj)
p3=pressure(air,s=s3s,h=h3s)
t3=temperature(air,h=h3)
s3=entropy(air,h=h3,p=p3)
p03=pressure(air,h=h03,s=s3)
h03ss=enthalpy(air,s=s1,p=p03)

Ratio=p03/p01

eta_tt=(h03ss-h01)/(h03-h01)
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SOLUTION

Unit Settings: SI K bar kJ mass deg

α_1 = 5 [Degree]
α_2 = 40.34 [degree]
β_1 = -66.44 [degree]
β_2 = -56.86 [degree]
c1 = 105.4 [m/s]
c2 = 137.8 [m/s]
c3 = 105.4 [m/s]
cz = 105 [m/s]
η_{tt} = 0.9481
h01 = 306 [kj/kg]
h02 = 326 [kj/kg]
h03 = 326 [kj/kg]
h03ss = 325 [kj/kg]
h1 = 300.4 [kj/kg]
h2 = 316.5 [kj/kg]
h2s = 315.8 [kj/kg]
h3 = 320.4 [kj/kg]
h3s = 320.2 [kj/kg]
hr1 = 335 [kj/kg]
p01 = 1.066 [bar]
p03 = 1.315 [bar]
p1 = 1 [bar]
p2 = 1.19 [bar]
p3 = 1.239 [bar]
ϕ = 0.42
ψ = 0.32
R = 0.8033
Ratio = 1.234
s1 = 5.706 [kj/kg-k]
s2 = 5.708 [kj/kg-k]
s2s = 5.706 [kj/kg-k]
s3 = 5.709 [kj/kg-k]
s3s = 5.708 [kj/kg-k]
t01 = 305.5 [k]
t1 = 300 [K]
t2 = 316 [k]
t3 = 319.9 [k]
u = 250 [m/s]
W = 20 [kj/kg]
w1 = 262.7 [m/s]
w2 = 192.1 [m/s]
ζ_r = 0.04055
ζ_s = 0.0475

No unit problems were detected.

"Turbo HW5"
"Zhaoyi Jiang (.1364)"
"Problem 3"

"Given"
c1=6
w2=15
alpha_1=0
alpha_2=65
N=1800 [1/min]
r1=6.5*convert(cm,m)
r2=15*convert(cm,m)
eta_p=.75
rho=997.1
u1=(pi*2*r1*N)/60[s/min]
u2=(pi*2*r2*N)/60[s/min]
cz=c1
c2=cz/cos(alpha_2)
cu2=cz*tan(alpha_2)
wu1=u1
beta_1=arctan(wu1/c1)
w1=c1/cos(beta_1)
Q=pi*(r1^2)*c1
W=u2*cu2*convert(J,kJ)
W_dot=Q*rho*W*(1/eta_p)
ap=(rho*W)*1000*convert(Pa,bar)
ap0=ap-(rho*(c2^2-c1^2)/2)*convert(Pa,bar)
keabs=(c2^2/2)-(c1^2/2)
kerel=(w2^2/2)-(w1^2/2)
kecent=(u2^2/2)-(u1^2/2)
ratioabs=keabs/W
ratiorela=kerel/W
ratiocent=kecent/W

SOLUTION
Unit Settings: SI C kPa kJ mass deg

α_1 = 0 [degree]
ap = 3.628 [bar]
β_1 = 63.91 [degree]
c2 = 14.2 [m/s]
cz = 6 [m/s]
keabs = 82.78 [kj]
kerel = 19.44 [kj]
Q = 0.07964 [m^3/s]
r2 = 0.15 [m]
ratiocent = 892.4
ρ = 997.1 [kg/m^3]
u2 = 28.27 [m/s]
w1 = 13.64 [m/s]
wu1 = 12.25 [m/s]

α_2 = 65 [degree]
ap0 = 2.802 [bar]
c1 = 6 [m/s]
cu2 = 12.87 [m/s]
η_p = 0.75
kecent = 324.7 [kj]
N = 1800 [1/min]
r1 = 0.065 [m]
ratioabs = 227.5
ratiorela = 53.44
u1 = 12.25 [m/s]
W = 0.3638 [kJ/kg]
w2 = 15 [m/s]
$\dot{W}$ = 38.52 [kW]

7 potential unit problems were detected.

"Turbo HW5"
"Zhaoyi Jiang (.1364)"
"Problem 4"

"Given"
t0=55[c]
ps=0.25[bar]
rho=1000[kg/m^3]
z0=1[m]
lambda=0.025
Q=150*convert(l/min,m^3/s)
La=0.5[m]
Lb=1[m]
D=0.05[m]
g=9.81[m/s^2]
p0=1[bar]

z1a=3[m]
c=Q/(pi*D^2/4)
hfc=2.3
hfd=lambda*((La+Lb)/D)*c^2/(2*g)
m_dot=rho*Q
hfcd=hfc+hfd
(p0*convert(bar,pa)/(rho*g)+z0)-(p1a*convert(bar,pa)/(rho*g)+z1a)=-hfcd
NPSH_a=5[m]
NPSH_a=p1b*convert(bar,pa)/(rho*g)-ps*convert(bar,pa)/(rho*g)-hfcd
(p0*convert(bar,pa)/(rho*g)+z0)-(p1b*convert(bar,pa)/(rho*g)+z1b)=-hfcd

SOLUTION
Unit Settings: SI C bar kJ mass deg

c = 1.273 [m/s]	D = 0.05 [m]
g = 9.81 [m/s^2]	hfc = 2.3 [m]
hfcd = 2.362 [m]	hfd = 0.06197 [m]
La = 0.5 [m]	λ = 0.025
Lb = 1 [m]	$\dot{m}$ = 2.5 [kg/s]
$NPSH_a$ = 5 [m]	p0 = 1 [bar]
p1a = 1.036 [bar]	p1b = 0.9722 [bar]
ps = 0.25 [bar]	Q = 0.0025 [m^3/s]
ρ = 1000 [kg/m^3]	t0 = 55 [C]
z0 = 1 [m]	z1a = 3 [m]
z1b = 3.645 [m]	

No unit problems were detected.