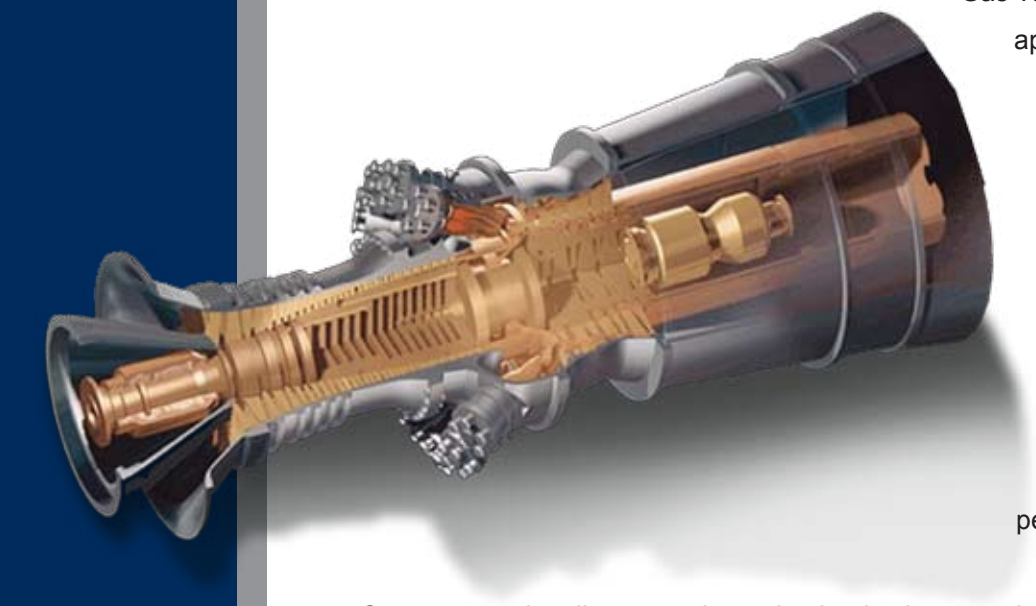
GTE
GAS TURBINE EFFICIENCY

EcoValue™
Industrial Compressor Cleaning System

- **3% performance recovery, 1% heat rate and 2% availability improvements***
- **792 units with 17 million operating hours of demonstrated recovery and erosion robustness**
- **Return on investment in less than 3 months***
- **Optimized nozzle placement more effectively cleans**
- **Reduces water consumption by up to 65%**

Compressor Water Wash



Gas Turbine Compressors consume approximately 60% of the overall cycle energy during operation. This cycle consumes very large quantities of air and although this air is filtered, small quantities of dust, aerosols and water pass through the filters and deposit on the blades. These deposits decrease the air flow of the compressor and the overall performance of the gas turbine.

Compressor cleanliness can be maintained using a routine program of water washing. There are two water wash maneuvers performed on gas turbines: Off-Line and On-Line. An Off-Line maneuver is conducted with the gas turbine in a cooled state using cranking speed, while an On-Line maneuver is conducted with the machine at operating temperature and uses water only. Both Operations use highly atomized water spray patterns designed to completely enter the compressor core. The Off-Line cleans the entire core and recovers lost performance, while the On-Line cleans the early stages and maximizes the time period between needed Off-Line washing to provide peak availability.

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Water Droplet Size

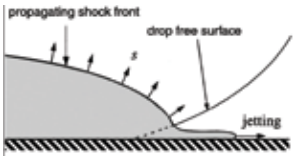
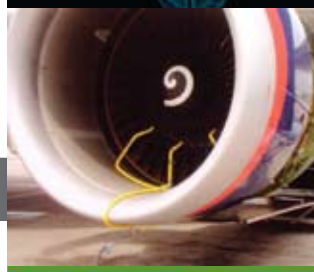


Figure 1 (Reference Computational study of high-speed liquid droplet impact K.K. Haller, Y. Ventikos, D. Poulikakosa and P. Monkewitz)

The GTE process uses a smart, simply designed and proven water delivery system to create a controlled distribution of water droplets.This size range of droplet can effectively enter the compressor inlet air stream without evaporating prior to wetting the compressor blade. The droplet mass and momentum are adequate to penetrate the pressure wave surrounding each compressor blade and wet the blade. The droplet distribution of this magnitude has an impact force that is benign to erosion. At the same time, the droplet impact produces a very significant lateral stress, or jet, to locally scrub the blade surface of fouling materials. Figure 1 describes the impact. Water droplet size is controlled by the combination of supply pressure and the specially designed nozzle.

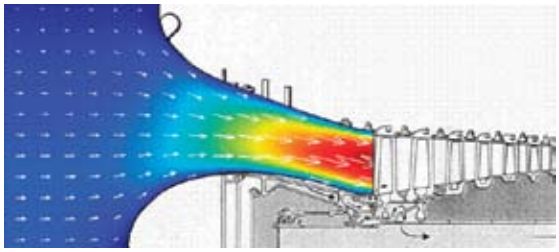
Proven Results

The procedure of the highly atomized water wash system has been optimized using mechanical principles to perform an effective wash without degrading the machine by erosion or over wetting.



Computational Fluid Dynamics

After the selection of a droplet distribution, the location of the injection nozzle within the gas turbine bellmouth is the next important design consideration.The point is selected by modeling the gas turbine air inlet, configuration and air flow rate, with Computational Fluid Dynamics. By varying the location of nozzle position, the optimal distribution of the atomized water wash to cover the throat of the compressor is identified. Both Off-Line (Crank Speed) and On-Line (Base Load) Speed are modeled in an effort to identify a single nozzle position to cover each case. This step minimizes parts, needed water volume thru the use of a smart - simple design.



RR	# Units
Avon	18
RB 211	25
RC 7B	6
	49
Solar	**# Units**
Centaur, Taurus	15
	15
Siemens	**# Units**
GT 10	183
GT 35	24
GTX 100	57
501F	9
v93	6
Cydone	196
Tornado	47
Typhoon	49
	571
GE	**# Units**
FR 5	23
FR 6B	32
FR 6FA	9
FR 7B/EA	7
FR 9E	9
LM 2500	76
LM 6000	1
	157
Total	**792**

Water Solubility and Volume

A final consideration in the optimization of water wash process is the solubility and the volume of the water. First, water with a low total dissolved solids count (typically less than 5ppm) is selected to allow the water to wet the blade and attach to fouled deposits. Second, heated water to 60C is applied to improve the solubility. Finally, the amount of water is set to a specific air to water ratio. This level of water has been shown by experience to be adequate for an effective wash. This water volume does not overly wet the machine and cause excess water throughout the machine.

Fleet Operating Hours	
Oil & Gas	3806732
Marine	500261
Power Gen	13012461
Total	**17319454**

*Consult a GTE technical advisor for estimates on your potential improvements and ROI

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