Jandar Power Plant
GT4 Overhaul

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Sunday, December 17, 2017

Introduction

The conflict in Syria is currently into its seventh year and has taken a huge toll on the infrastructure of the country. The power sector has been one of the hardest hit by the war. Reports indicate that the total power produced in the year 2011 was about 50 billion kWh, while the volume of production in 2014 fell to 22 billion kWh. Thus there was a measurable decrease in electrical production by 56% due to the unrest.

The generation of power plants has suffered greatly from the lack of spare parts needed either for essential routine maintenance or for emergency repairs on the units due to sanction imposed on Syria. In addition to the lack of fuel and gas, this has contributed to a huge power shortage in Syria, thus creating an urgent humanitarian need for the international community to step in and help with importing essential spare parts to keep the plants running.

Within the scope of this project, the United Nation Development Programme (UNDP) has supplied spare parts to perform an overdue rehabilitation of gas turbine GT4 of the Jandar power plant under close supervision of C.M.C power experts and in collaboration with Jandar power plant management.

Jandar Power Plant and GT4 Background

Jandar is situated 30 km south of the Syrian city of Homs. The original plant was constructed by Mitsubishi Heavy Industry (MHI) of Japan in 1995 and an extension was constructed in 2010 by Mapna Group of Iran. The existing plant consists of three blocks:

Block 1 by MHI consists of GT1 + GT2 + ST1 – total output (ISO conditions): 350 MW
Block 2 by MHI consists of GT3 + GT4 + ST2 – total output (ISO conditions): 350 MW
Block 3 by Mapna consists of GT5 + GT6 + ST3 – total output (ISO conditions): 480 MW

MHI gas turbine type: MW-701D
Serial number: 352-353-354-355
Output/capacity of GT4 (ISO conditions): 125 MW

Since the plant was built in 1994, GT4 underwent three major overhauls. The first major overhaul took place in 2001 under the direct supervision of MHI experts. The second one took place in 2007 under the supervision of Italian experts from Turbo Care. The third overhaul took place in 2012 by Jandar local engineers and technical staff. Routine inspections of the turbine and combustor engine were done alternatingly by the technical staff. Inspection of the generator was also completed at routine intervals.

Routine maintenance does not always take place on time due to high demand of the network and power shortage in Syria. On average, maintenance occurs about 4000 hours beyond the manufacturer recommendation.

Rehabilitation Maintenance Procedure

The overhaul and rehabilitation of GT4 started on September 29, 2017 and was completed on November 2. GT4 was placed back into operation to feed the Syrian network on November 16. The sequence of procedures took place in the following order:

Phase 1 – Disassembly of GT4

Removed insulation from the turbine, dismantled the air ducts and flame tubes, then released locks, opened manholes and lifted ceiling of the turbine.

Removed screws and bolts from the turbine casing, airway ducts, and compressor casing.

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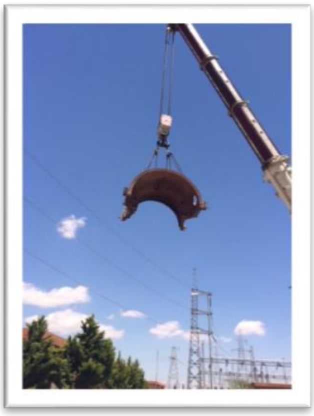
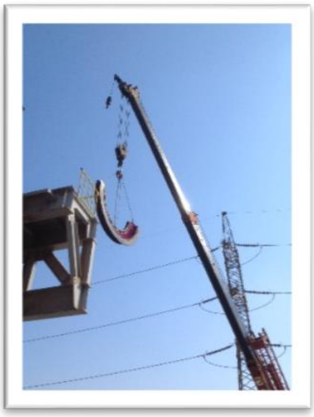
Removed flame detectors, flame igniters and18 combustor baskets and transition pieces.

Cleared and dismantled the beds, air ducts and oil circuit pipes.

Lifted casings of the turbine, compressor and exhaust then dismantled the acceleration mechanism.



Cleared the way for removal of all stages then disassembled the upper stationary blades starting with the first stage of the turbine till the fourth, and 19 stages of the compressor.



Removed the torque tube cover and air ducts inside the combustion chamber, then lifted the turbine axis from its bed and placed it on the fixed base.

Phase 2 –Cleaning, Testing and Rehabilitation

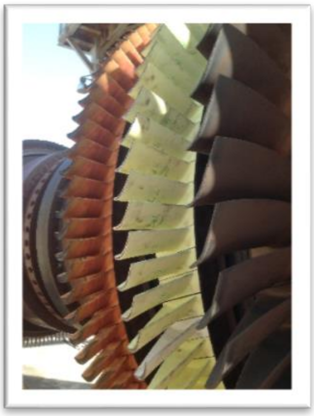
After GT4 was dismantled, the rotor, blades and all peripherals were carefully cleaned and soldered in preparation for the maintenance process.

A full inspection of all the dismantled parts took place. The types of tests implemented on the stationary blades and rotating blades were non-invasive and included paint tests (PT) and ultrasonic tests (UT). The inspection and tests conducted revealed some cracks, defects and decomposition of blades and other parts.

Parts that were diagnosed as being damaged beyond repair were replaced with new parts provided by UNDP. Most of the damaged parts that were replaced had undergone 80,000 hours of operation which exceeded the manufacturer recommendation by 5000 hours. The major parts donated by UNDP used in the rehabilitation were the following:

- Stationary blades for stage 3 of the turbine

- Rotating blades for stage 2 of the turbine axis rotor



- Hot gas paths

- Stationary blades for stage 12 of the compressor

The new stationary blades for stage 12 of the compressor are a different design from the old one, and not a perfect fit. So the manufacturer proposed a modification on the upper casing of the compressor to accommodate the new blades. A special tool, the compressor diaphragm drill, was donated by UNDP to rectify this discrepancy so the new blades could be installed.

Phase 3 – Reassembly of GT4

After all the parts had been inspected and repaired, reassembly of GT4 took place in the following order of parts being assembled:

Stationary stages, the rotor, beds, acceleration mechanism, rotor casing, exhaust casing, compressor cover, hot gas paths, combustion chambers, locks, flame detectors, lighters, air and oil pipes, air ducts, man holes, and turbine ceiling and insulation.

There was a short delay of five days during the reassembly process which occurred when the crane broke down and another crane was requested and arrived at the site a few days later.

UNDP Parts Installed on GT4

The following is a comprehensive list of spare parts that were installed on GT4. The additional parts were very carefully and thankfully put into on-site storage to be used in case of a future emergency to ensure minimal disruption to the operation of the power plant.

UNDP No	Part Name	رقم المادة	اسم المادة	Qty
13+46	Compressor diaphragm row 12	844	شفرة ثابتة للضاغط مرحلة 12	2
20+31	Combustor basket (flame)	146	حراق كاشف لهب	8
21+32	Combustor basket (igniter)	147	حراق قادح مشعل	8
23	Combustor basket (standard)	602	براغي للحراقات	72
54	Transition cylinder	741	اسطوانة ممر الغازات	54
55	Nozzle ass y	139	فالة الحراقات	72
56	Row 1 ring segment ass y	822	حلقة إحكام شفرات الصف الأول مع الصفيحة	180
57	Hex socket head nut	889	برغي (عزقة) مسدسة خاصة	10
58	Hex nut	2164	¼ w2عزقة مسدسة	40
59	Box nut	2258	¾ w2عزقة خارجية	40
60	Bolt taper m 22	989	برغي بدون عزقات	10
61	Hex socket head cap	602	برغي للحراقات	288
62	Bolt & washer (weld) M12	737	برغي مع رنديلة ملحومة M12 للحراقات	288
63	Washer- Special	638	رنديلة خاصة للحراقات	288
64	Self-Lock Nut	639	عزقة تثبيت للحراقات	576
65+66	Straight pin	825	مسمار امان	288
67	Screw Socket Head M16	604	برغي قطعة مم الغازات	144

68	Screw taper	874	برغي مسدس خاص	16
69	Nut W1 1/2	1183	عزقة خارجية خاصة لمقطع غطاء العنفة	16
70	Hex. Nut M20	936	عزقة خاصة لغطاء العادم M20	100
71	Double Nut Dowel Bolt	1185	برغي كيجون خاص	32
72	Hex Nut	1053	عزقة خاصة لغطاء العادم M18	64
73	Hex Socket Head Cap Screw M16	1055	برغي مسدس خاص لغطاء العادم	16
74	Dowel Stud Bolt 76-399	2257	برغي تثبيت خاص	4
75	Extension Nut W2	2258	3/4 عزقة خاصةW 2	4
76	Dowel Stud Bolt 70 #384	2260	برغي تثبيت خاص	4
77	Extension Nut W2 1/2 #130	2203	1/2 عزقة فنجانW2	20
78	Stud Bolt W2 3/4 #348	2263	برغي تثبيت3/4 W2	16
79	Extension Nut 3/4 #137	2258	عزقة خارجية3/4 W2	16
80	Stud Bolt W2 1/2 # 336	2264	برغي تثبيت1/2 W2	20
81	Microseparator type Msr 200 San – sindustry Co. Ltd	3106	مغناطيس خاص لخزان زيت التحكم للغازية	8
107	Slot Large Head Screw	3107	برغي ذو راس كبير	20
Special Tools for Installation of Fixed Blades of the Compressor				
108	Magnet Drilling Machine	1283	مثقب مغناطيسي	1
108	Bush	1284	دافع	10
108	Drill (17.5)	1285	ريشة ثقب 17.5	10
108	Tap (#2-M20)	1286	دكر قلوظة M20	4
108	Bit Chucks Tool	1287	أداة فتح ثقوب	1
108	Bit	1288	لقمة لأداة فتح الثقوب	25
108	Jig	1289	قطعة مثقبة للعيار	1
108	Drift	1290	أداة لتوسيع الثقوب	1
108	Positioning jig	1291	معايير للسطح	1

Key Performance Indicators of GT4

The efficiency of GT4 has increased measurably after the maintenance and rehabilitation. The orders for operation are received directly from the central dispatching center in Damascus. Additionally, the maintenance ensured a better availability factor to be able to dispatch as the power network requires.

The following two tables are a summary of the main operation figures of GT4 running as simple cycle before and after the overhaul. Items 1 and 2 are cumulative numbers over the indicated period. Items 3, 4 and 5 (highlighted in yellow) are the “average” indicators which show a clear improvement in consuming less gas while operating at a higher efficiency in both simple cycle and combined cycle.

Table 1: Calculated over a period of 6 days before the overhaul:

Item	Description	Unit	Figures
1	Total produced quantity	MWh	8507
2	Net produced quantity	MWh	8455
3	Gas consumed per KWh	m^3	30657.0
4	Average efficiency (simple cycle)	%	30.33
5	Average efficiency (combined cycle)	%	41.36

Table 2: Calculated over a period of 6 days in November immediately after the overhaul:

Item	Description	Unit	Figures
1	Total produced quantity	MWh	9018
2	Net produced quantity	MWh	8964
3	Gas consumed per KWh	m^3	30502
4	Average efficiency (simple cycle)	%	30.59
5	Average efficiency (combined cycle)	%	41.50

However, efficiency isn't the only factor which contributes to the improvement in performance of GT4. The maintenance and replacement of cracked parts allows the turbine to be run at a higher load capacity and produce a higher output than before without fear of vibration. The higher output contributes to higher efficiency as is the case for all engines including cars.

Another point to highlight, the maximum output before maintenance was capped at 105 MW due to limitations in the machine response capability, whereas the table shows GT4 currently able to reach 111 MW output running as simple cycle and could potentially go higher.

Situation of Jandar Power Plant

The following table shows the situation of Jandar Power Plant since its installation in 1996 and to date:

Year	Capacity	Production ratio from the capacity	Efficiency	Comments
1996 (year of installation)	703 MW	57 %	47 %	
2014	628 MW	72 %	40 %	Due to the damage of some spare parts
June 2015	538 MW	88 %	36 %	Because some fans get out of service
After receiving a part from the top urgent list on July 2015(funded by JICA)	600 MW	90 %	41 %	Some fans are stable now and are in service again
After receiving the remaining spare parts in	628 MW	95 % (expected value)	43 %	The capacity will improve around 4 %

November 2015 from the top urgent list (funded by JICA)				
After receiving list A1,A2 from MHPS at the end of 2015 and March 2016 (funded by JICA)	628 MW	95 % (expected value)	43 %	In case of not receiving the mentioned spare parts, one of the gas turbine will shut down causing a reduction of 130 MW
After receiving list B1,B2,B3 from MHPS at September 2016 (funded by JSB)	628 MW	95 % (expected value)	43 %	In case of not receiving the mentioned spare parts the second gas turbine will shut down causing a reduction of additional 130 MW
Actual situation up to date	490 MW	95%	40%	GT1 is currently out of service awaiting new generator rotor

The following table shows how the maintenance at hand improved the total output of the power plant and how the contribution of GT4 increased:

	Total Output of Jandar Power Plant	**Nominal Output of GT4**	**GT4 Percentage of Total Output**
Before GT4 Maintenance	487 MW	105 MW	21.56 %
After GT4 Maintenance	490 MW	111 MW	22.65 %

Our recommendation to improve the capacity and efficiency of Jandar Power Plant is to change the rotor of the low pressure steam turbine in Block 1. The output of the steam turbine will then increase more than 15 MW. The same is true for Block 2.

Conclusion

The work completed on GT4 was a huge success thanks to the generosity and support of UNDP. Jandar Power Plant staff and management displayed a high level of competence and professionalism and an admirable level of cooperation with the UNDP consultant.

The spare parts supplied by UNDP were very much needed and appreciated by the operations team and management of Jandar. The maintenance contributed to a measurable increase in efficiency and performance of the turbine. The maintenance revealed many cracks and defects in the blades and were replaced in due time. Had these cracks been ignored, the machine could have tumbled into catastrophic failure and would have required much more down time or complete shutdown. A country in crisis cannot afford the time or cost of such a catastrophe.

This maintenance is assurance the plant will continue to provide the national grid with thousands of uninterrupted MWh and assist in reaching a solution to the power crisis in Syria.