MONITORING COMPRESSOR EFFICIENCY FOR MAXIMUM PERFORMANCE

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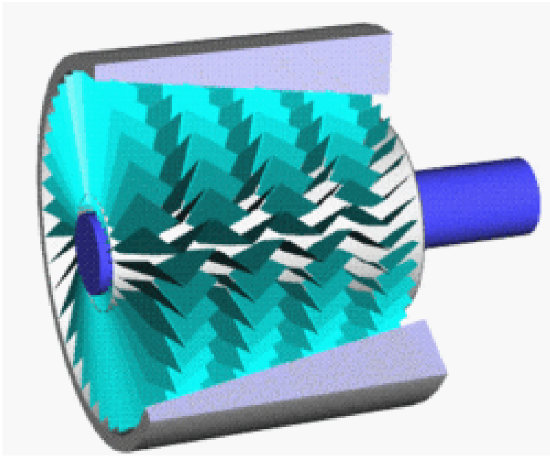
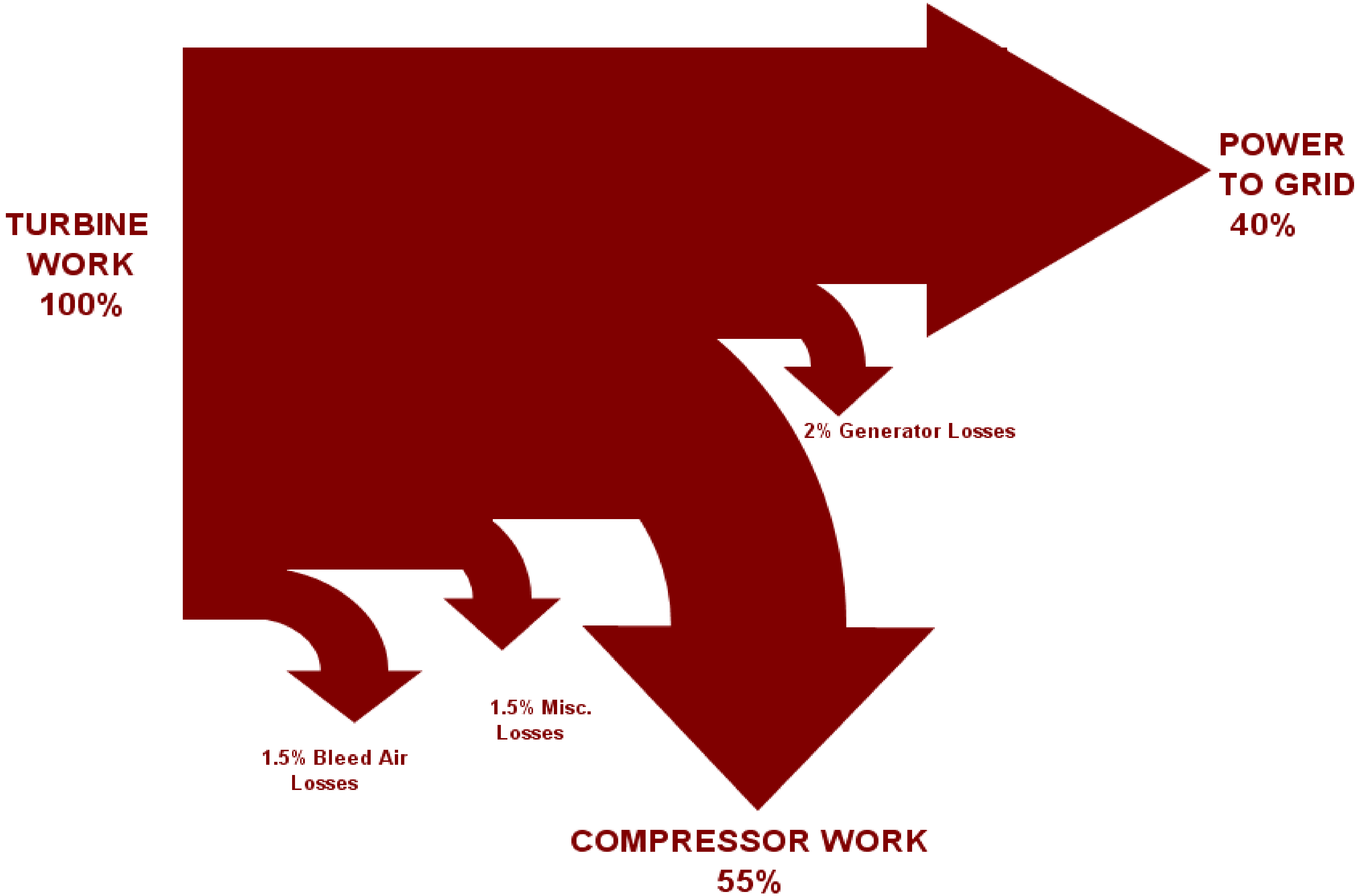
Gas turbines, Compressors and Air Density

- $PV = nRT$
- $m = PV / ZRT$

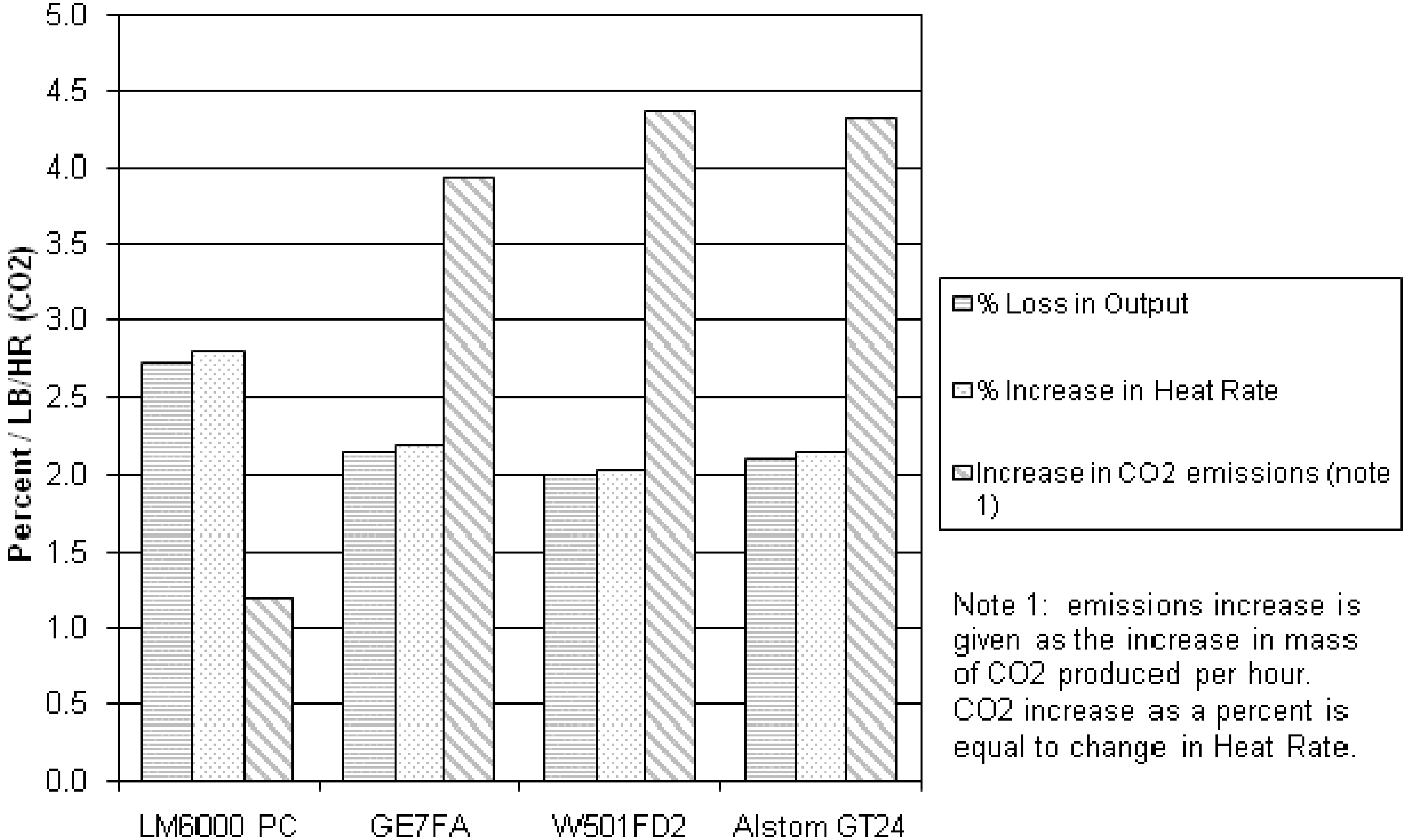
- Increase mass flow by
  - Increasing Pressure
  - Increasing Volume
  - Reducing Temperature



Impact of Compressor Performance



Impact of 1% Lost Compressor Efficiency



Note 1: emissions increase is given as the increase in mass of CO2 produced per hour. CO2 increase as a percent is equal to change in Heat Rate.

Isentropic Compressor Efficiency

- Isentropic Process Efficiency

$$\eta_{s,process} = \left(\frac{Z_1}{Z_2}\right)\cdot\left(\frac{T_1}{T_2}\right)\cdot\left(\frac{P_2}{P_1}\right)^{\frac{(k-1)}{k}}$$

- Isentropic Work Efficiency

$$\eta_{s,work} = \eta_{a,work} = \frac{\left(\frac{P_2}{P_1}\right)^{\frac{(k-1)}{k}} - 1}{\left(\frac{T_2}{T_1}\right) - 1}\cdot\left(\frac{Z_1}{Z_2}\right)$$

Compressor Efficiency

- Polytropic Work Efficiency

$$\eta_{p,work} = \frac{\left(\frac{P_2}{P_1}\right)^{\frac{(n-1)}{n}} - 1}{\left(\frac{T_2}{T_1}\right) - 1} \cdot \left(\frac{Z_1}{Z_2}\right) \qquad or \qquad \eta_p = \left(\frac{k-1}{k}\right) \cdot \left(\frac{n}{n-1}\right)$$

- where

$$n = \frac{ln\left(\frac{P_2}{P_1}\right)}{ln\left(\frac{P_2 \cdot T_1}{P_1 \cdot T_2}\right)}$$

Parameters to Monitor for Compressor Performance

- Compressor inlet temperature and pressure
- Compressor discharge temperature and pressure
- Rotor Speeds (HP and LP, if applicable)
- Operating mode of unit (base, part load, T3 control, T48 control, etc.)
- Auxiliary systems in use (inlet cooling, SPRINT, bleed heat, etc.)

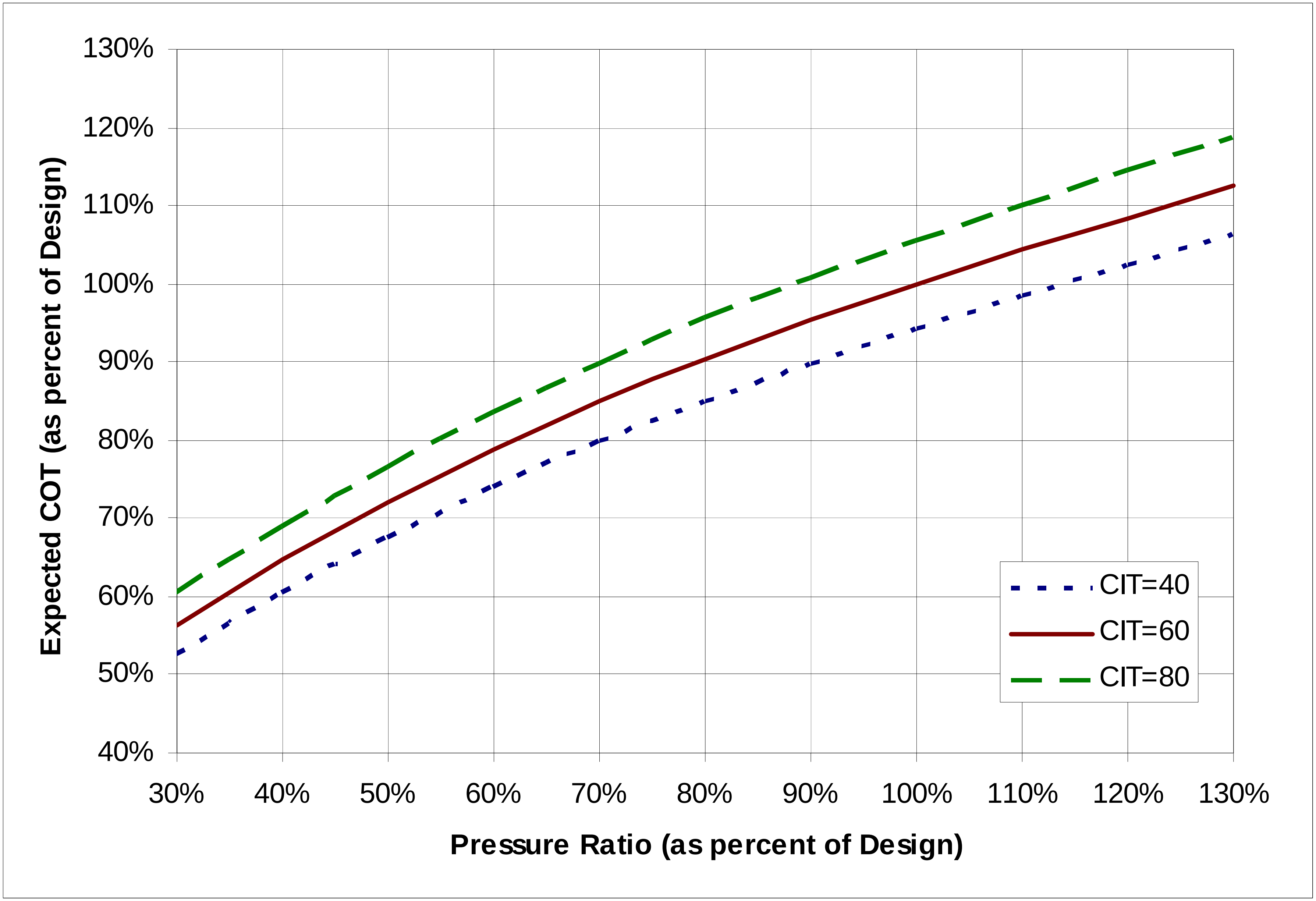
$$m = PV / ZRT$$

Factors that Impact Compressor Performance

- Inlet temperature
- Pressure Ratio
- Humidity

$$m = PV / ZRT$$

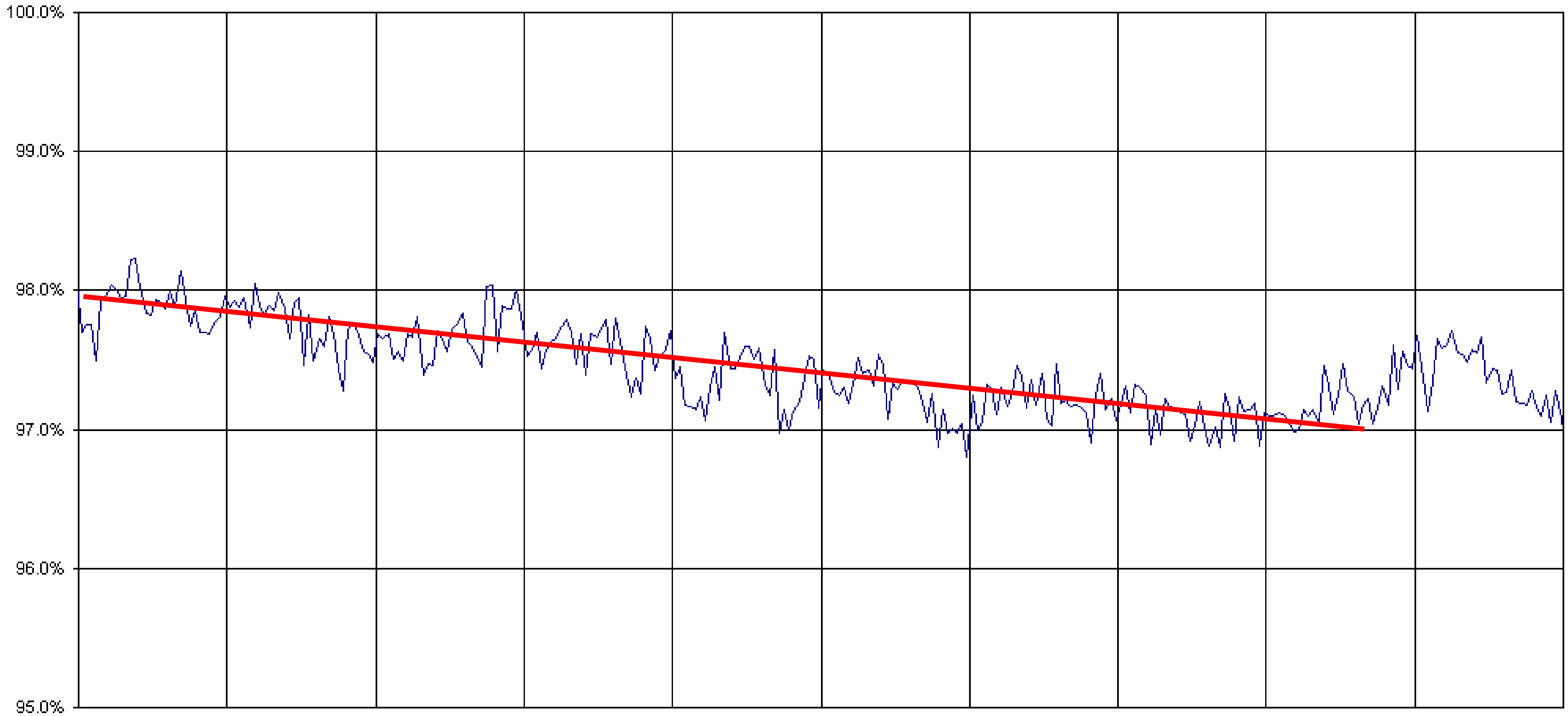
Expected Changes to Compressor Discharge Temperature



Compressor Performance Ratio

- Step 1: Calculate current operating compressor efficiency
- Step 2: Determine expected compressor discharge temperature (CDT) at current operating conditions
- Step 3: Determine expected compressor efficiency based on calculated CDT
- Step 4: Calculate compressor performance ratio as measured divided by expected efficiency
- Step 5: Trend performance ratio over time

Using Compressor Efficiency



Optimizing Water Wash Schedules

Conclusions

- Compressor performance has a significant impact on overall plant performance
- There are multiple means of calculating compressor efficiency – pick one
- A real-time performance monitoring system is not required to trend compressor efficiency.
  - Planned periodic manual calculations can lead to a greater understanding of expected efficiencies and fouling rates
- Monitoring compressor efficiency can lead to optimized water washes, resulting in:
  - Higher output
  - Lower heat rate
  - Lower CO_2 emissions

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