BLOWDWON HEAT RECOVERY CALCULATIONS

Performance Data:

2 Boilers each 30,000 pounds per hour
Boiler operating pressure 150 psig
B=Boiler water TDS Manual Control Range (1800 to 2200 ppm)
F=Feedwater water TDS (120 ppm)
Average steam rate 20000 lb/hr
MWT=Makeup Water Temperature 50 F
AOH=7000 Annual Operating Hours
Fuel Cost: #6 Oil $2.02/gal 1.33 per Therm
Steam Plant Annual Fuel Use 900,000 gal
BE=Boiler Efficiency 80.5%
Fuel Oil Specific Heat: 0.5 Btu/lb-F
WC=$5.00 per 1000 gallons
Cooling Blowdown Condensate to 120 F

$\$:= ¤$

$AOH := 7000 \cdot hr$

$FuelCost\$:= \frac{1.33\ \$}{100000 \cdot Btu}$

$BE := 0.805$

$WC := \frac{5.00 \cdot \$}{1000 \cdot gal}$

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Install Electronic Automatic Blowdown Control System:

Existing Condition: Currently blowdown is controlled manually to maintain TDS setpoint at 2200 maximum. This is done by periodically blowing down boiler to 1800 TDS.
Proposed Modification: Install an electronic control system to automatically blowdown to more accurately track and maintain the setpoint of 2200 TDS. Savings would be in the ability to maintain the boiler TDS closer to the setpoint of 2200 and is estimated to provide an annual average increase in TDS of 200.

Existing Blowdown:

Blowdown Rate = (FxS)/(B-F)
F=Feed Water TDS (ppm)
S=Steam generation rate (lb/hr)
B=Required boiler water TDS (ppm)

$F := 120 \qquad B := 2000 \qquad S := 20000 \cdot \frac{lb}{hr}$

$Blowdown := \frac{F \cdot S}{B - F} \qquad \frac{Blowdown}{S} \cdot 100 = 6.38$

$Blowdown = 1277\ \frac{lb}{hr} \qquad PercentBlowdown := \frac{Blowdown}{S} \cdot 100 = 6.38$

Proposed Blowdown:

Blowdown Rate = (FxS)/(B-F)
F=Feed Water TDS (ppm)
S=Steam generation rate (lb/hr)
B=Required boiler water TDS (ppm)

$F := 120 \qquad B := 2200 \qquad S := 20000 \cdot \frac{lb}{hr}$

$Blowdown := \frac{F \cdot S}{B - F} \qquad \frac{Blowdown}{S} \cdot 100 = 5.77$

$Blowdown = 1154\ \frac{lb}{hr}$ $PercentBlowdown := \frac{Blowdown}{S} \cdot 100 = 5.77$

$EnergySavings := \frac{(1277 - 1154)}{BE} \cdot \frac{lb}{hr} \cdot 339 \cdot \frac{Btu}{lb} \cdot AOH$

$EnergySavings = (362.58 \cdot 10^6)\ Btu$

$EnergyCostSaved := EnergySavings \cdot FuelCost\$ = (4.82 \cdot 10^3)\ \$$ **$4,820**

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Install Blowdown Heat Recovery System:

Existing Condition: Currently the blowdown is flashed vented and remaining condensate is cooled to 120F before being sent to drain.

Proposed Modification: Available blowdown heat is not being utilized. This proposal would be to install a new blowdown heat recovery system to recover the flash steam for the deaerator and new heat exchanger that would use the available heat in the blowdown condensate water to preheat makeup water to the boiler.

% Flash Steam = ((SH-SL)/H)*100
SH=Sensible heat in the condensate at the higher pressure before discharge
SL=Sensible heat in the condensate at the lower pressure to which discharge takes place
H=Latent heat in the steam at the lower pressure to which the condensate is discharged
Assuming the blowdown water is released to a flash steam system operating at 30 psig

$SH := 338 \cdot \frac{Btu}{lb}$ $SL := 243 \cdot \frac{Btu}{lb}$ $H := 929 \cdot \frac{Btu}{lb}$

$PercentFlashSteam := \left(\frac{SH - SL}{H}\right) \cdot 100$ $PercentFlashSteam = 10.23$

Energy in flash steam (EFS):

$EFS := \frac{PercentFlashSteam}{100} \cdot Blowdown \cdot (H)$ $EFS = (109.62 \cdot 10^3)\ \frac{Btu}{hr}$

Energy in condensate (EC):

$$EC := Blowdown \cdot \left(1 - \frac{PercentFlashSteam}{100}\right) \cdot (SL) \qquad EC = \left(251.71 \cdot 10^3\right) \frac{Btu}{hr}$$

Energy Savings with blowdown heat exchanger efficiency of 99%:

$$EnergySavings := \frac{EFS + (EC \cdot 0.99)}{BE} \cdot AOH \qquad EnergySavings = \left(3.12 \cdot 10^9\right) Btu$$

$$EnergyCostSaved := EnergySavings \cdot FuelCost\$$$

$$EnergyCostSaved = \left(41.5 \cdot 10^3\right) \$$$

$41,500

Water Savings Flash Steam Plus Condensate Cooling (Water):

$$Water := Blowdown \cdot \frac{PercentFlashSteam}{100} + \frac{EC}{SL} \cdot \left(\frac{274 - 120}{120 - 50}\right) \qquad Water = \left(2.4 \cdot 10^3\right) \frac{lb}{hr}$$

$$WaterCostSaved := \frac{Water}{8.34 \cdot \frac{lb}{gal}} \cdot WC \cdot AOH \qquad WaterCostSaved = \left(10.06 \cdot 10^3\right) \$$$

$10,600

SUMMARY

Total Annual Cost Savings = **$56,920**
Total Annual Energy Savings = **3.12x10^9 Btu**
Total Annual Fuel Oil Savings = **20,700 gallons**
Total Annual Water Savings = **2.12x10^6 gallons**
Total Annual Carbon Dioxide Reduction = **516,260 pounds** (Ref. AP-42 Vol I:1.3: Fuel Oil)