A Review on Renovation of Gas Turbine to Improve Efficiency by Using Compressor Water Wash

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Abstract

The ability to predict the behavior of a turbine engine and optimize its performance is important in economic, thermal and condition observation studies. Fouling is one of the major sources of compressor deterioration. So, the paper presents an analysis of the effectiveness of online and offline compressor washing using numerous purity grade waters and industrial washing detergents. From gas turbine axial compressor blades fouling dirt of blade surface was obtained at numerous field sites. To see the composition and consistency of typical blade surface fouling materials the dirt was analyzed. An exemplary dirt formula and blade coating procedure was formulated so comparative tests can be performed using numerous cleanup fluids. To see the capability or benefits of any liquid a spray nozzle upstream of the blade test section was used for cleaning blades with five totally different cleaning liquids. In different residue experiments the impact of high-purity water versus regular water on fouling dirt was conjointly studied. Results showed that an important means of cleaning compressor blade is spraying cleaning fluid into a flowing air stream. Every of the fluids were ready to clean the test blade at each low and high air velocities and at totally different blade incident angles. The Results showed that compressor blade washing is primarily a mechanical work and does not rely on the kind of fluid used for washing. The results also showed that almost all of the cleaning happens shortly when the cleaning fluid is introduced into the flow stream. As the cleaning fluid is evaporated, the dirt aloof from the blades might redeposit in different areas. To optimize the performance of turbine engines, it is therefore suggested that operators ought to perform a mix of mechanical device hand cleanup, offline and on-line cleaning at the same time.

Keywords: *Off-line nozzle system, On-line nozzle system, Degradation, Fouling, Dispersion Fields.*

1.0. Introduction

Gas Turbines (GTs) have wide range of commercial applications. Gas turbine engine was designed originally for aircraft. Due to its weight and small sizes, the GT has become an appreciated machine for other applications such as industrial and power generation [1]. Proper maintenance and operating practices can significantly affect the level of performance degradation and thus time between repairs or overhauls of a GT [2-6]. Gas turbine cleanup was created within, the period of time by crank soak washing and/or by injecting solid compounds equivalent to nutshells or rice husks at full speed with the unit on line. This methodology of on line washing by soft erosion has primarily been replaced by wet washing since the introduction of coated axial compressor blades for corroding corrosion protection. From the point of view of application, the GT's compressor is affected by the environmental conditions of the site [7-8]. With increasing operating time, degradation of the compressor manifest in the form of reduced performance [9]. The major cause of reduction in compressor efficiency and inlet air mass flow is fouling [9]. Moreover, un-burnt solid cleansing compounds and ashes can also cause blockage of subtle turbine engine blade cooling systems if ingress into the turbine air cooling stream. At the start of the introduction of compressor wet cleansing within the 1980's [10], time intervals between on line cleaning and also the combination with off line cleaning had to be established. Gas turbine performance degradation is inevitable like alternative machinery that operates incessantly in associate surroundings that's full of all sought-after of impurities. Operation of a GT at steady outputs will cause deposition from the combustion gas on the blades. Deposits cause output and potency to call in reducing the potency of energy transfer and eventually limiting the flow of the combustion gases.

However, with applicable air inlet filtration system and schedule compressor water wash turbine performance improvement might be achieved. Optimum performance of turbine would result into greater power output, reduced heat rate, improved engine life cycle and reduced maintenance value. This fouling considerably affects the gas compressor's mechanics performance and potency, thus, forcing the operator to often close up the unit for offline water-washing of the compressor. As an alternative, on line cleaning technologies are developed to wash the compressor throughout operation to reduce turbine shutdowns and optimize accessibility [11]. Performance analysis is applied to each rotating and stationary components of the GT. it's one condition monitoring technique that permits the optimum time for restorative maintenance to be calculated, wherever the deterioration may end in enhanced fuel consumption or in reduced output or each. The correct construction and operation of the components of GT plants are also necessary for proper understanding and monitoring [13]. To realize associate improved understanding of the effectiveness of on-line cleansing technologies, specifically the dirt removal and redeposit processes, variety of tests of fouled blades mounted in an exceedingly high-speed structure were performed.

2.0. Description

2.1. Model & design description

2.1.1. Turbine

STAGES: 3 SPEED: 3000 R.P.M.

Gas Turbine mainly divided in three sections:

· Compressor

· Combustion system

· Turbine

2.1.2. Compressor

Gas turbine compressors consume approximately 60% of the overall cycle energy during operation [14]. The axial flow compressor consists of compressor rotor and also the enclosures Casing. The compressor casing consists of inlet Guide Vanes, seventeen stages of rotor and stator balding, and a couple of exit guide vanes. In the compressor air is compressed in stages by series of alternate rotor and stator airfoil-shaped blades. The rotor blade provides the force required compressing the air in every stage and stator blade guides the air so it enters the subsequent rotor stage at correct angle. The compressed gas exits through the compressor discharge casing to the combustion chambers. Figure 1 and 2 [11] shows the compressor stages without and with coated rotor blades. Compressor degradation are caused by three major factors which include change in airfoil surface quality, increased tip clearance and changes in airfoil geometry [12].

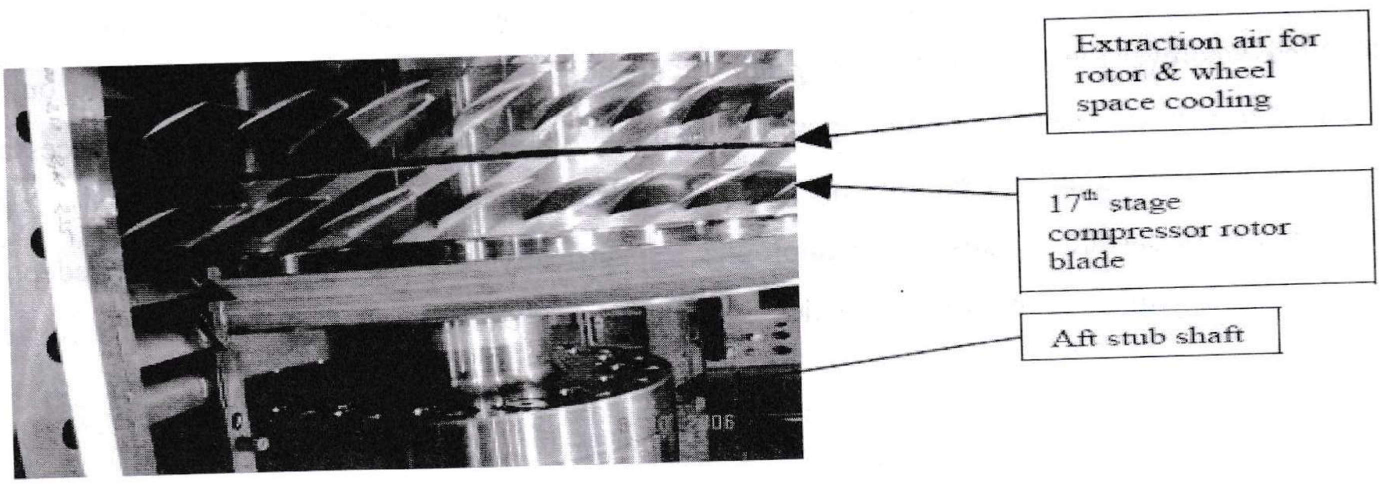

Fig.1:Compressor Stages[11]

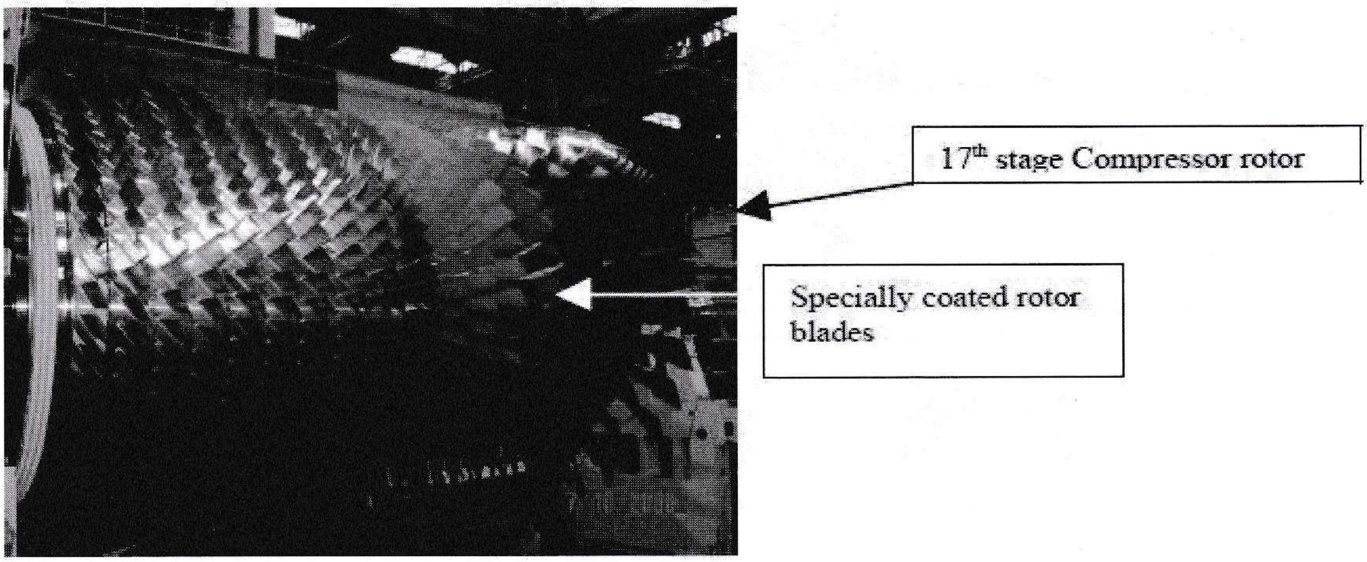

Fig.2: Compressor Stages (with coated rotor blades) [11]

2.2. Compressor cleaning process

2.2.1. Off-line nozzle system

Off-line cleaning with an appropriate cleaner will result in more intensive cleaning at crank speeds. Depending on the kind of fouling, the cleaning cycle can be repeated to improve the cleaning effect with the aim to achieve a further increase in output and efficiency. If practicable under the existing operating conditions, off-line cleaning should be performed once per month or on appropriate occasions (but at least 4 to 6 times per year) [6].

2.2.2. On-line nozzle system

This technique is generally done throughout GTs base-load operation with the IGVs within the totally open condition. The wash water resolution is delivered to the turbine unit at the correct pressure temperature and flow to clean the turbine.DM water is to be used for all washing. This water must have less than 5 PPM dissolved solids; less than 0.5 PPM sodium plus potassium, and have a P^H between 6.5 and 7.5. General turbine should be running at full speed and not in method of shutting down. The inlet guide vanes must be in the fully open position. Load must be reduced by 5% if operation at base loads. The on-line nozzle system includes nozzles that area unit mounted on the inner cone upstream of the spider that supports the compressor bearing within the casing. The hollow cone spray nozzles within the on-line nozzle system generate a water spray that covers the total device height. On-line nozzles area unit connected to a distribution ring line mounted within the inner cone. The process of water wash system is shown in fig 3 [14].

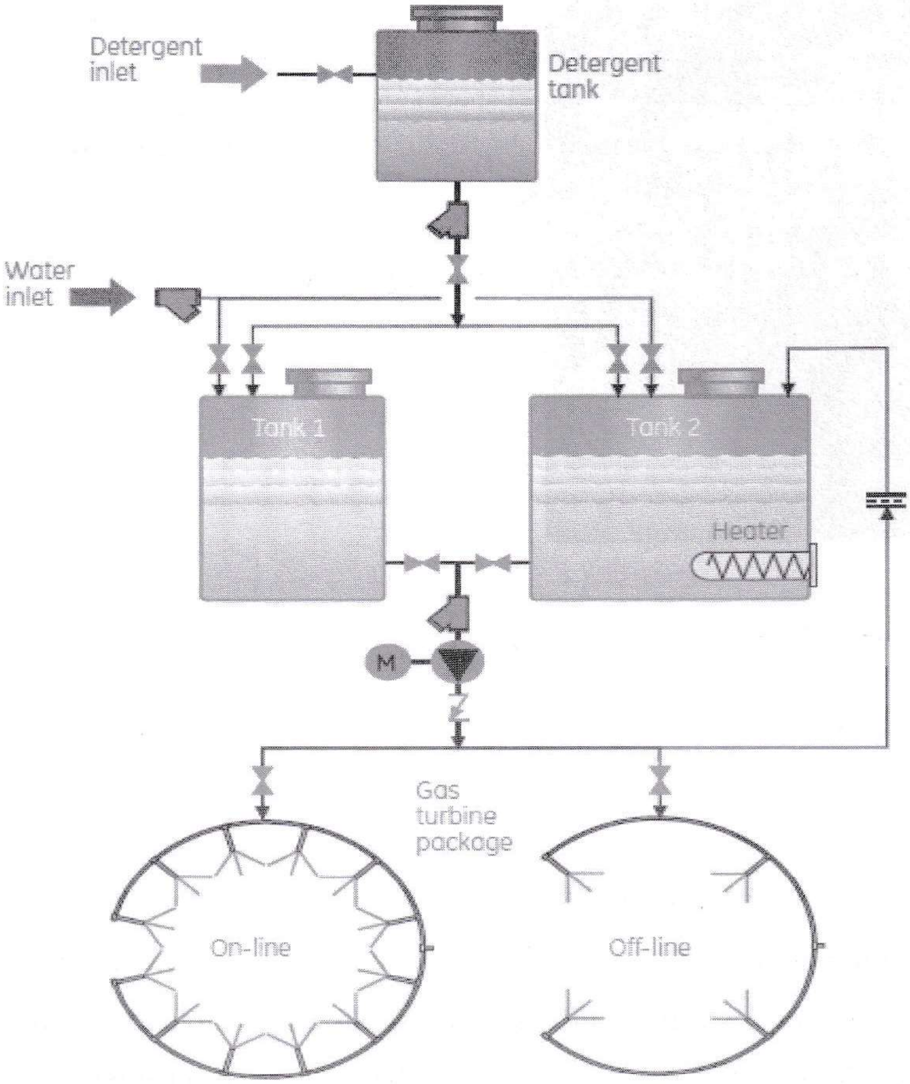

Fig.3 :Pictorial Representation of water wash system[14]

2.3. Performance

2.3.1. Wash skid

Presence of impurities in the ingested combustion air made the compressor blade to become fouled [15]. The water tank is loaded by a permanent supply connection. Filling the water tank with not mineralized water is performed automatically using a solenoid valve. Detergent is filled into the mixing tank. The detergent filling process is done by the means of an electrically driven drum. Pump is part of the wash skid hardware. The permanent not mineralized water connection allows for supplying the mixing tank with not mineralized water [6]. Optionally, transport containers for cleaning agent and antifreeze can be mounted above the not mineralized water and mixing tank.

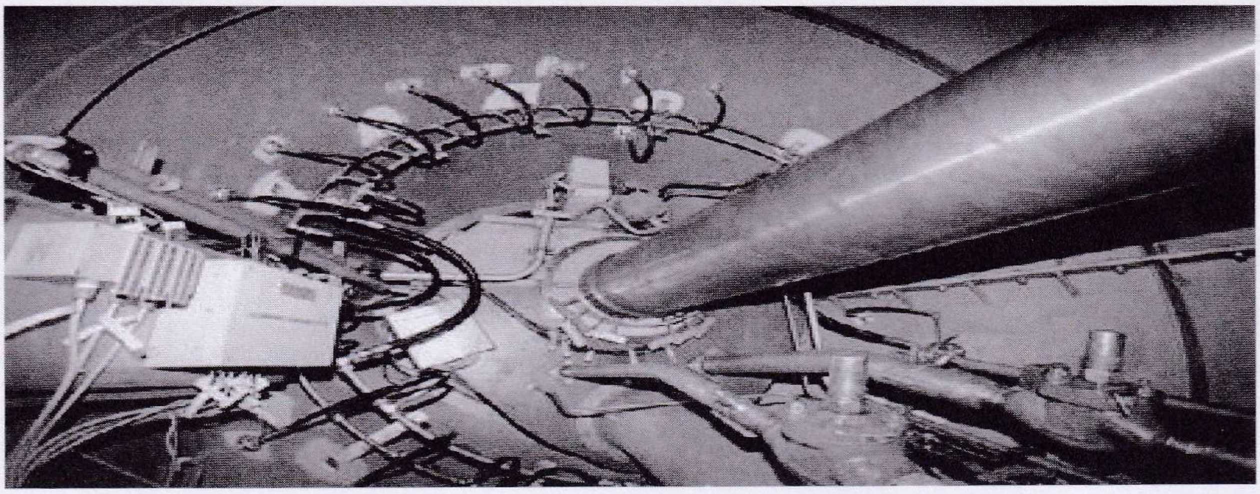

Fig.4: Water Wash Line [14]

A centrifugal pump is provided on the one hand to prepare a homogeneous mixture of not mineralized water and cleaning agent and antifreeze rinsing fluid in the mixing tank, by using a solenoid valve and to prepare a homogeneous mixture of not mineralized water and antifreeze Rinsing fluid in the water tank via another solenoid valve. On the other hand, this pump forwards the cleaning fluid through the solenoid valves at the skid output connections and then to the both nozzle systems. Figure 4 [14] shows the water wash line and figure 5 [15] shows the water flow trough the blades.

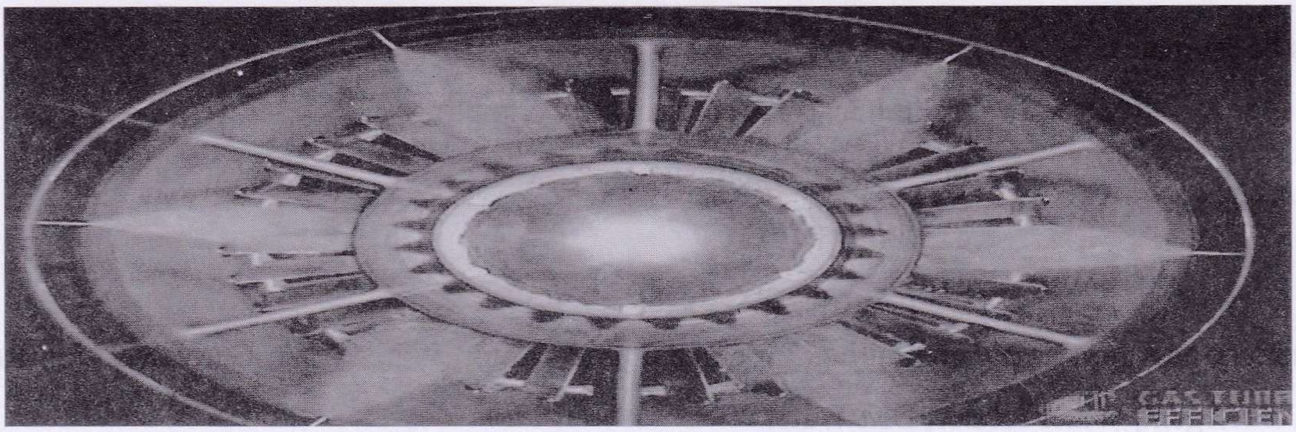

Fig.5 : Water Flow through the Blades [15]

2.3.2. Performance of Compressor Cleaning:

The consequence of dirty compressor blades includes rougher surfaces, higher turbulence levels, deteriorating flow patterns, reduced cross section of flow, higher compressor outlet temperatures and lower compressor outlet pressures, thus lower compressor efficiency. A frequent compressor cleaning has two positive effects on the compressor.

Optimization Parameters

- Water Temperature
- Water Pressure
- Water Droplet Size
- Water Volume
- Nozzle Placement and Dispersion Fields.

2.4. Field of application

2.4.1. Estimating and costing

This subject covers the assorted aspects of estimating of quantities of things of works concerned in washing, water and sanitary works, moving works and irrigation works. This additionally covers the speed analysis, valuation of properties and preparation of reports for estimation of varied things. At the tip of this course the client shall be able to estimate the material quantities, prepare a bill of quantities, build specifications and prepare tender documents. Client should also be able to prepare worth estimates.

Types of estimates:

-Preliminary or Approximate Computing
- Special repair estimate
- Revised estimate
- Supplementary estimate

Preliminary or Approximate computing: Pipe line, Pump, Motor, Water Tank, Get valve, Non-Return valve, Detergent, Water Heater, DM Water

Table.1: Preliminary or Approximated Estimation & Costing of Different Accessories

Name	**Specification**	**Cost**
Pipe line	3"×200' SS	260/ft
Name	Description	Cost
Pump	Tusaco pump, 50Hz 3 phase	2,50,000/-

Water Tank	2000 liters	3,50000/-
Get valve	4"	10,000/-
Non-Return valve	7m3/hr	16,000
Detergent Tank	210×4=840 liters	6,00000/-
Water Heater	34 KW ,4pcs	60,000/-
DM Water	2000 liters	4,00000/-

2.4.2. Customer Benefits

The Advanced compressor cleanup System upgrade (ACCS pro) will be an economical suggests that to assist you to enhance the performance of turbine plant. Figure 6 [16] shows the operational experience of optimizes washing system. There showed a comparison of gas turbine output deterioration without on-line washing system and installation of new gas turbine system. Benefits may include:

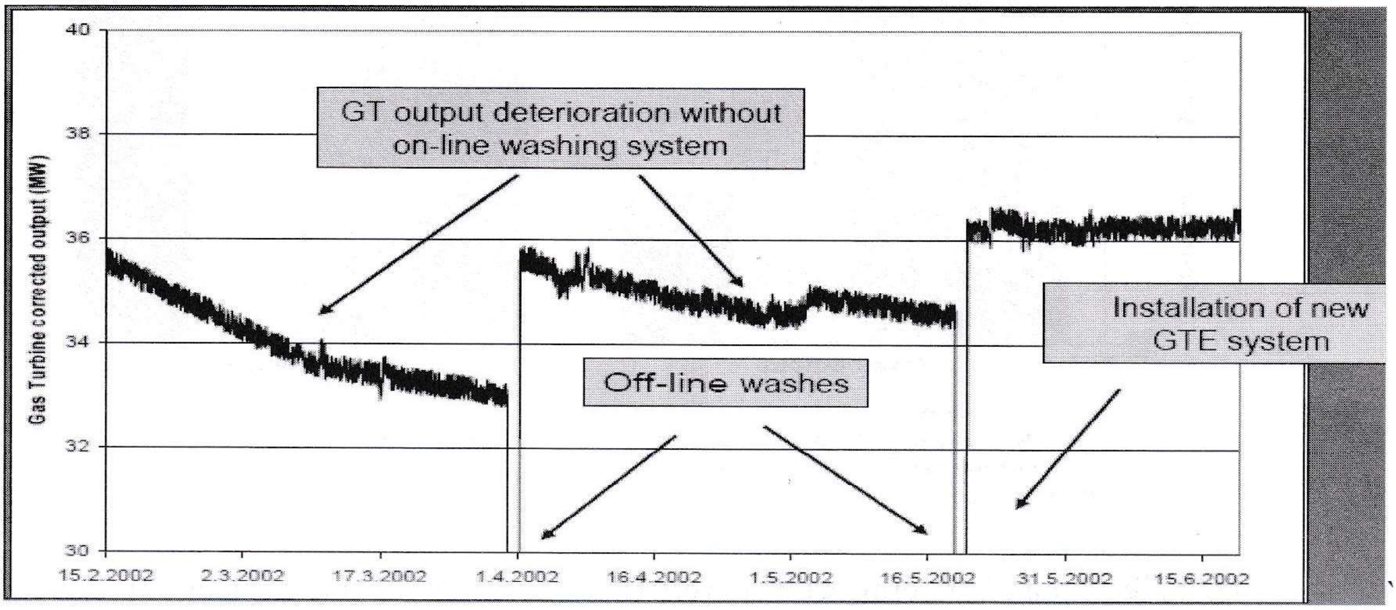

Fig.6: Operational Experience of Optimizes Washing System [16]

i. Avoidance of power loss up to 4% of maximum performance.

ii. Avoidance efficiency loss due to reduced compressor fouling.

iii. Fuel saving through keeping the specific heat rate.

iv. Increased availability and reliability of your gas turbine to deliver maximum power at base load.

v. Less water and detergent consumption during on-line wash due to optimized nozzle numbers and design compared to the traditional Siemens system (approx. 30% less water and approx. 25% less detergents).

vi. Uncomplicated use of cleaning agents and antifreeze rinsing fluids (all Siemens released cleaning agents and antifreeze rinsing fluids can be used for the ACCS pro system without any restrictions).

vii. Automatic skid with interconnection to instrumentation and control system for information and signal exchange including operator's visualization and on-line wash control (optional).

Optional Compressor Wash Prediction (COWAP) analyzer module allows visualization and prediction of performance losses and performance recovery, thereby determining the optimal timing for an off-line wash. Figure 7 [7] shows the power output and efficiency which predicts the performance recovery by compressor off-line cleaning.

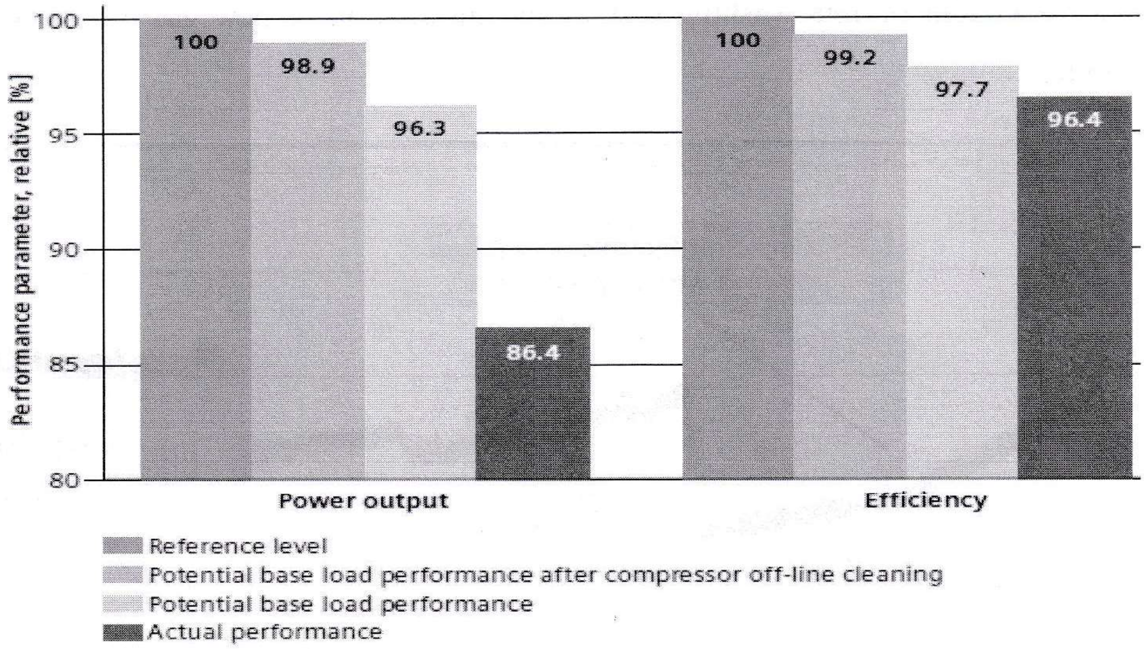

Fig.7: Prediction of Performance Recovery by Compressor Off-line cleaning [7]

3.0. Conclusion

This paper shows a comprehensive overview of controlling axial compressor fouling and washing of gas turbine. It also presents the causes and effects of compressor fouling. Regular cleaning of compressor has become certain so as for the company for maximizing its economic gains, optimizing its instrument utilization and credibility. The installation of top-quality filtration system solely reduces the amount of dirt into turbine however important amount penetrates through the filter overtime and cling to the axial blade in accordance with fouling mechanism, as mentioned during this work. Though, industrial improvement incorporated in filtration system like filter self-cleaning system solely elongate filter life usage however large dirt accumulates on the filters that shows the amount of particulate that are present within the mass flow of air consumes by the engine and inside the turbine water volute. Combination of offline and online washing usually gives the best results in helping operators to cope with the operating problem. Plant productivity and profitability can be improved by careful monitoring of compressor performance.

Nomenclature

GT	: Gas Turbine
COWAP	: Compressor Wash Prediction
TDM	: Thermodynamic Diagnostic
CC	: Combined Cycle
HP	: Horse Power
KW	: Kilo Watt
SS	: Stainless Steel
AISI	: American Iron & Steel Institute
TW	: Thermo-well
WW	: Water Wash
DM	: De-mineralized
PPM	: Permutation Parity Machine
PH	: Potential of Hydrogen
LPM	: Liters Per Minute
h	: Specific Enthalpy, $kJ \cdot kg^{-1}\ k^{-1}$
p	: Pressure, kPa
T	: Température, K
t	: Celsius Température, °C
V	: Volume, m^3

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