STEAM TURBINE PERFORMANCE IMPROVEMENTS

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STEAM TURBINE PERFORMANCE IMPROVEMENTS

Presented by

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STEAM TURBINE PERFORMANCE IMPROVEMENTS

This Paper was written for the following reasons:

- Indications of the areas of potential performance improvements for steam turbines.
- Guidance on where to locate the greatest potential of efficiency improvements
- Quantify values of improvement.

STEAM TURBINE PERFORMANCE IMPROVEMENTS

Areas Covered in Paper:

- Steam Chest Design
- Control Valve Design
- Control Valve Leakage
- Labyrinth Seals (Inter-stage, end gland, Retractable and Brush)
- Journal Bearing Design
- Thrust Bearing Design
- Nozzle Ring Design
- Diaphragm Design
- Rotating Airfoil Design
- Shroud Construction
- Rotor Design
- Casing Body Design
- Exhaust Construction
- Rotor Leakage Re-induction
- Tip Seals
- Rim Seals
- Wind Shields

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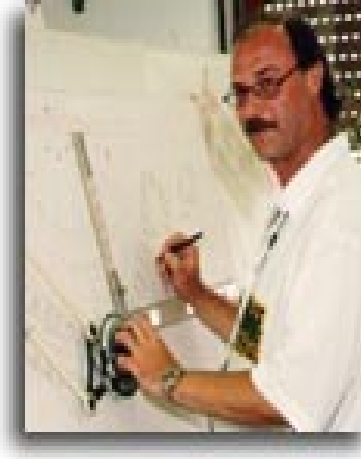
STEAM TURBINE PERFORMANCE IMPROVEMENTS



The Presentation Will Cover only the Major Performance Improvement Areas

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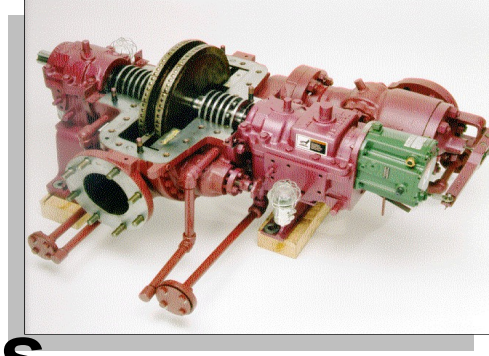
STEAM TURBINE PERFORMANCE IMPROVEMENTS

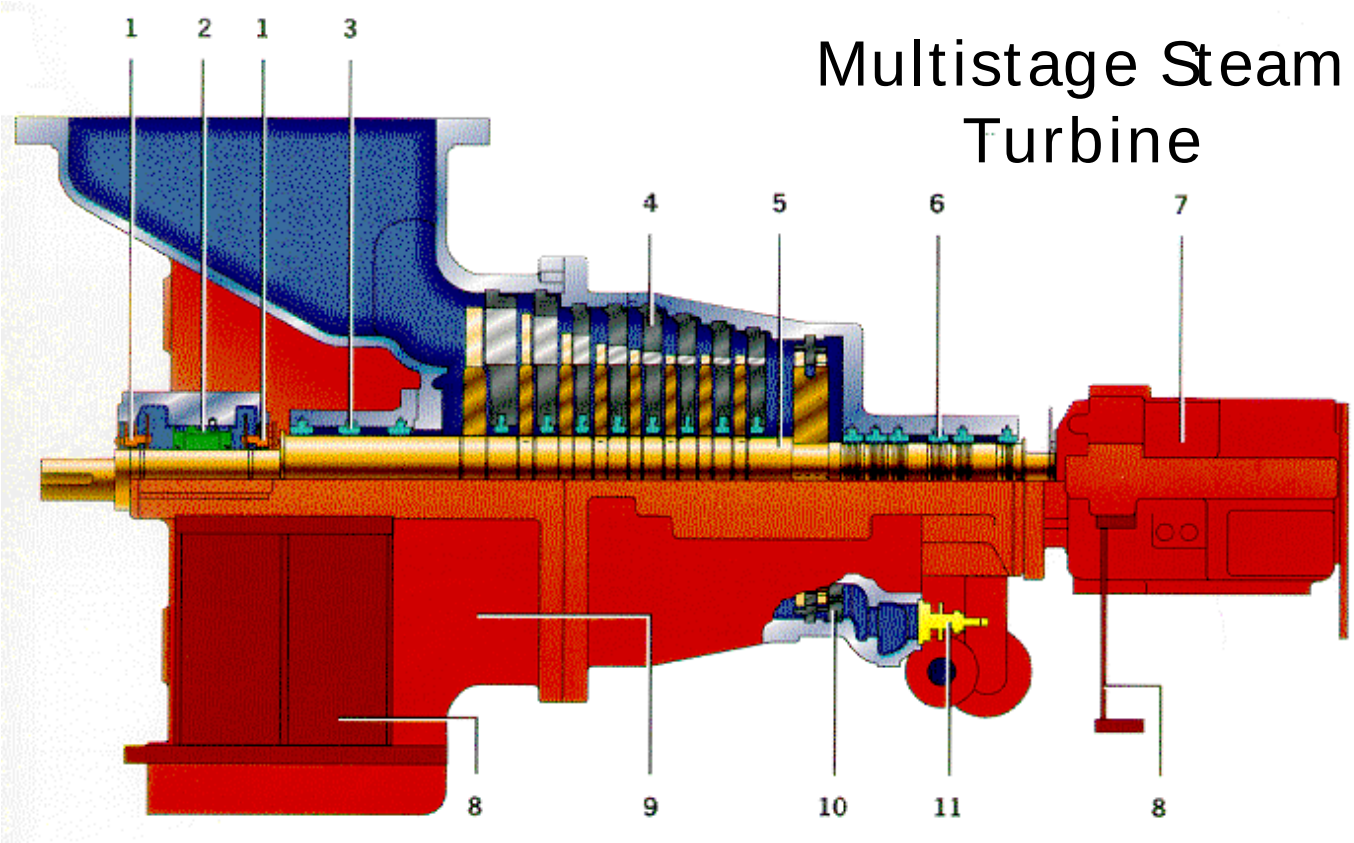
Areas to be covered in the presentation:

- Labyrinth Seals (Inter-stage, End Gland, Retractable, and Brush)
- Nozzles/Diaphragms
- Rotating Airfoils



Steam Turbines

Steam Turbine Components



Multistage Steam Turbine

STEAM TURBINE PERFORMANCE IMPROVEMENTS

Shaft Seals:

- **Carbon**

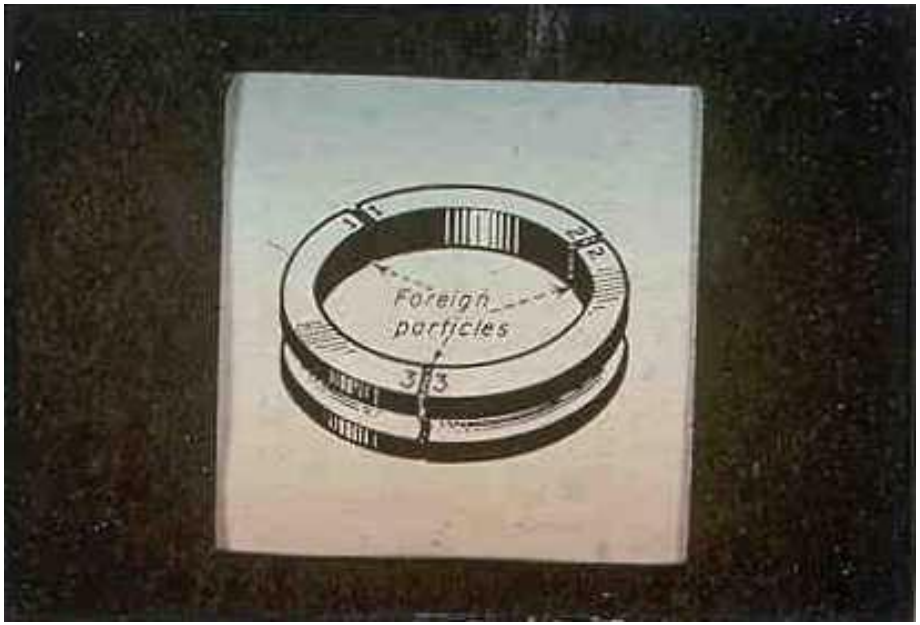
1) Normally utilized on single stage turbines

2) New improved design materials will increase efficiency by .5 to 1.0 percent

3) You are able to decrease shaft to carbon clearances with improved material

Carbon Rings

Carbon ring match marks
& segments

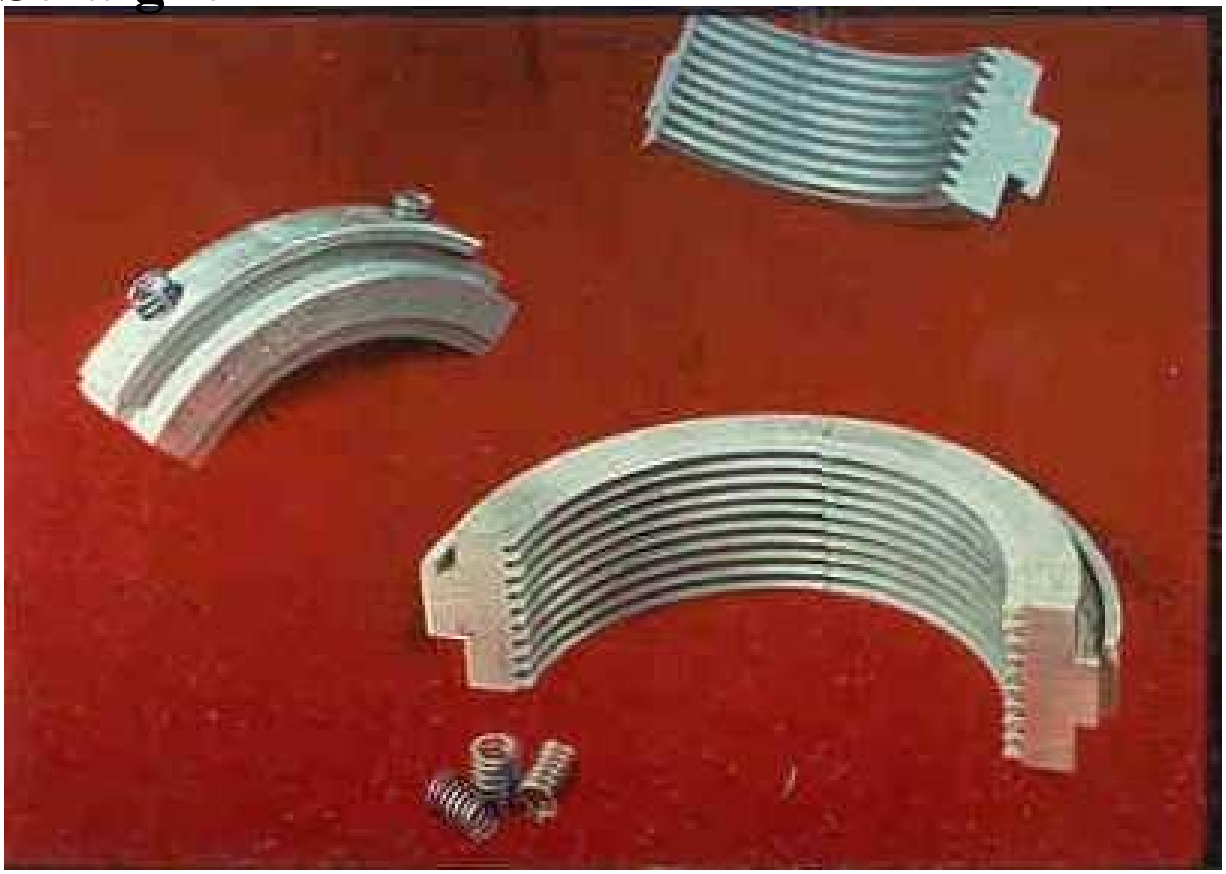


Shaft Labyrinth Seals:

- Straight or Stepped

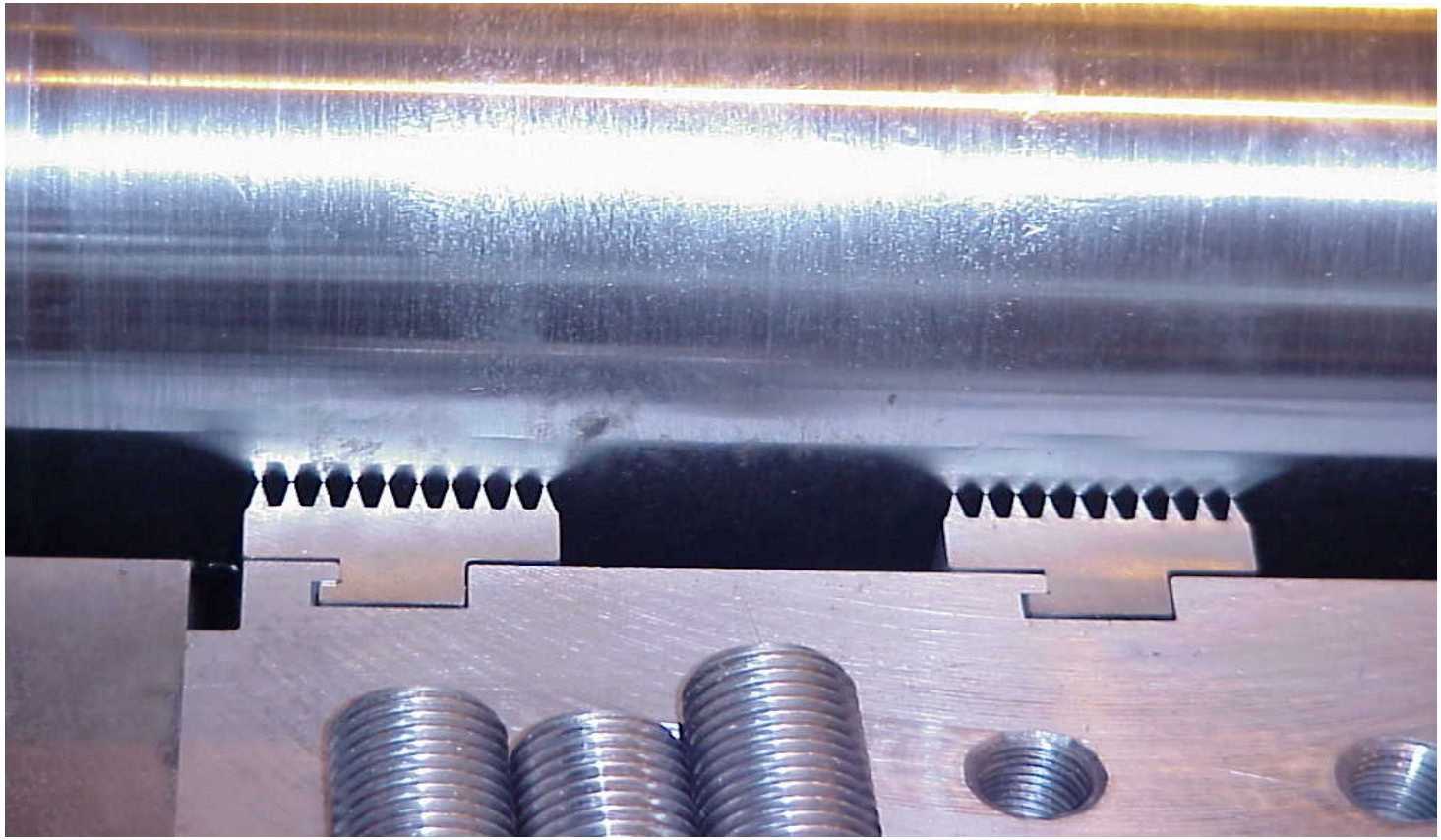
Labyrinth Seals

- **Straight**



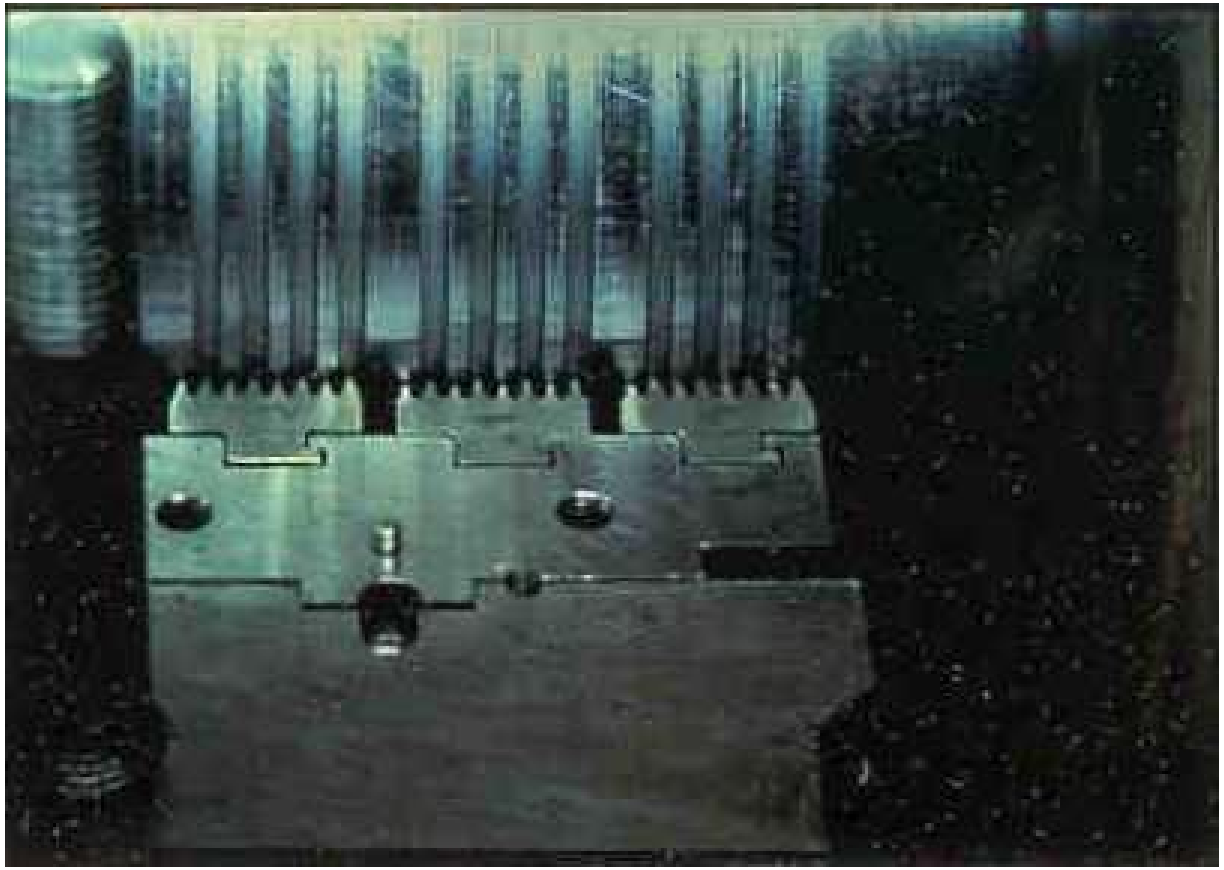
Labyrinth Seals

- **Straight**



Labyrinth Seals

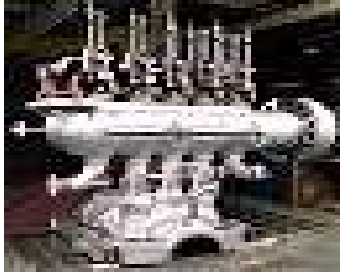
- **Stepped**



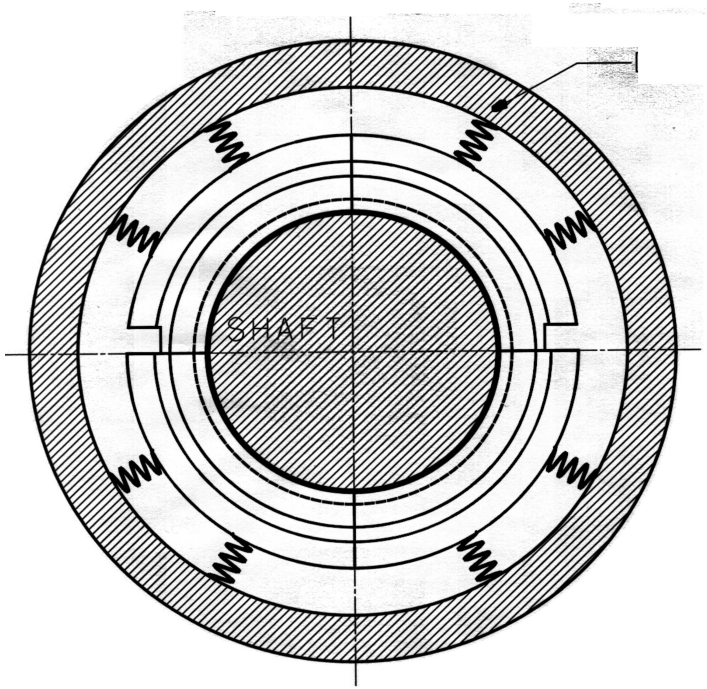
STEAM TURBINE PERFORMANCE IMPROVEMENTS

Shaft Labyrinth Seals:

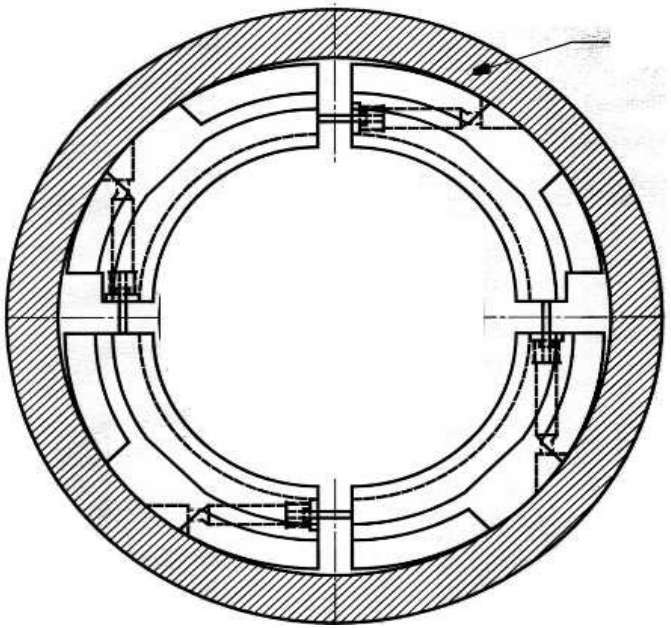
- **Retractable**



Retractable Seal Upgrade

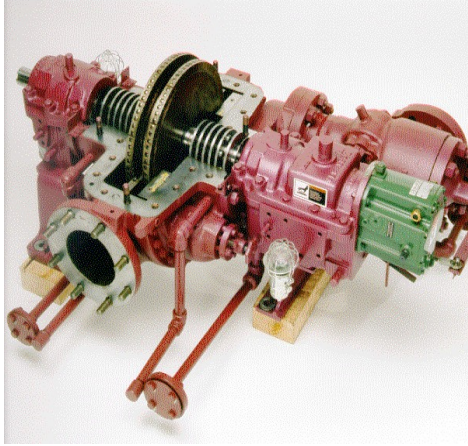


Conventional Labyrinth Ring



Retractable Labyrinth Ring

STEAM TURBINE PERFORMANCE IMPROVEMENTS



Shaft Labyrinth Seals:

- **Retractable Brush**

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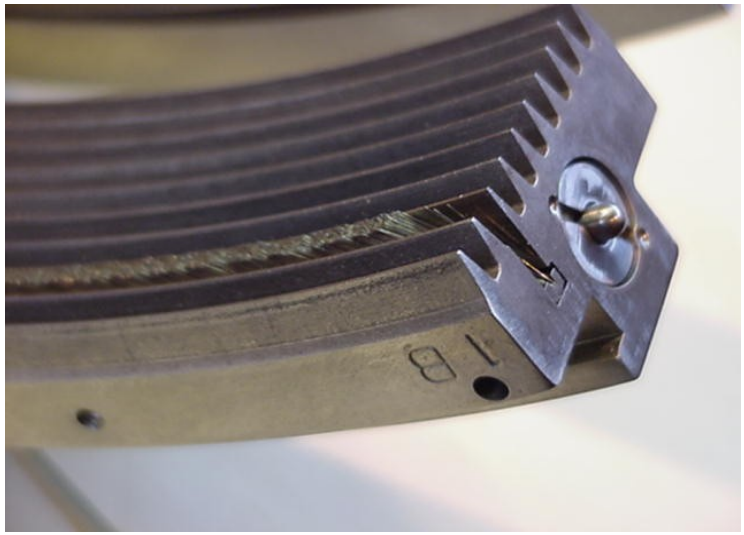
Brush Seals

- **Brush seals are available as an integral part of labyrinth seals or may be installed in the pressure closing seals as shown below.**



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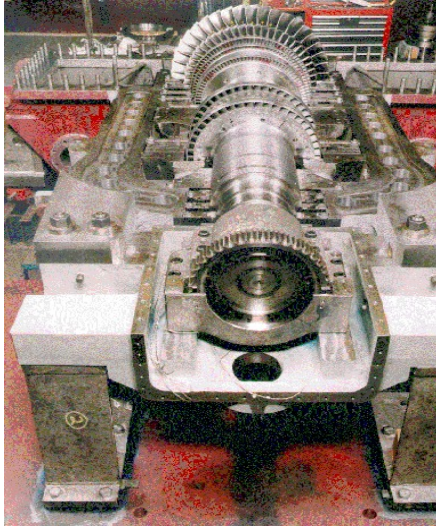
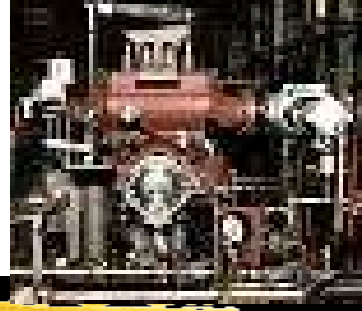


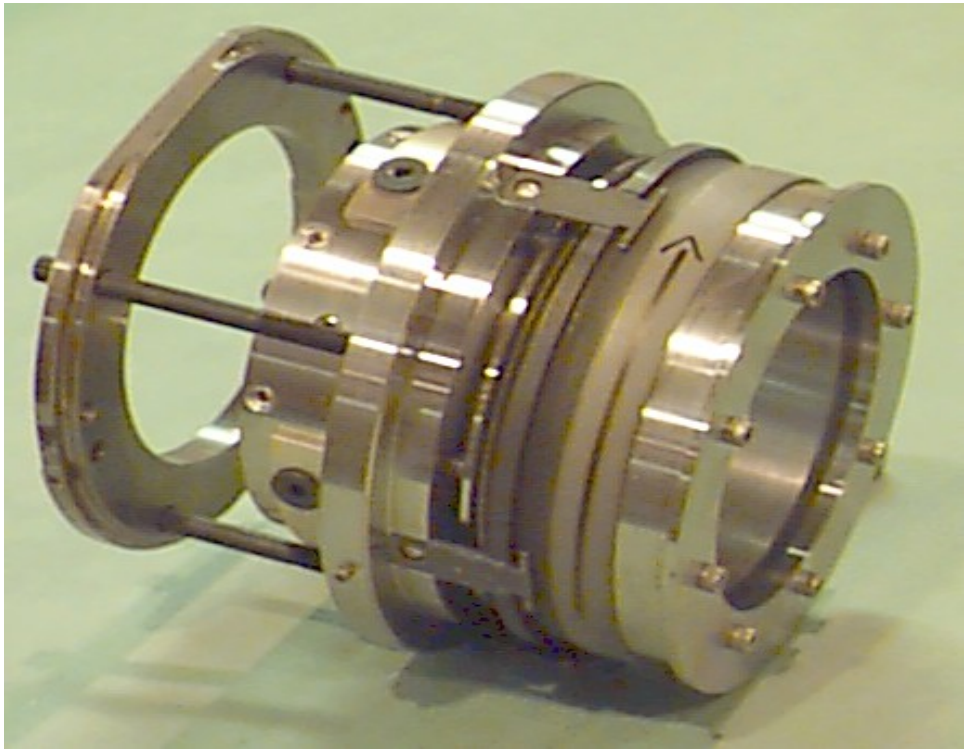
Shaft Seals:

- Mechanical Seals



Steam Seals

Mechanical Seals



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Shaft Seals:

Extremely Important Area for Efficiency Improvement

- Potential Inefficiency of 3 to 5 Percent.
- Retractable Seals Increase Clearance at Startup.
- Retractable Seals Hold Clearance Between outages.
- Retractable/Brush Seals Have Zero Clearance.
- Brush Seals Improve Efficiency in the area of 1.0 percent.

STEAM TURBINE PERFORMANCE IMPROVEMENTS

Nozzles/Diaphragms:

- Reamed

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- **Reamed**

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Nozzles/Diaphragms:

- **Investment Cast**

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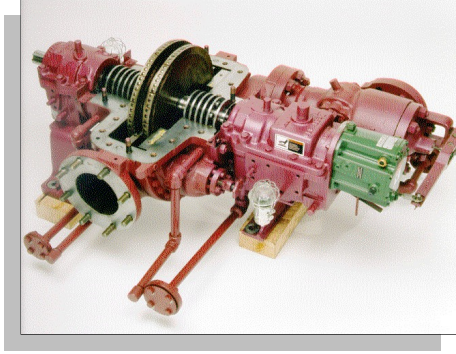
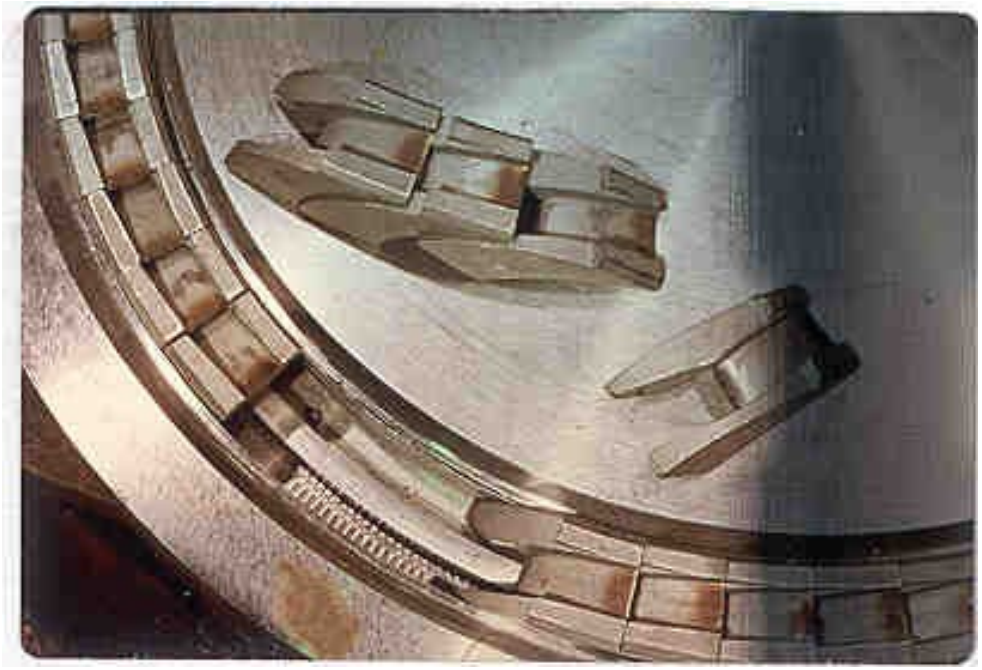


Steam Turbine Components

Diaphragm Designs



STEAM TURBINE PERFORMANCE IMPROVEMENTS

Nozzles/Diaphragms:

- **Milled and Welded**

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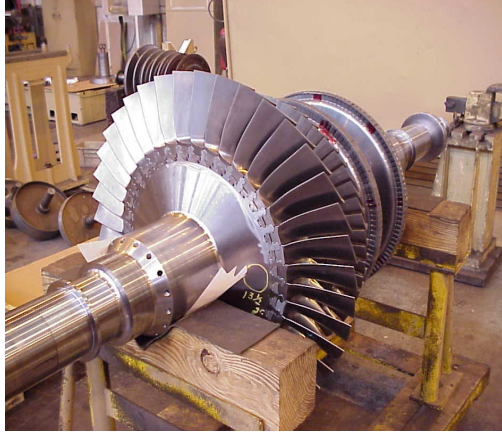
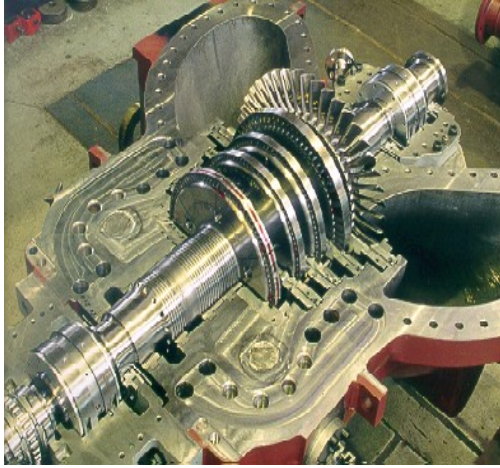


Steam Turbine Components

Diaphragm Designs

STEAM TURBINE PERFORMANCE IMPROVEMENTS



Nozzles/Diaphragms:

- **Profiled Ring and Vain:**

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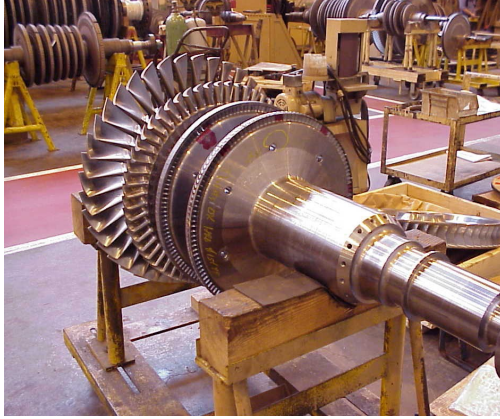

Steam Turbine Components

Diaphragm Designs

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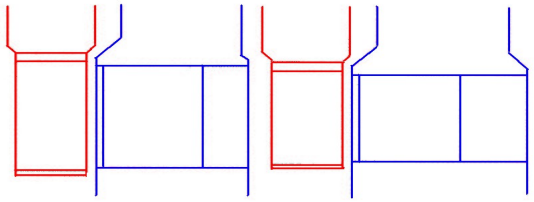
Nozzles/Diaphragms:

- Constant Ring and Vane
- Cast

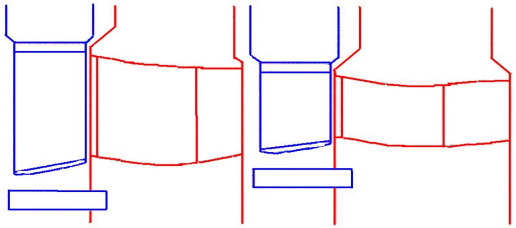
PRV Diaphragms

Flow Paths Used In Comparative Tests

Cylindrical End Walls



Profiled End Walls, High-Efficiency Airfoils



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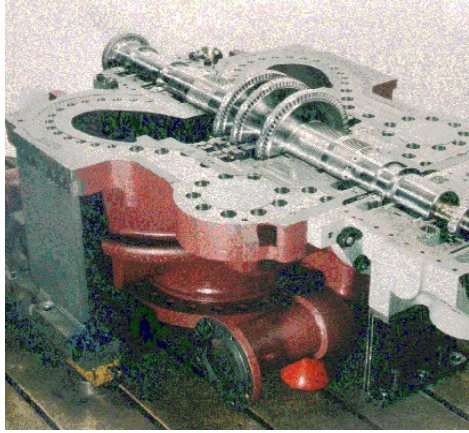
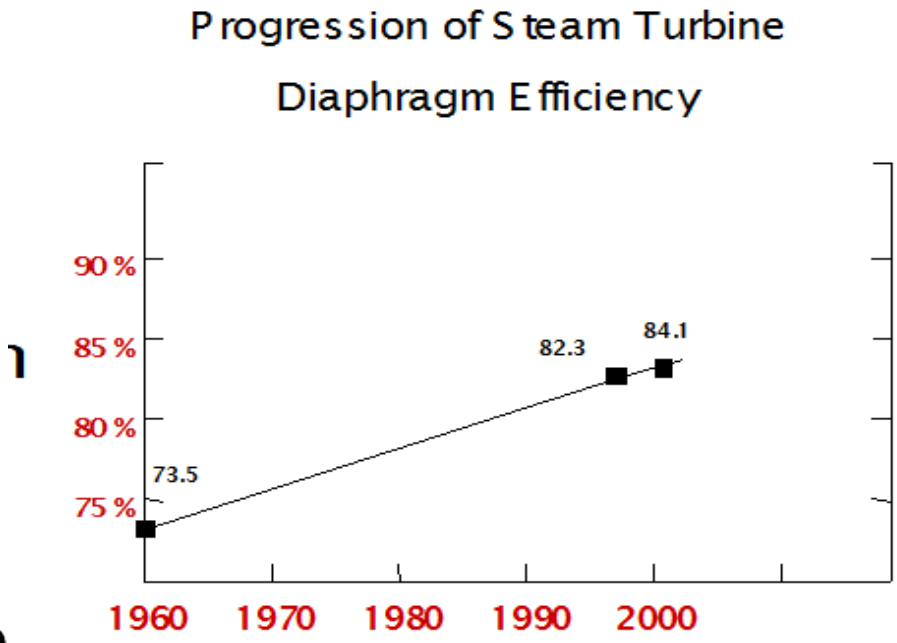


Nozzles/Diaphragms:

- Highest potential for improvement.
- Design initiatives to obtain approximately 10 percent increase in efficiency in the past 20 years.
- Possible 15 percent improvement due to ware/damage.



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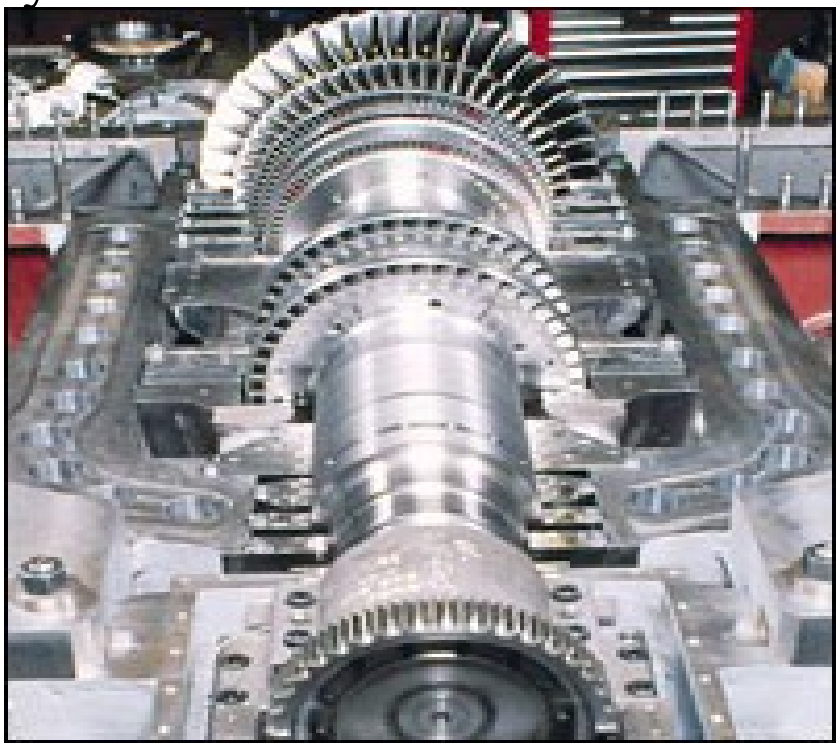
Rotating Airfoils:

Root Design

- Internal fir tree
- External fir tree
- Axial entry



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Rotating Airfoils:

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Rotating Airfoils:

- Efficiency Improvements of 5% in the Past Ten Years
- More Than 5% Due to Ware/Damage

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Conclusion:

- Know where you plan to operate your turbine.
- Know how you want to operate the turbine.
- Understand the inefficiency of off designs.
- Keep informed of all O.E.M's efficiency upgrades.
- Complete value calculators on all potential upgrades.
- Track performance of unit continuously.
- Shaft seals and airfoils are normally the areas to concentrate on.

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