Power Lost per Tonne of Process Steam Extracted from a Turbine

Generator power given up when steam is extracted for process instead of expanding to the condenser, per t/h and per year, and process heat gained per kWh lost.

Input parameters

Unit system: SI

Parameter	Value	Unit
Turbine inlet pressure (absolute)	66.000	bar
Turbine inlet temperature	485.00	°C
Extraction pressure (absolute)	4.0000	bar
Condenser pressure (absolute)	0.10000	bar
Efficiency, inlet to extraction	80.000	%
Efficiency, extraction to condenser	78.000	%
Gearbox and generator efficiency	96.000	%
Process steam extracted	20.000	t/h
Operating hours per year	7,000.0	h
Value of electricity per kWh	6.0000	

Calculated results

Parameter	Value	Unit
Extraction steam enthalpy	2,829.3	kJ/kg
Extraction steam temperature	185.00	°C
Exhaust enthalpy	2,378.0	kJ/kg
Power lost per t/h extracted	120.35	kW
Power lost for the extraction	2,407.0	kW
Energy lost per year	16,849	MWh
Value of the energy lost per year	1.0109e+08	
Process heat delivered per kWh given up (condensate returned saturated)	5.1346	

Notes for this case

- Steam extracted at p_x would otherwise have expanded on to the condenser; that LP work is what is given up. The throttle flow is assumed unchanged. Each kWh given up delivers several kWh of process heat, which is why extraction is the efficient way to supply process steam. Value is in the currency of the price entered.

Formula and method

$$e_t = \eta_g (h_x - h_c), \quad \Delta P_{el} = \dot{m}_x e_t, \quad \frac{q_x}{e_t} = \frac{h_x - h_{f,x}}{\eta_g (h_x - h_c)}$$

Variables

p_0	Turbine inlet pressure (absolute)	Pa
T_0	Turbine inlet temperature	K
p_x	Extraction pressure (absolute)	Pa

p_c	Condenser pressure (absolute)	Pa
η_{HP}	Efficiency, inlet to extraction	-
η_{LP}	Efficiency, extraction to condenser	-
η_g	Gearbox and generator efficiency	-
$\dot{m}_x$	Process steam extracted	kg/s
t_a	Operating hours per year	s
c_e	Value of electricity per kWh	-
h_x	Extraction steam enthalpy	J/kg
T_x	Extraction steam temperature	K
h_c	Exhaust enthalpy	J/kg
e_t	Power lost per t/h extracted	W
ΔP_{el}	Power lost for the extraction	W
E_a	Energy lost per year	J
C_a	Value of the energy lost per year	-
q_x/e_t	Process heat delivered per kWh given up (condensate returned saturated)	-

Method and standards

LP-section work foregone by extraction.

Assumptions and limits

- Constant throttle flow and section efficiencies; LP section has enough cooling flow.

Report details

Report reference	FCC-BAC9-VGZ6 (the same inputs always give the same reference)
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Calculator	Power Lost per Tonne of Process Steam Extracted from a Turbine
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Release checks	3 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/boilers-power-plant/steam-turbines/extraction-power-loss-per-tonne

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.