Power Conversion Issues

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High Temperature Corrosion

- Li, LiPb and Flibe can be very corrosive, especially at high temperatures.
- For He, impurity control will be important.
- Corrosive issues during a phase change have to be assessed.
- Tritium permeation and confinement for a high temperature system will be a challenge.

Conclusions

- The coolant minimum temperature is important to assess
  - Power conversion efficiency
  - Pinch point issue
  - and material problems.

- Material selection and material issues for a high temperature power conversion system are challenge.

- Tritium confinement issues have to be assessed.

- The power conversion group will work with the proponents of the concepts to develop power conversion system unique to each concept.

Misconception of Carnot Efficiency

- Usual definition of Carnot efficiency is

  Efficiency = (Ta-Tr)/Ta

- This is true only if the heat is added and rejected at constant temperatures.

- The Tr is not the heat sink temperature, but is the coolant temperature at the heat rejection system.

The Definition of Carnot Efficiency

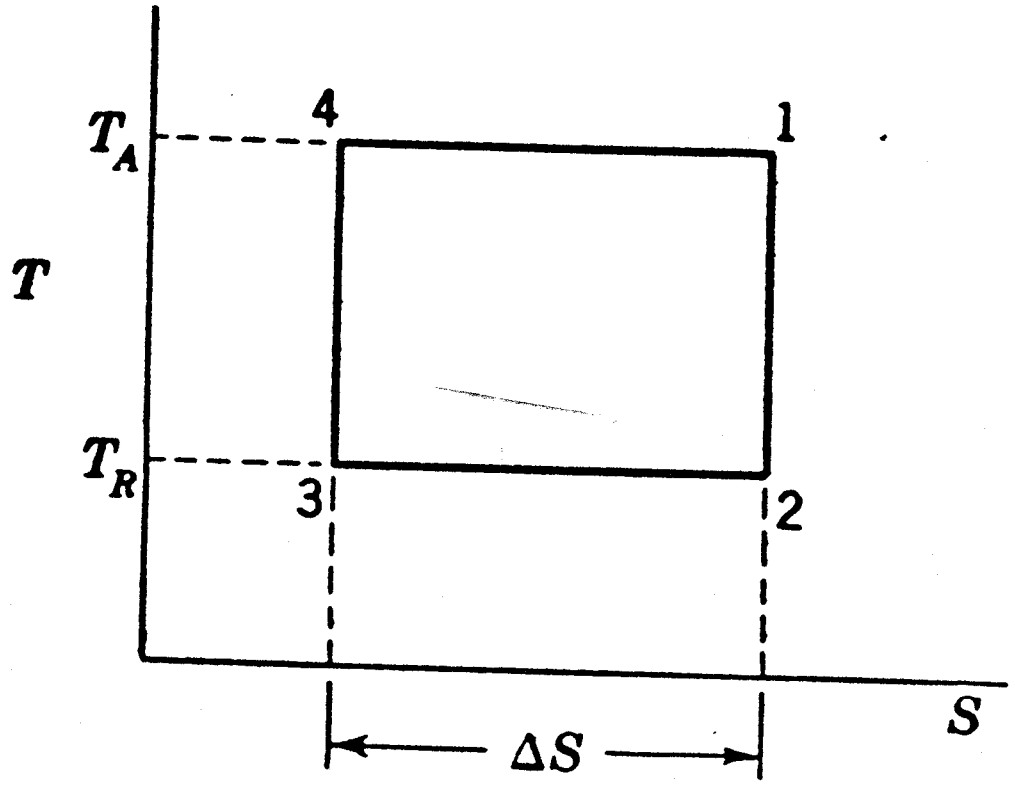
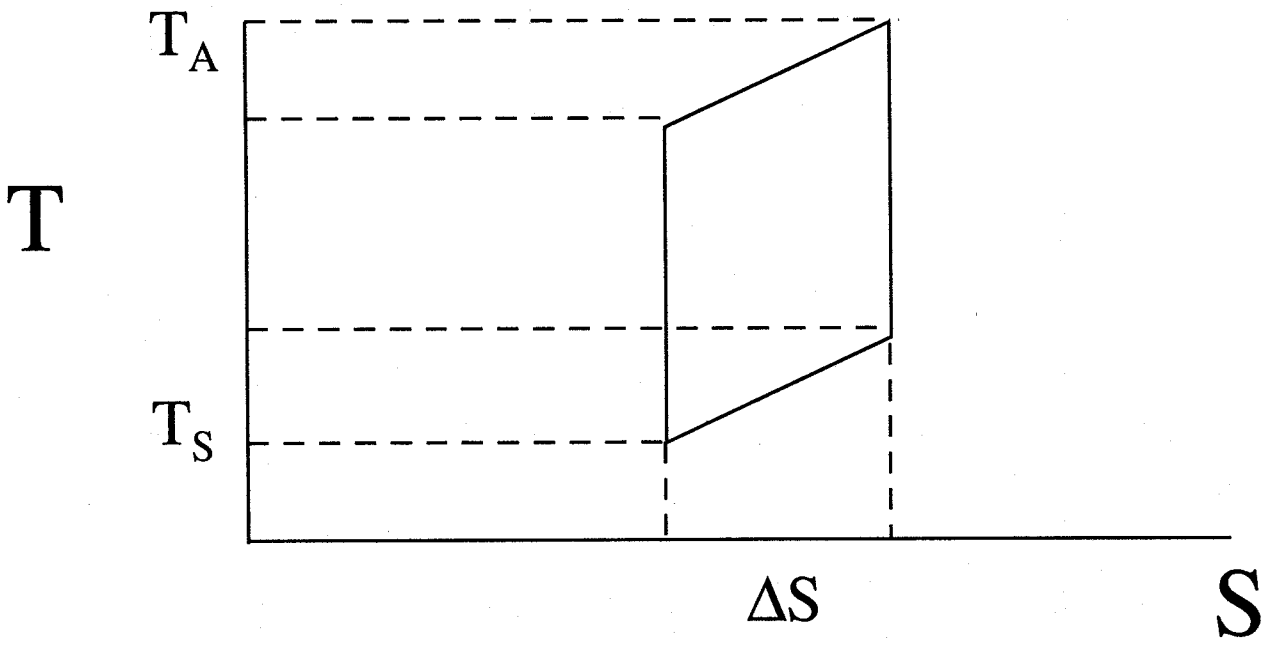


Fig. 7-1. *Ts* diagram of Carnot cycle.

Carnot Efficiency with Variable Temperatures



Efficiency = 1- (Tr/Ta) ave

Thermal Conversion with Large DT

- The efficiency is not a function of T)max, but is a function of T)ave.
- The sink temperature will have to be much higher than the minimum sink temperature.
- There are other considerations of picking minimum T)in.

Other Tin)min Considerations

- Material may have embrittlement issues at low temperature.
- For a Rankin cycle, the pinch point problem limit the Tin to be >300 C.
- For a He-cycle, the large coolant DT increase the compression ratio of the cycle.
- The thermal efficiency of a He-cycle have a maximum at a compression ratio of near 2.

THERMAL EFFICIENCY OF BASIC CYCLE

WORKING FLUID – HELIUM
I INTERCOOLER
REGENERATOR
PRECOOLER

a) TURBINE INLET TEMP. EFFECT
COMPR. EXIT PRESS. – 300 PSIA
COMPR. INLET TEMP. – 100°F

b) COMPRESSOR INLET TEMP. EFFECT
COMPR. EXIT PRESS. – 300 PSIA
TURBINE INLET TEMP. 2000°F

c) COMP OUTLET PRESSURE EFFECT
COMP. INLET TEMP. – 100°F
TURBINE INLET TEMP. – 2000°F

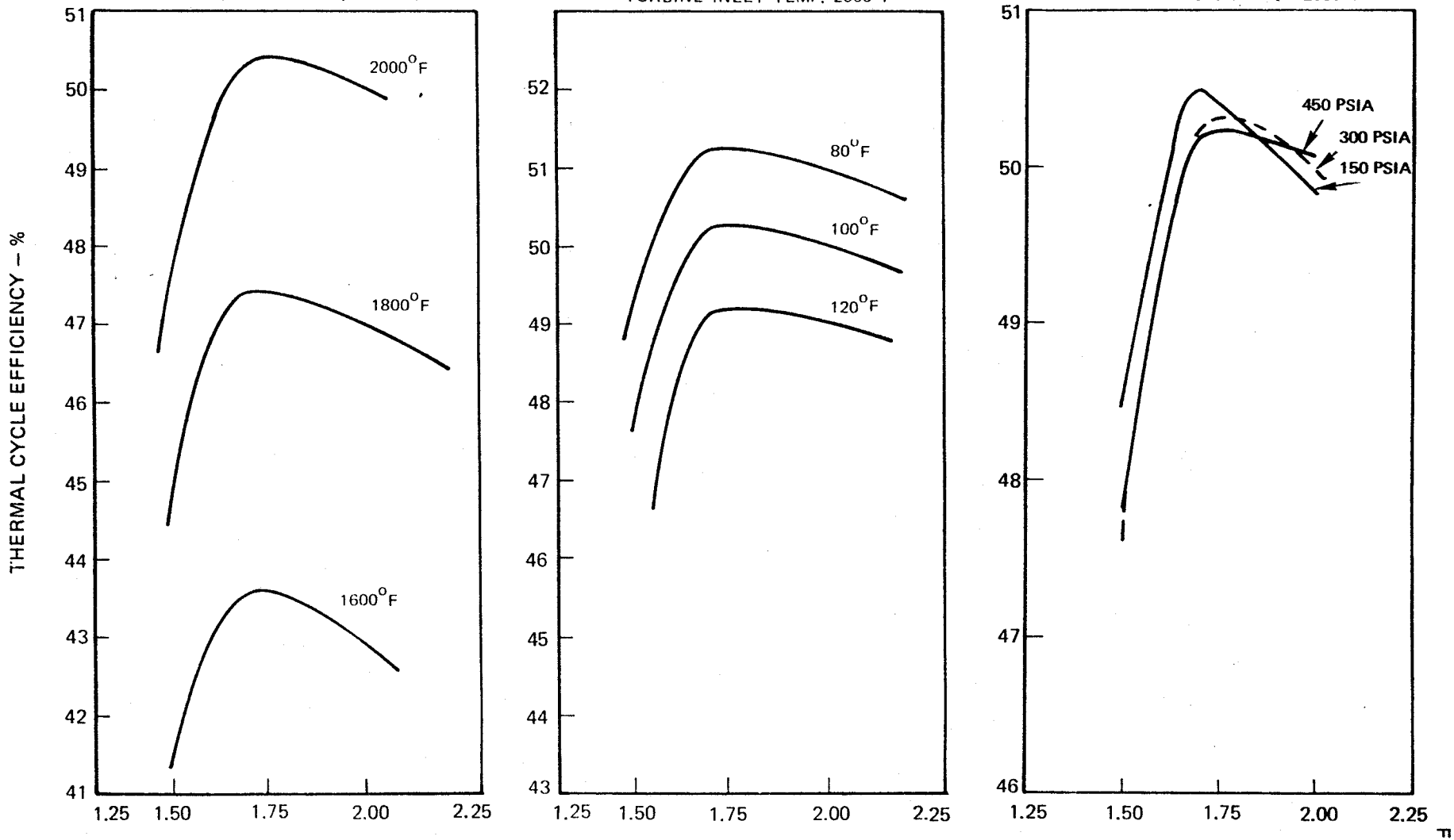


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FIG. 3

N03–270–1

High Temperature Material Problems

- With a power conversion system exceeds 500°C, the structural material selection for the power system becomes more difficult.
- The maximum allowable temperature for the structural materials are

Material	**T)max**	**Other issues**
FS	550°C	Low efficiency
316 SS	650°C	Moderate efficiency
V-alloy	700°C	Interstitial impurity issues (T and O) High cost
Nb-alloy	850°C	Tritium solubility Cost
Super alloy	900°C	
SiC	1200°C	Fabrication cost tritium solubility
W and Mo	1500°C	Fabrication Cost

Tritium Issues

- Tritium becomes very mobile at high temperatures.
- With maybe the exception of using Li as the breeder, the tritium partial pressure in the purge gas and/or in the coolant can be very high.
- Therefore, the power conversion system will have a high tritium partial pressure (~ Pa's).
- Tritium confinement and tritium dissolution in the structural materials will be a severe issue.