PROTECTIVE COATINGS FOR GAS TURBINE BLADES

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PROTECTIVE COATINGS FOR GAS TURBINE BLADES

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INTRODUCTION

INTRODUCTION

i- Electric Power Generation in Egypt.

With the increase of population in Egypt there is an equivalent increasing demand for electric power generation. The installed capacity was increased from 511 MW in 1958 to 11281 MW by 1990. In the last two decades it was recognized that the principal expansion for electricity generation should be towards gas turbines.

The Egyptian electricity authority had, since 1976, been installing gas turbine units of around 20 MW. These were associated mainly with large power stations where they have two functions : The basic one was to assist with generation at times of peak demands and particularly with sharp increases of demand when the rapid start-up characteristics of gas turbine are a unique advantage. The other was to provide emergency stand by power for use in the event of routine overhaul of the main units of a major plant. By 1980 the gas turbine began to assume greater importance for future programmes and the plan was to install major groups of gas turbine generators with total output on one site of 100 to 300 MW. These were built close to the areas of maximum load and would give a very convenient balance in the whole network of generation.

At present gas turbine fulfills an important role in the networks. The installed capacity (1) of gas turbine compared to other sources is shown by the following table

Generation	Installed capacity	%
Thermal, stream	6043	53.6
Thermal, G.T.	2523	22.4
Hydro	2715	24
Total	11281.5	100

On the other hand, gas turbine units of much increased power output were installed. Whereas machines providing 15-20 MW of electrical output had been the rule, it is becoming usual to install units of 110 and even 125 MW. The evolution of installed capacity for gas turbine power plants is shown in the following Table (1) :-

Power station	No. of units	Installed capacity (M.W.)	Commissioning time
Suez (gas)	1 X 17	17	1976
Ismailia (gas)	1 X 20	20	1977
Cairo East (gas)	2 X 23	46	1979
El Tebbin (gas)	2 X 23	46	1979
Talkha (gas)	8 X 24.2	193.5	1979
Heliopolis (gas)	3 X 12.5	37.5	1980
Helwan (gas)	5 X 24.2	121	1980
Karmous (gas)	2 X 12.5	25	1980
Suif (gas)	1 X 20 + 6 X 33.3	220	1981
Mahmoudia (gas)	4 X 45 + 8 X 24.2	376	1981
Shabab (gas)	3 X 33.3	100	1982
Port Said (gas)	1 X 21 + 1 X 23	44	1984
Wadi Hof (gas)	3 X 33.3	100	1985
Damanhour (gas)	2 X 24.2	97	1985
Cairo South (gas)	3 X 110	330	1989
Demeitta (gas)	6 X 125	750	1989

The main manufacturers of the above mentioned units are :

General Electric, U.S.A

Brown Bovari, Germany

Westing house, U.S.A

Ralls Royce U.K.

The gas turbine machines have excellent characteristics which make them very useful. Some of the many advantages of these machines can be quoted as follows :-

- low installation costs,
- Short erection time : 6-12 months compared to 4-5 years for steam generators,
- Fast start-up : 5-10 min.,
- Availability : Particularly easy to site,
- Ability to burn large variety of fuels : ranges from clean one as natural gas to residual or even crude oils,
- Availability of large amounts of exhaust heat,
- Easy to add to other units,
- No cooling water requirements.

Some uneasy characteristics, can-not be denied such as:

- Running costs using distillate fuel is about double that for an oil-fired steam power plant.
- The severe operating conditions in the machine require the use of sophisticated materials to withstand the high temperature high stress factors.

ii- The Need for Material Protection.

Whilst manufactures continued to build up larger units the material of construction has moved towards the more advanced high strength nickel and cobalt based superalloys.

Corrosion do not generally cause premature failure or unprogrammed replacement, however, there were serious outbreaks of blade corrosion which occurred in several sites (2,3). There is also a possible interest in a gas turbine which would accept a less pure fuel such as a more or less untreated crude or a light residual oil which would contain significant amounts of inorganic materials including sodium salts, metal oxides and vanadium compounds.

The research which was undertaken to explain corrosion failures draw attention for the need of protection of the expensive blade material by metallic coatings.

Because of the non-uniform temperature profiles typically found on the rotating airfoils, the coating surface must be capable to withstand oxidation and hot corrosion attack over a wide range of temperature for the types of fuel oils and contaminants contemplated.

Various classes of metallic coatings were considered for blade protection. These are flame sprayed, pack cementation, slurry (fusion), and modified chemical vapour deposition (CVD).

iii- Aim of the work

The objectives of this thesis are :-

- Review and study of the different factors affecting the high temperature corrosion of the superalloy blade materials in gas turbine. This is considered with regard to the interest of E.E.A. to operate gas turbine machines with less pure fuel containing significant amounts of polluting elements. The operation of gas turbine units in urban areas or near sea costs with airborne contaminants is also considered.

- To promote basic research work on the different techniques of coatings build-up on gas turbine blade material. Emphasis is directed to aluminide diffusion coatings. The mechanisms of formation of the coatings are treated in details.,
- To investigate the relationship between the microstructure and exposure to high temperature.,
- Selection of the best coating scheme which can secure the maximum efficiency of operation, maintenance and replacement.
- To evaluate the performance of the selected coating scheme for protection against thermal effects and corrosion in the gas turbine atmospheres. The evaluation is based on laboratory tests as well as operation in a test rig simulating the dynamic environment of a high pressure liquid-fueled combustion effluents.