TNChE Asia 2024

EFFICIENCY IMPROVEMENT AND DECARBONAIZATION

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EBARA ELLIOTT ENERGY

ENERGY SAVING AND OPTIMIZATION

EBARA ELLIOTT ENERGY

ENERGY Community of Practice

TIChE

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BIOGRAPHY

Takano is Sr. Engineer of Engineering and development at Ebara Elliott Energy. Takano holds a Bachelor's degree in engineering from the Meiji University .

I have 14 years of experience in the product engineering and development of new turbomachinery products, including: compressors for Oil&Gas, novel turbomachinery applications.

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MAJOR INSTALLATIONS – TURBO MACHINERIES IN THAILAND

UPSTREAM, MIDSTREAM
AND DOWNSTREAM:
TOTAL ESTIMATED 600+ CASINGS

Rayong

Sriracha

Offshore

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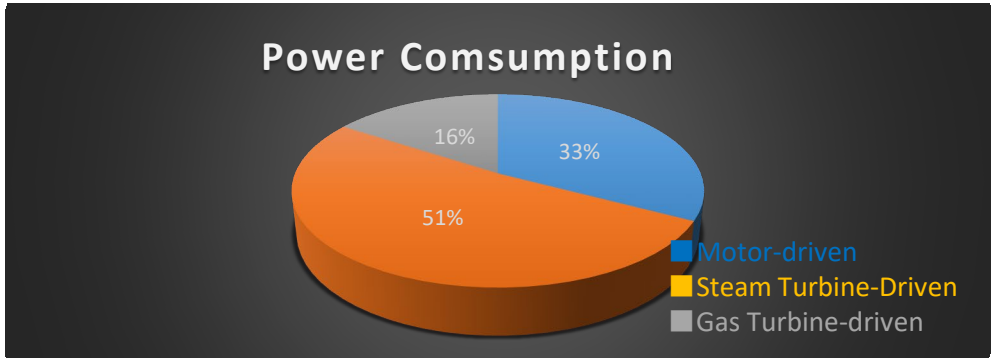
HOW MUCH ENERGY CONSUMPTION? IF ENERGY SAVING ?



- Total Power Requirements : 392MWh
- The above turbine drive accounts for more than 50% of the total.
- Electrified train is about 33%.

If 2% efficiency improvement for compressor is possible

⇒Annual Energy Saving : 55,000,000kWh per year.

Reduction of CO2 : 55,000 ton per year

IGES List of Grid Emission Factors https://www.iges.or.jp/jp/pub/list-grid-emission-factor/en,

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CO2 EMISSION FOR CHEMICAL INDUSTRIES

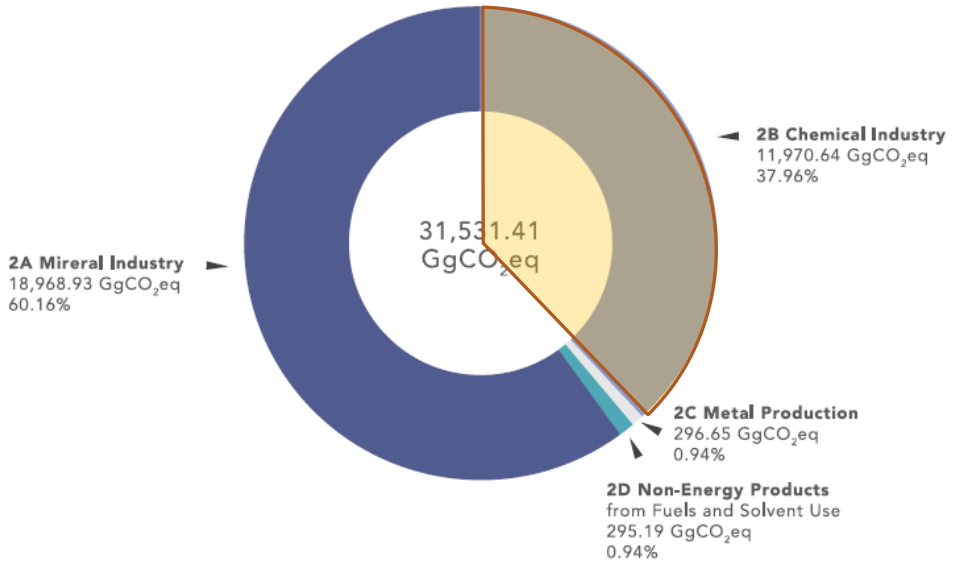

Figure 2-5: GHG emissions in IPPU sector 2016

$$\frac{\text{CO2 reduction : } 55{,}000 \text{ ton}}{\text{CO2 emissions : } 11{,}970{,}640 \text{ ton}} = 0.5\%$$

(In National greenhouse gas inventory of Thailand 2016)

This reduction is only Elliott Compressor
(Total only 100 casing)

If applying to others ?

CO2 Reduction : 3% more over

You may think it is only 3%…

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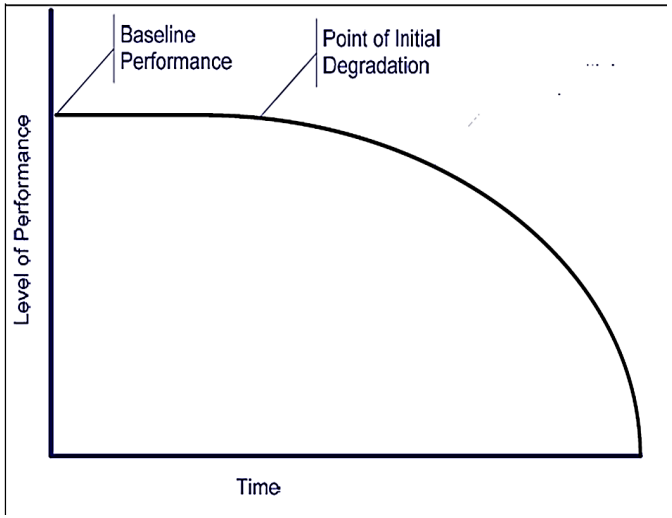
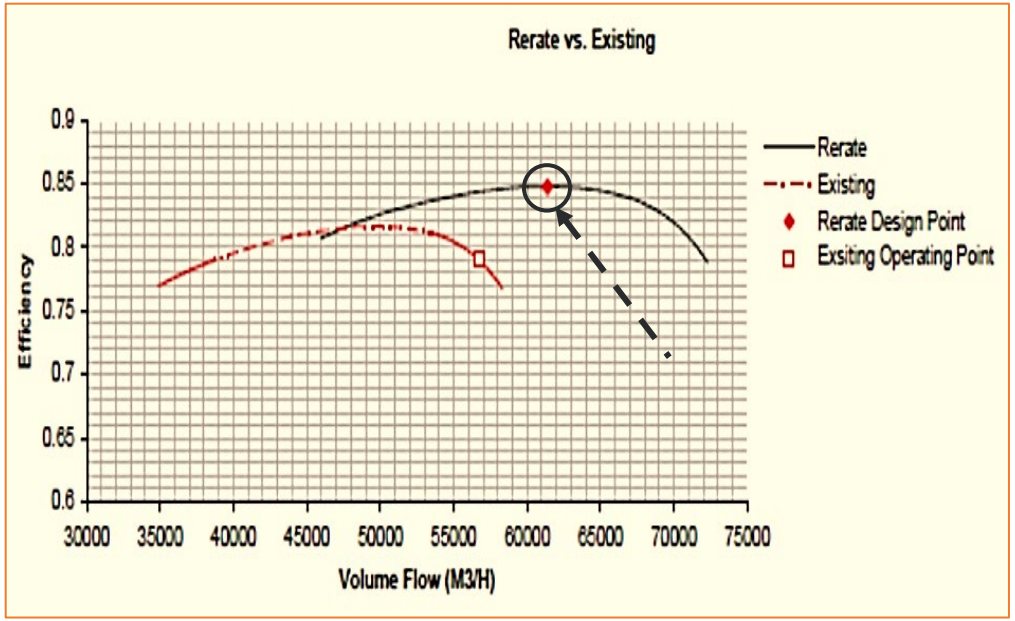
HOW TO IMPROVE EFFICIENCY?



As plants and facilities get older

- **installed turbomachinery ages**
- **efficiency and reliability decline**
- **equipment does not operate at best efficiency**



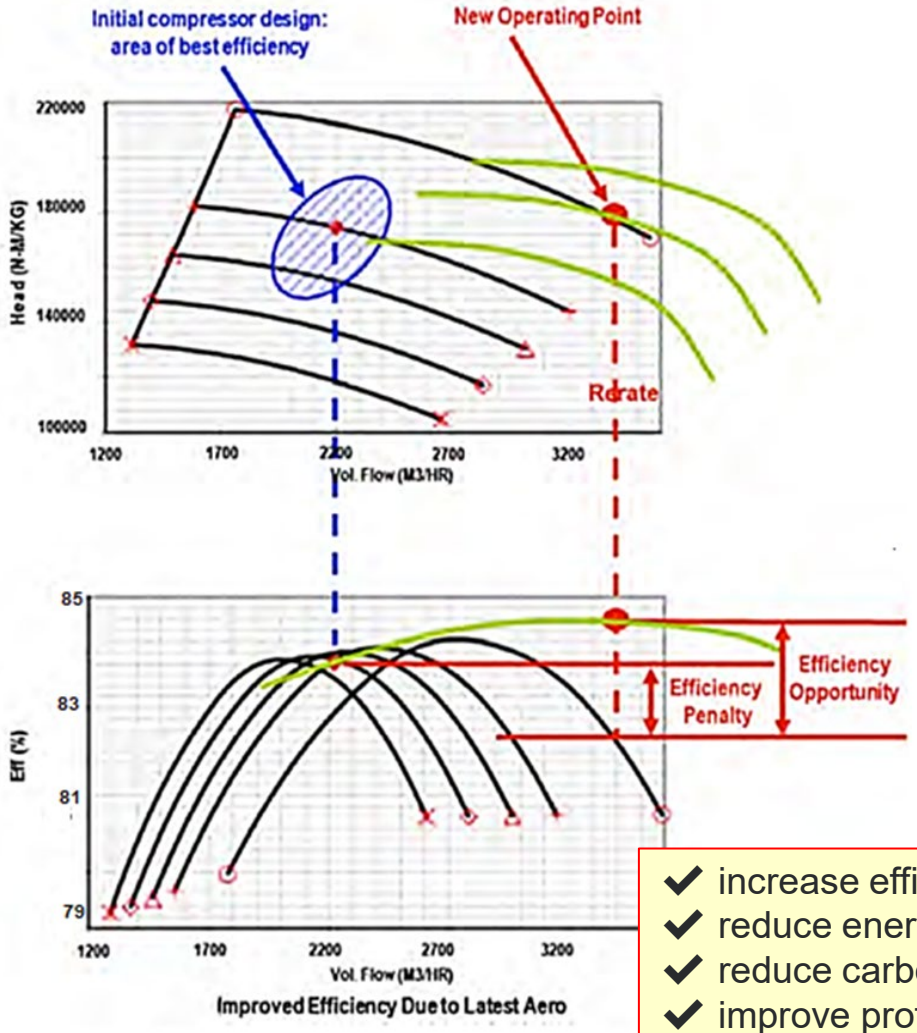
Top Objectives for Turbomachinery Rerates

- Recover or enhance lost efficiency
- Plant Capacity (Increase production)
- Combination of both above

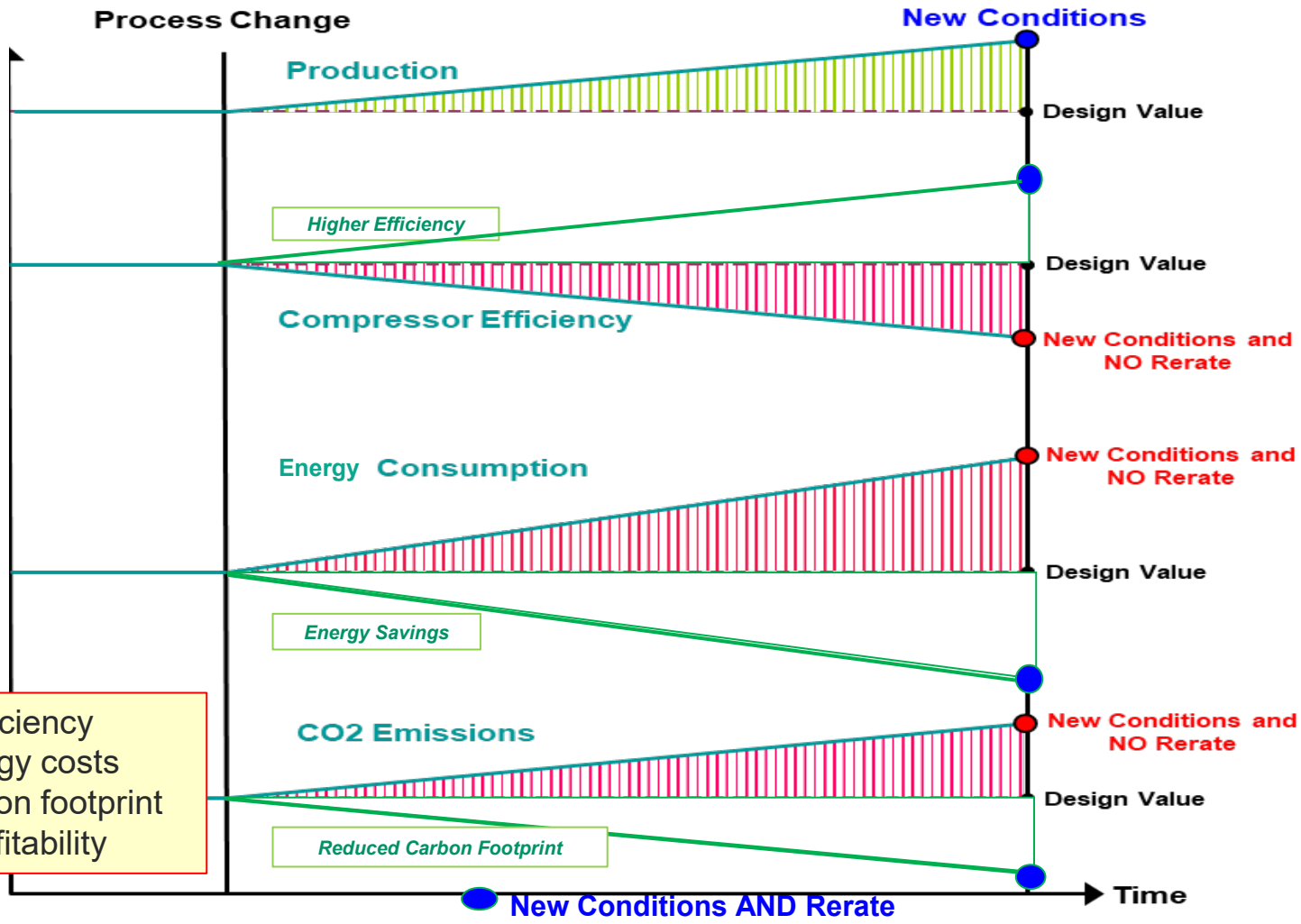
Turbomachinery Rerates can

- **Increase capacity AND operating efficiency**
- **Reduce energy costs**
- **Reduce carbon footprint**
- **Improve profitability**

HOW TO IMPROVE EFFICIENCY?



- ✔ increase efficiency
- ✔ reduce energy costs
- ✔ reduce carbon footprint
- ✔ improve profitability



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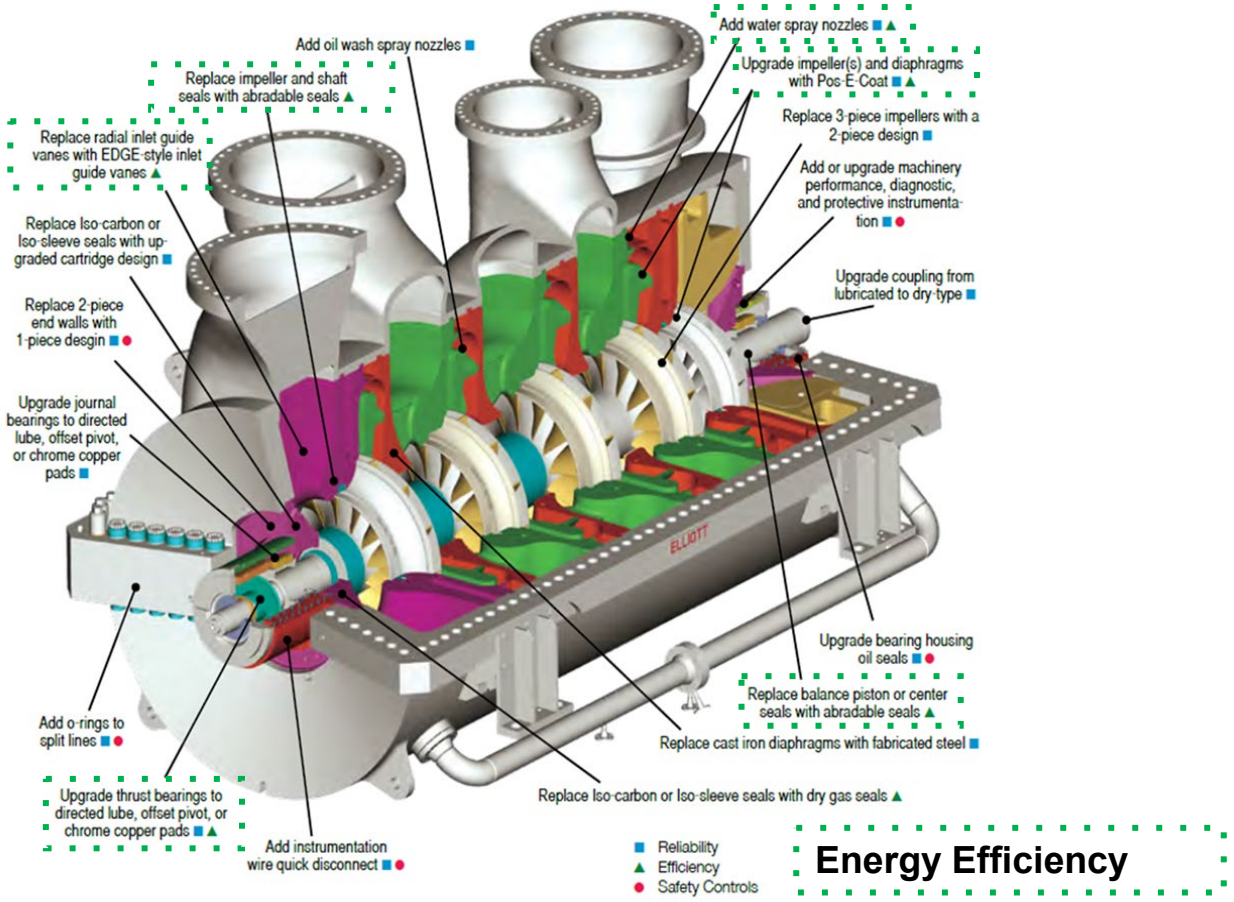
HOW TO IMPROVE EFFICIENCY?



<Energy Efficiency modifications

- ✓ Bearing upgrades
- ✓ Seal replacements
- ✓ **Impeller replacement**
- ✓ **Optimized flow path**
- ✓ Flow path coatings
- ✓ Spray nozzles
- ✓ Inlet Guide Vanes
- ✓ Material Upgrades
- ✓ Controls upgrades

Other benefits

- ➢ extended time between shutdowns
- ➢ shorter turnarounds
- ➢ fewer unplanned outages

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AERO PERFORMANCE IMPROVEMENT

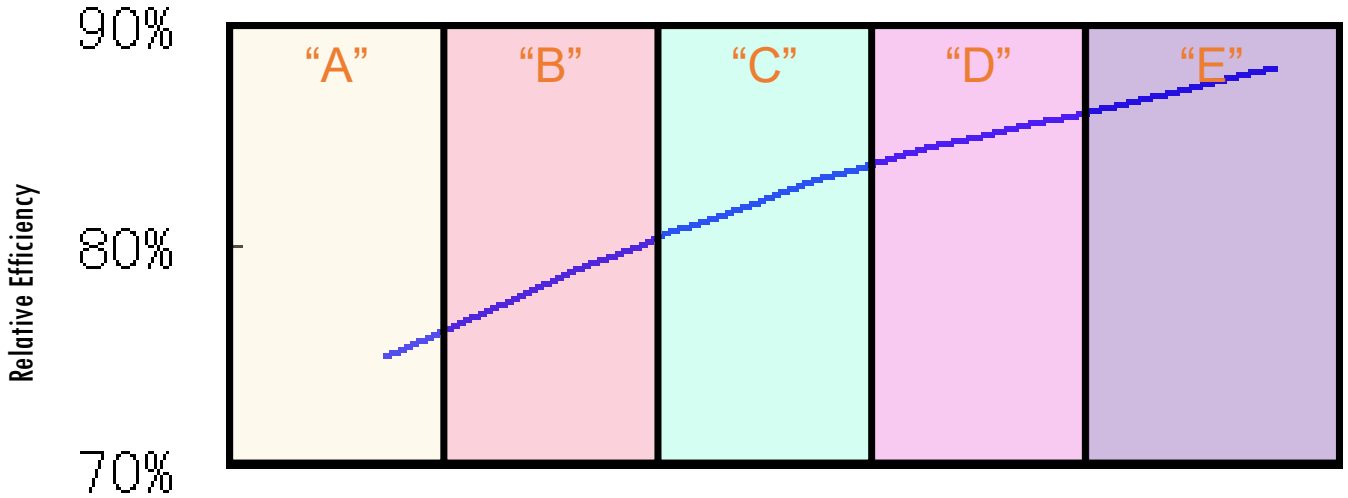
A. ~1980's **1D Design Concept:** One-dimensional Aerodynamic theory

B. 1980's~1990's **Quasi-3D Design Concept:** Performance expectation · Loss expectation.

C. 1980's~Now **Full-3D Design Concept:** Phenomenon elucidation: Secondary flow; Reflux; Rotating stall; Leak flow

D. 1990's~Now **3D Inverse Design Concept:** Flow optimization: Secondary flow restraint; Fluid detachment prevention

E. 2000's~Now **Adjoint Method Concept:** Multi-objective optimizations; Fluid-Strength complex optimizations



Design method For Elliott current impeller line up

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AERO PERFORMANCE IMPROVEMENT

Elliott Current Typical Modern Impeller line up

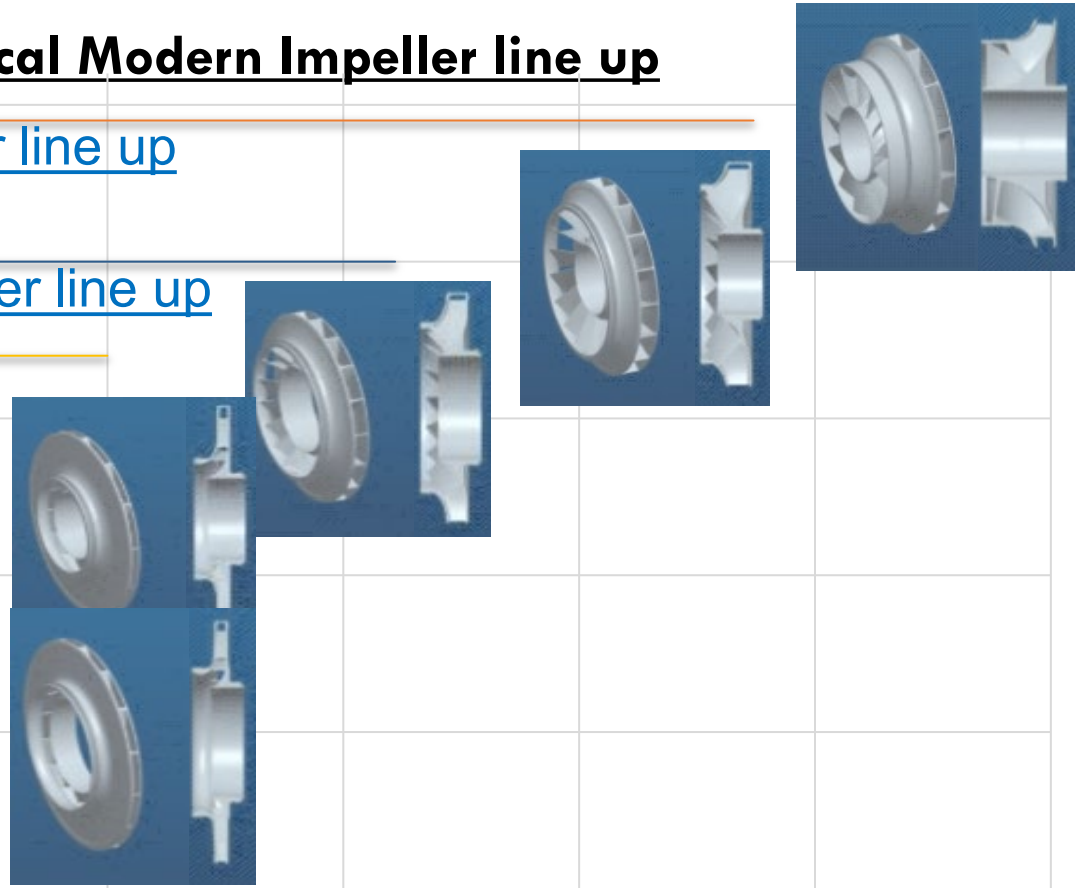
*. 3D Full-inducer line up

*. 3D Semi-inducer line up

*. 3D large bore Line up

*. 2D line up

*. 2D large bore line up



0.00 0.05 0.10 0.15 0.20 0.25 0.30

Φd

Largest flow capacity; best efficiency; but long space.

Large flow capacity; better efficiency; short space.

Large flow capacity; better efficiency; high rotor stability.

Small flow capacity; short space

Small flow capacity, high rotor stability

High flow capacity, High efficiency, High Rotor stability; Suitable for variable services!

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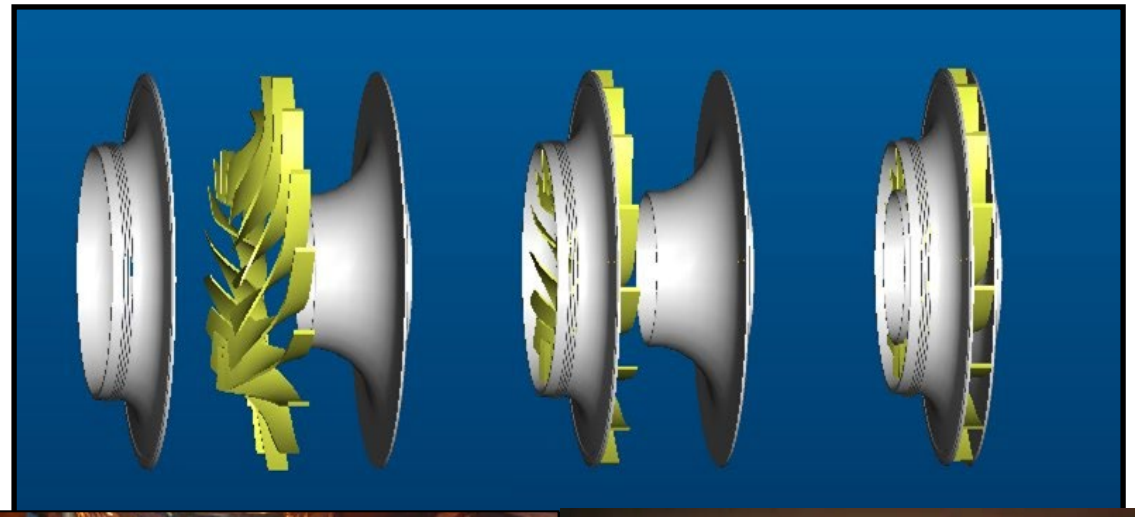
MANUFACTURE IMPROVEMENT



~Mid of 1990's: 3-Pieces

- Hub, blades, and cover by separated pieces
- Joint method: Riveting or Welding
- Full Manually: depends on the skills of workers.

Obsolete method by Elliott

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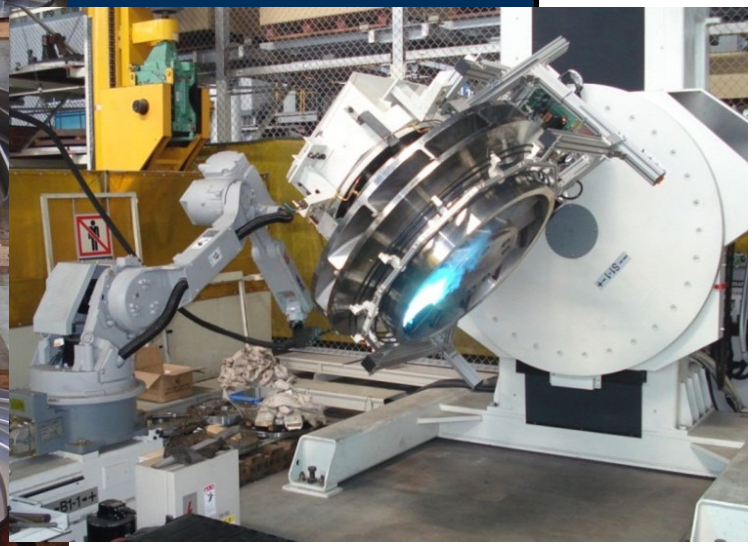
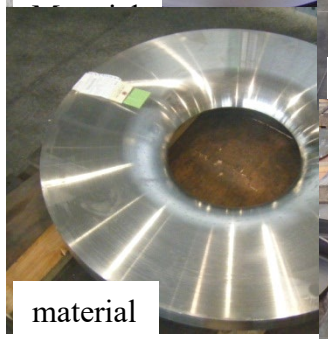
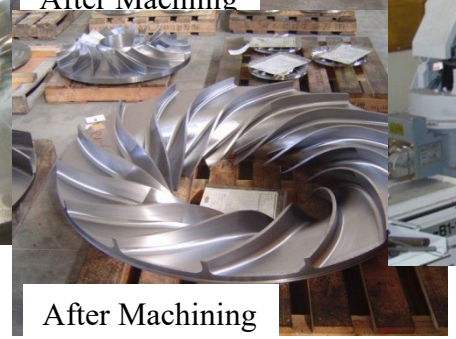
MANUFACTURE IMPROVEMENT





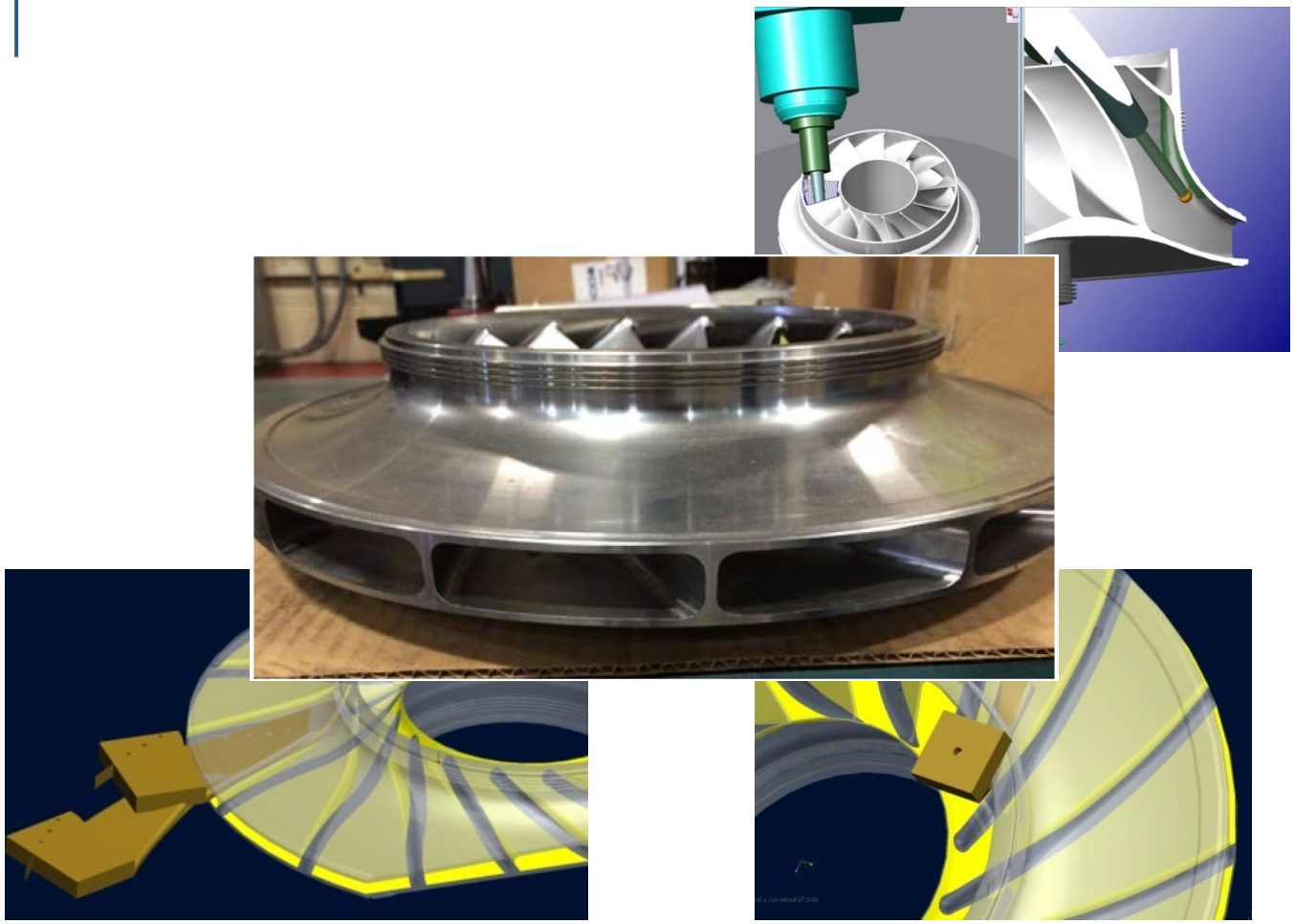


1990's ~ Now: 2-Pieces

- Blades fabricated with hub or cover, 2-pieces
- Joint method: Welding or Brazing
- Auto & Partial Manual: High precision, Stable manufacture quality and aero performance.

Standard method

MANUFACTURE IMPROVEMENT



2000's ~ Now: 1-Piece

- Manufactured from 1-piece raw material construction.
- Manufacture method: 5-axis CNC milled or EDM (Electro discharge machining).
- Full Auto: Most High precision, enhance mechanical and performance quality.

New Standard

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COMPRESSOR IMPELLER OPTION

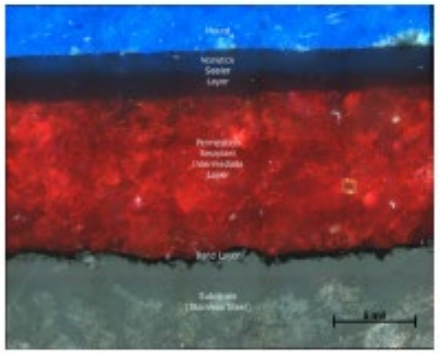

Figure 2. Fouling damage caused by salt carryover.

- To Protect critical components from fouling and corrosion.
- Maintains compressor performance over a longer period of time.
- Turnarounds may be easier since cleaning may be minimized.

Elliott is keeping to improve

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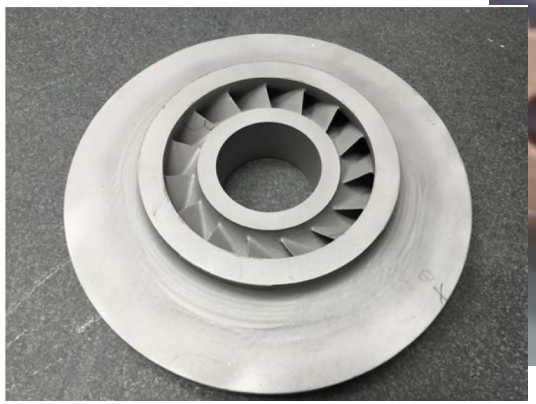
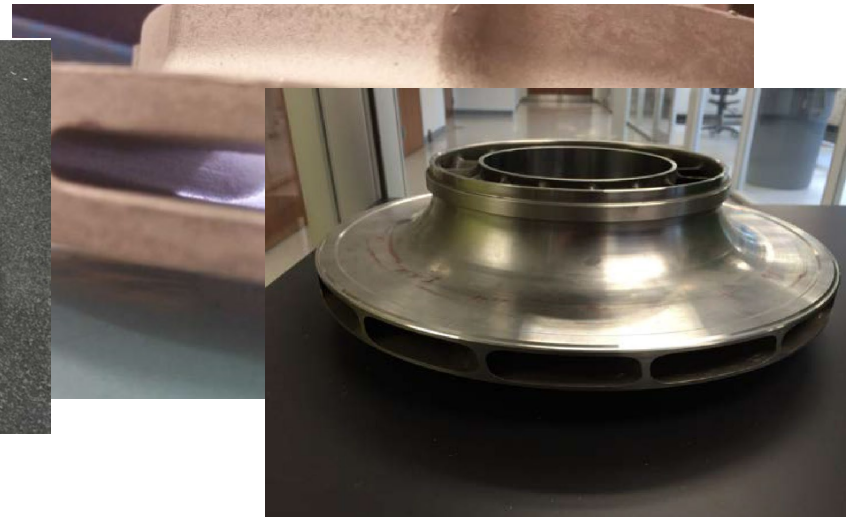
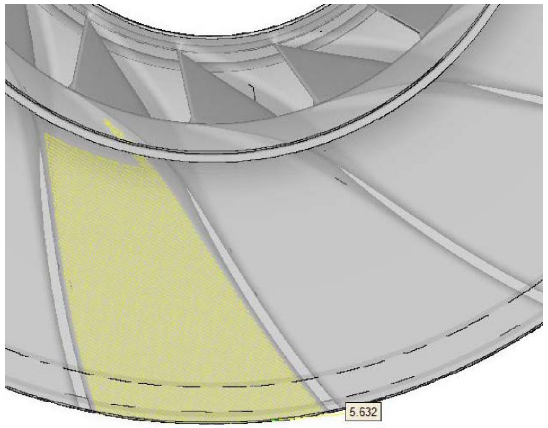
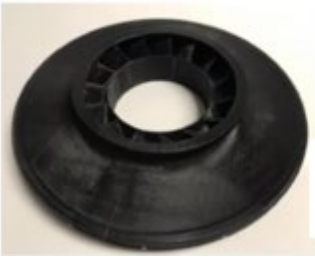
COMPRESSOR IMPELLER OPTION









Continuously wound carbon fiber in epoxy matrix through additive process

2010's ~ : Future method

- High Precision Casting
- Hot Isostatic Pressed Powder Metal.
- 3D Print

……

Elliott is keeping to improve the technology for better equipment for all Customers!

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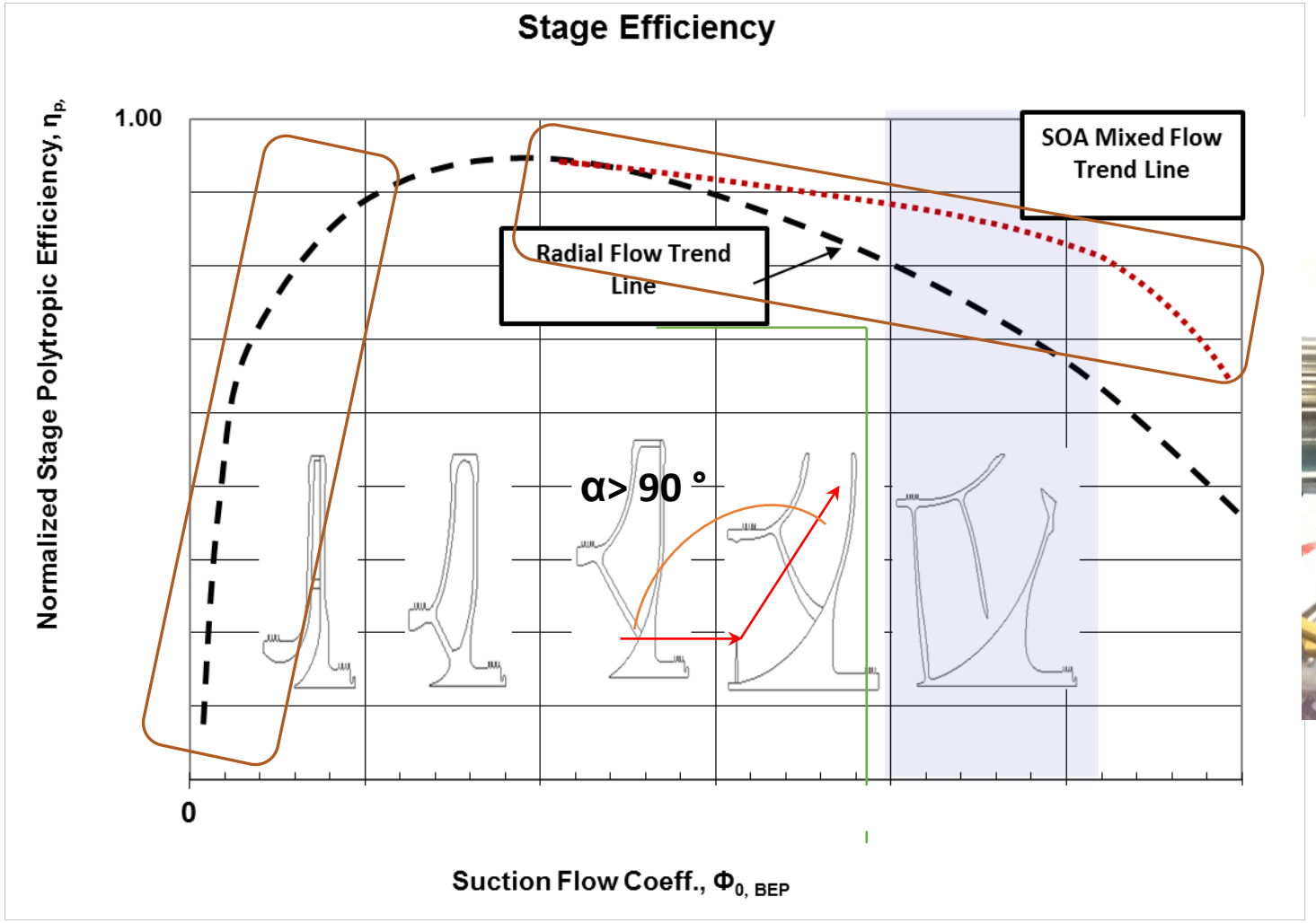
AERO PERFORMANCE IMPROVEMENT

Characteristics:

Exit Flow angle **α**=90°

Peak Efficiency ~ Φ= 0.1



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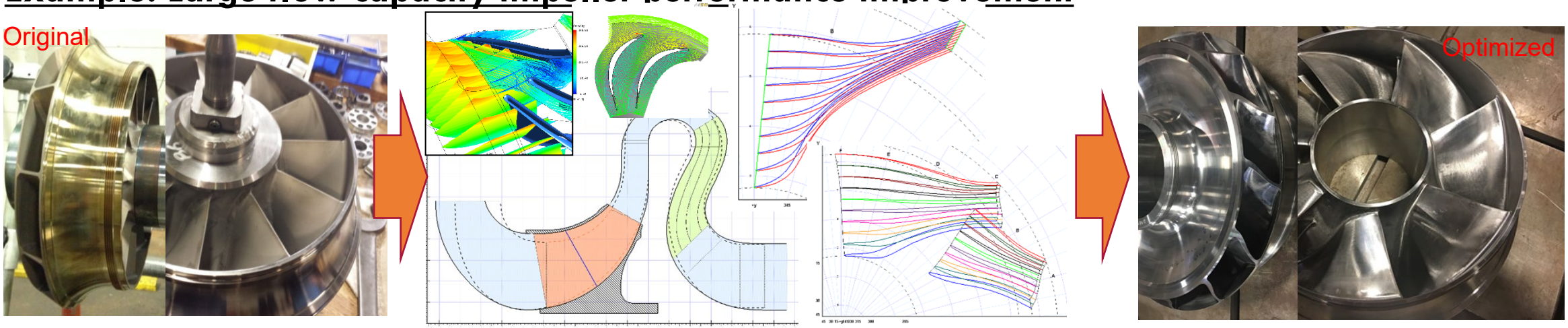
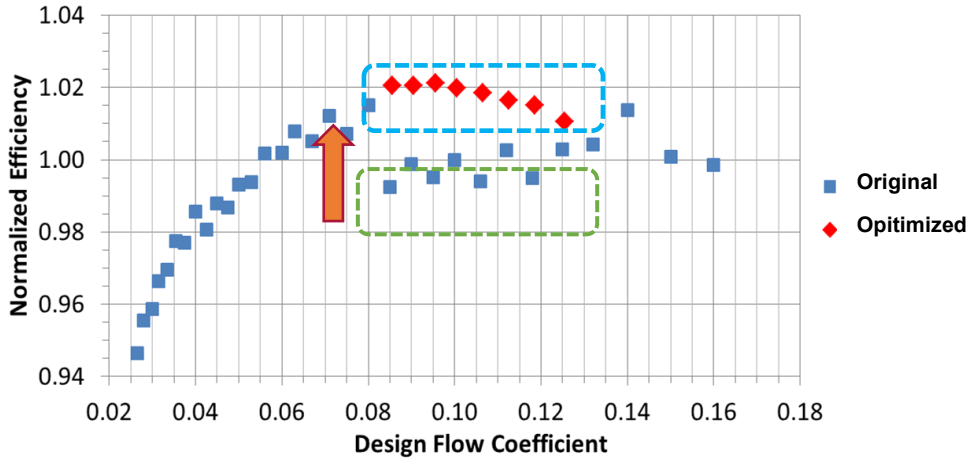
AERO PERFORMANCE IMPROVEMENT FOR HIGH FLOW

Example: Large flow capacity impeller performance improvement

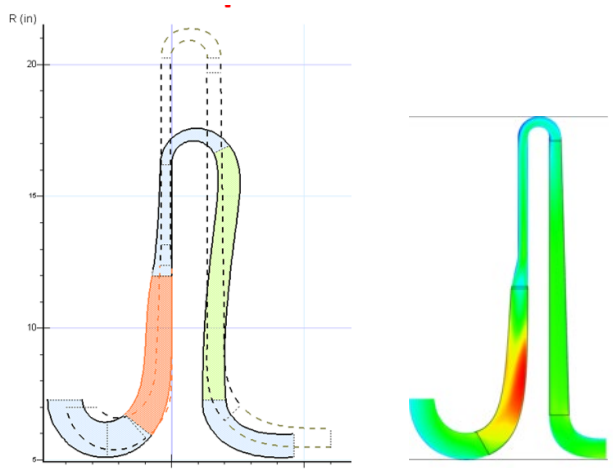




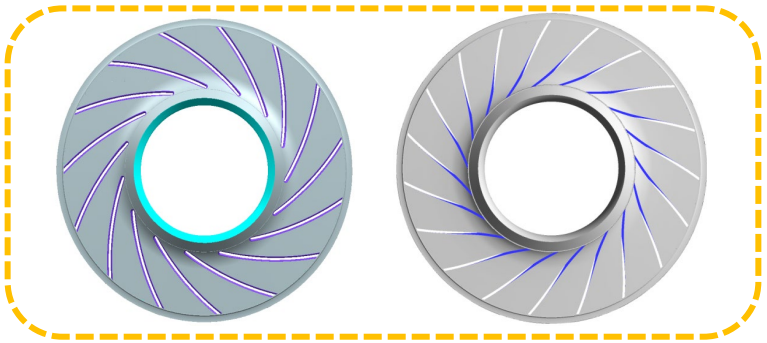
- CFD utilized aero design: Blade shape modify
- Combination with return channel
- Inverse analysis to achieve the best flow path

Around 2% efficiency up for existing impeller

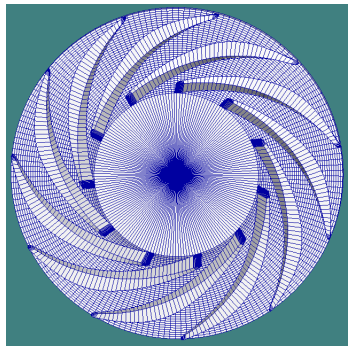
AERO PERFORMANCE IMPROVEMENT FOR LOW FLOW

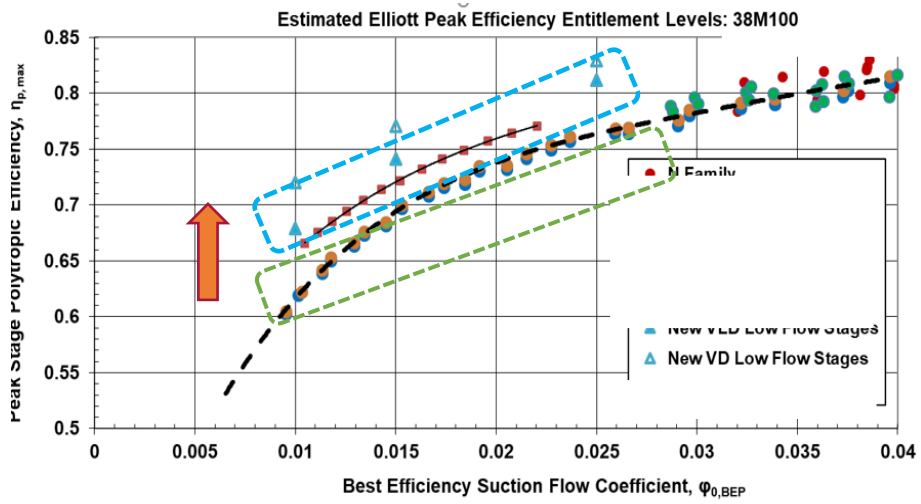


OLD



New





- CFD utilized aero design: Blade shape modify
- Optimized return channel

Around 2% efficiency up for existing impeller

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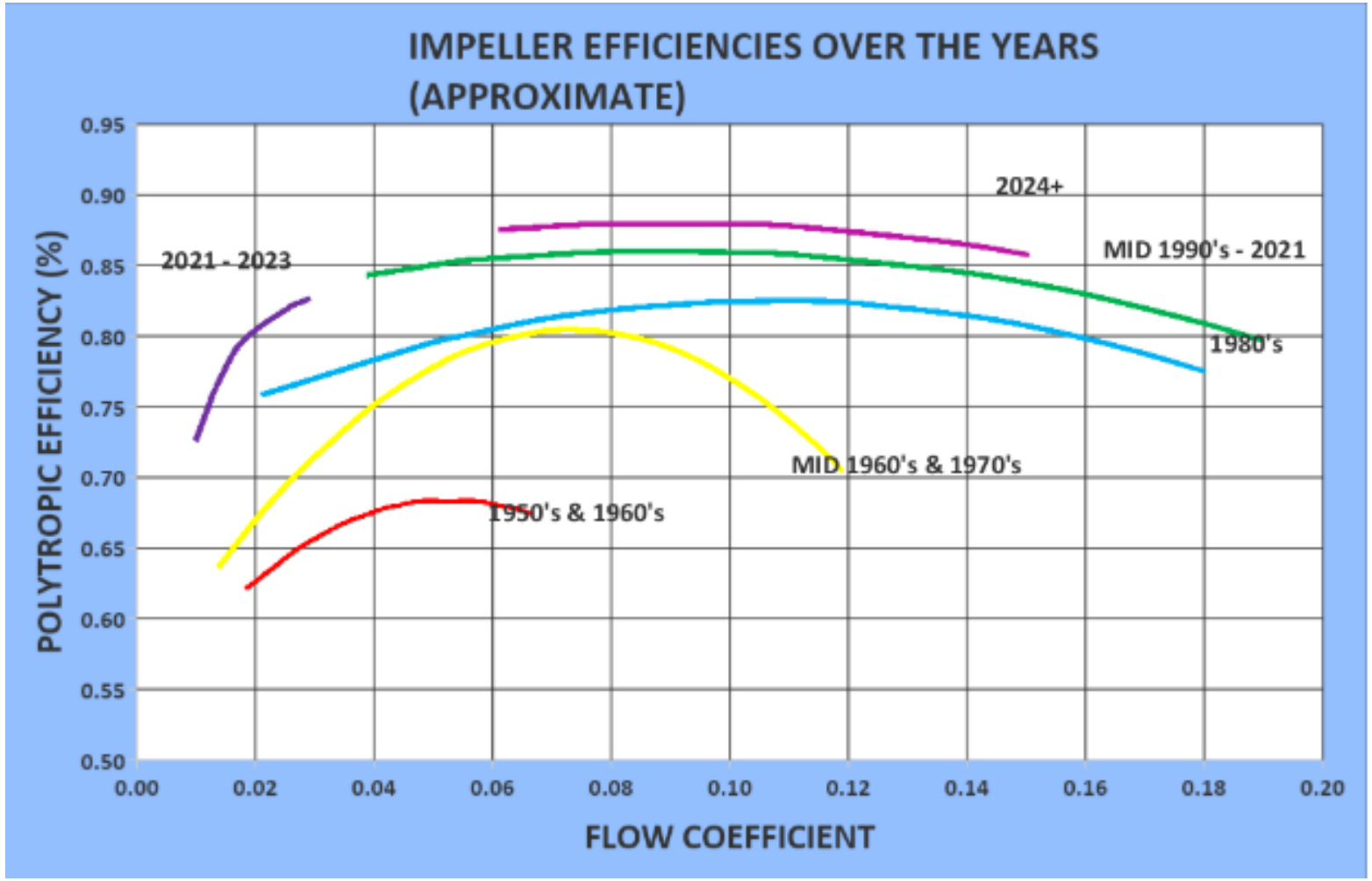
AERO PERFORMANCE IMPROVEMENT



Improved efficiency by 2% or more throughout all areas

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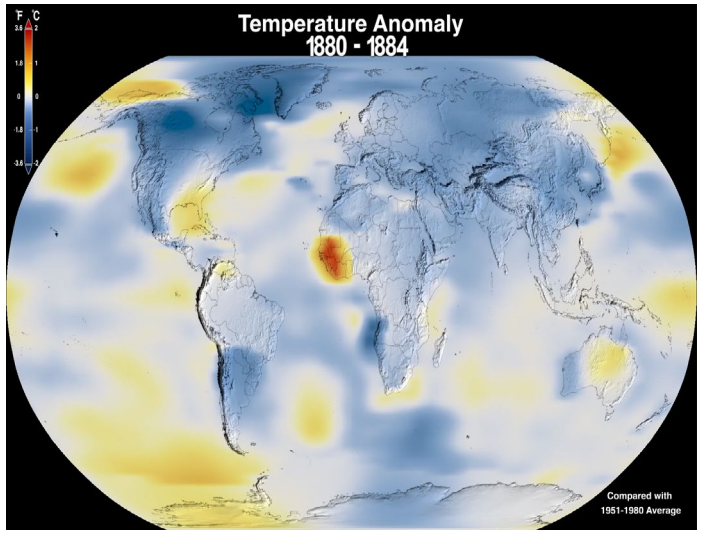
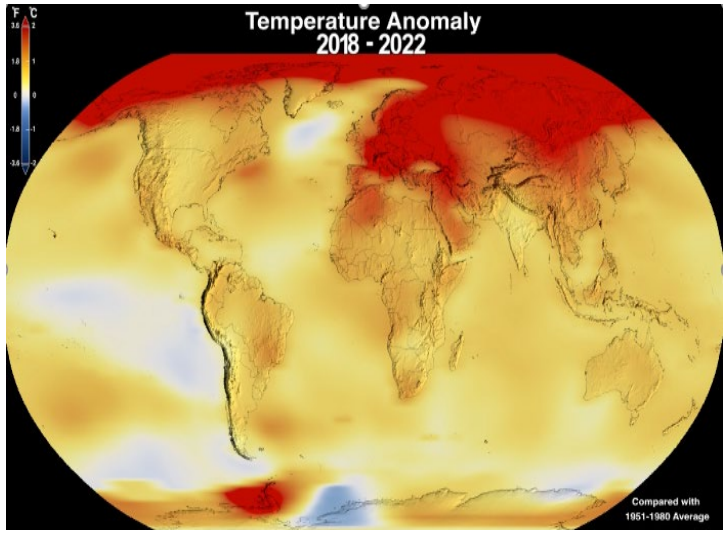
WE CHANGING WORLD





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Decarbonisation is the immediate key opportunity to create and sustain a better world for future generations.