TURBO-GENERATOR AT KUDANKULAM, INDIA– OVERHAULED BEFORE GRID CONNECTION?

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Synopsis

The first VVER-1000 reactor at the Kudankulam Nuclear Power Project in India under commissioning tests has been lying idle since 26 September 2014 due to problems of turbo-generator. Two years before its grid connection, the turbine was overhauled by a private contractor and this fact was kept as a guarded secret. Usually the first overhaul of a new turbine is done after completion of 5 to 10 years of work. In spite of the overhaul, KKNPP turbine failed within hours of grid connection and was responsible for five trips, which kept the reactor off-grid for 59 days. The turbine-generator could not be revived even after a two-month long maintenance during August- September. The extreme damage of the turbine is indicative of the failure of instrumentation which should have detected the defects on day one. Such failures in other systems have the potential for catastrophic accidents, unprecendented in the history of the nation. The Government of India has so far failed miserably to notice and to investigate the grave violations reported earlier. Or is it that there no government at all in our country? The situation warrants the urgent attention of the Prime Minister.

DAMAGED TURBO-GENERATOR AT KUDANKULAM NPP, INDIA– OVERHAULED BEFORE GRID CONNECTION?

Introduction

The VVER-1000 (MW) reactor at Kudankulam in India (8°10′08″N 77°42′45″E) now under commissioning tests was connected to the Southern Regional Grid on 22 Oct 2013, 4253 days after the first pour of concrete. This is a Generation-III reactor designed by OKB Gidropress, a subsidiary of the Russian state atomic energy corporation Rosatom. The date of commercial commissioning planned initially for 22 April 2014 has been postponed three times to 22 Jul 2014, 22 Oct 2014 and recently to 22 Jan 2015. The delay is due to defects of turbine-generator and according to media reports, the root cause is domestic object damage (DOD) in the Low Pressure (LP) sector. In the petition to the Central Electricity Regulatory Commission (CERC) for the last postponement, the operator, the Nuclear Power Corporation of India Limited (NPCIL) submitted that "while raising power, an increase in turbine thrust bearing temperature was observed and the temperature touched the operational limit on reaching power level of 850 MW. For attending this technical problem, turbine-generator was taken off the bar and reactor was shut down on 26 September 2014. (The) first and 2nd stage turbine blades and diaphragm have been damaged which are being replaced by taking from Unit-II. The replacement of blades and diaphragm would take about from 7 to 8 weeks time".[1] NPCIL also stated that as on 27 Oct 2014, "turbine high pressure casing" was "being dismantled to carry out inspection and to identify the problem along with specialists of the turbine manufacturer from Russian Federation and the rectification ... *may take* two more months".[1] As the problem has not been identified, there is no certainty that the reactor will be operational in the near future.

Brief History of Performance since grid connection.

During its 365 days of 'marriage' with the grid, the reactor operated only for 182 days. There were 14 unplanned, automatic shut-downs known as trips, a major accident in the feed-water system and two maintenance outages. The trips and maintenances kept the reactor off the grid for 175 days. The accident[2] and the performance of the reactor since grid connection[3] have been analyzed and reported earlier. Nine out of 14 trips were due to problems of the reactor and the feed-water system. The turbine-generator (T-G) was involved in 5 trips which kept the reactor idle for 59 days. Trips and maintenances related to the T-G kept the reactor idle for a total of 123 days.

The T-G is a key component with about two years of manufacturing lead time, weighs 1700 tons and costs about Rs 1000 crores. Its non-performance is causing a production daily loss of 24 million units of electricity and a financial loss of Rs 10 crores, besides the interest on the capital investment. In spite of these, the authorities concerned have not explained the causes of TG complications. After blocking more than Rs 15,000 crores as dead investment, the NPCIL clarifies that the problem will be solved by cannibalisation of the second reactor, as if the second reactor is a reserve of spares and equipment for the first one.

Overhaul before the grid connection?

A Hyderabad based private contractor specialising in maintenance and repairs of TG and other machines claims to have overhauled the T-G set well before its grid connection. The website of the company, Powermech Projects claims that they had "executed overhauling of 1000 MW Nuclear Turbine, at KKNPP. The works included disassembly, paint removal of internal components and assembly of the turbine set consisting of one HP Cylinder, three LP cylinders and 5 bearing pedestals in KKNPP Unit # 1".[4]

There is no mention about this major event in the milestone of KKNPP anywhere in the NPCIL documentations. The time of the overhaul is not precisely known, but it appears that it was done in 2011, when the defects in the equipment were reported by a section of the media. In a strongly worded response to this, the NPCIL praised her Russian partner saying that they "have, *in fact*, supplied an upgraded rotor in place of earlier version and they actually test their turbines in a test-bed to check whether it functions as per specifications before they are shipped out. Around 120,000 tonnes of power plant equipment have landed in Kudankulam, and during transit some got damaged. The Russians have replaced the damaged items free of cost. It is normal for technical personnel from the equipment suppliers to come to the project site and there is nothing unusual about it".[5]

Turbine History

According to the Russian website nuclear.ru, "on February 27, 2004 Silovye Mashiny Concern steam-tested 1000-MW turbine manufactured for the Indian Kudankulam nuclear power plant under construction. This is the first of two turbines Silovye Mashiny (now OJSC Power Machine) is to manufacture for the Indian plant as part of US$ 200 million-contract for supply of equipment".[6] Erection of the Turbine-Generator was completed during September 2008.[7]

There are altogether 10 turbine plants of this genre in Russia, China, Ukraine and Iran with a total operating experience of more than 100 years. The average availability factor is claimed to be 99.6%. The vendor, OJSC Power Machines, with "unique technical and technological experience in designing and manufacturing power plant equipment for Tianwan NPP, Kudankulam NPP, Bushehr NPP, confirms its readiness to take part in the projects of new NPP unit construction in the countries of

South-East Asia. The equipment (K-1000- 60/3000-2 HPC + 3 x LPC) has the following passive and active measures to protect these parts against erosion”[8]:

- turbine HPC, carriers and *diaphragms* are made of stainless steel that allowed to solve totally the problem of crevice erosion which requires considerable expenses for repair work in operation;
- *HPC blade shrouds* are made with inclined inner surface stabilizing the flow of pellicular moisture and its further removal with extracted steam.

The turbine blades and diaphragm are the components that have been damaged, according to NPCIL!

Such a wonderful, world-class, test-bed-checked machine with an upgraded rotor and improved diaphragms and blades, had to be overhauled even before generating a single unit of electricity. Even after the overhaul, the machine worked on and off for just 4700 hours, tripped five times and was forced on a maintenance outage lasting 59 days. Neither the overhaul, nor the long duration maintenance helped.

Vibration Monitoring Instruments for a fraud company

Prof V Prakash says monitoring of vibration is very important for safe operation of all kinds of turbines. While working, a turbine is in perpetual motion which produces vibration, which are monitored continuously by a series of measuring devices. Such monotoring has been useful to identify the onset of many problems and prevent damages. There will be multiple monitoring equipment, all of which will work in tandem to ensure that there is no loss of information. This method of using multiple number of equipment for the same measurement is called ‘redundancy’. In May 2012, Alexander Murach, head of Informtekh was convicted and sentenced to three years in prison with an 18-month probation period for fraud and for selling counterfeit measuring equipment meant to measure the vibration of nuclear and hydro power turbines, without the necessary license necessary. The company gave fake certificates claiming that the equipment had passed the mandatory tests. In a reply To a Right to Information (RTI) querry, NPCIL replied that it received “communication equipment” from Informtekh, Russia.[9] Prakash underlines that turbine defect did not develop in one day and had the monitoring equipment been genuine, the defect could have been identified at the beginning itself.[10]

Outsourcing and counterfeit

Outsourcing is thought to be a major reason for counterfeit equipment in the nuclear supply chain. Atomstroyexport, the Russian supplier of Kudankulam plant outsourced the turbine contract to the Power Machine Group, which comprises of five joint-stock companies - Leningradsky Metallichesky Zavod, JSC Electrosila, Turbine Blades Plant, Kaluga Turbine Works and Energomachexport. In May 2002, the Power Machine Group announced that “JSC Electrosila has already manufactured the turbo-generators for the Tianvan (China) and Bushehr (Iran) and is about to start similar work for Kudankulam. The Plant manufactures all runner and guide blades”.[11] However, another firm, “Pumori Energy, a high technology Blade manufacturing company in Yekaterinburg, Russia" engaged in "manufacture of all types of Turbine blades, Generator fan blades, Guide Blades and other critical parts" claims that it is the "indirect supplier of 1000 MW Turbine blades to Kudankulam Nuclear Power Plant of NPCIL through JSC Power Machines".[12]

The industry norm and practices for T-G overhaul

According to the Recommendations for the Inspection and Overhaul of Steam Turbines (2nd Edition, 1995) by VGB PowerTech Service Gmbh the first T-G overhaul may be conducted after 100,000 equivalent operating hours (EOH) and if no major issues or problems are found during that overhaul, subsequent overhaul may be conducted at the 100,000 EOH intervals.[13] The US Electric Power Research Institute (EPRI) specifies that overhauls should be conducted every 80,000 EOH. General Electric advertises that their steam turbines are designed for 12 years (84,000 hrs) between major overhauls but their official service guidelines specify 5 years between overhaul.[14]

Two VVER-1000 T-G sets commissioned in this century were overhauled in China and Russia recently. China's Tianwan-1 reactor was grid connected on 12th May 2006 and its commercial operation commenced 110 days later. The first overhaul of Tianwan T-G commenced on the 7th refuelling (after 49,000 hrs of operation) on January 10th, 2014.[15] Russia's Kalinin-3 VVER-1000 reactor' T-G was grid connected in December 2004. The first overhaul of T-G and other equipment was carried out in July-August 2010,[16] after working for 38,000 hours.[17]

The Damaged Generator Transformers

In 2007, KKNPP received two single phase generator transformers (24-400 kV, 417 MVA) made in Ukraine in a damaged condition. The transformer upgrades 24 kV to 400 kV for eviction and if it trips, the reactor will have to be shut down. Larsen and Tuburo (L&T), NPCIL's construction contractor "dismantled the entire parts of the transformer, rectified, re-assembled and tested it without compromising the manufacturer's quality and safety standards."[18] It is not known if the NPCIL investigated this event to know the cause of damage and fix the responsibility. L&T says that the damage occurred during transit. The transformer has a manufacturing lead time of more than a year and costs about US$ 6 million. The receipt of two transformers in a damaged condition is not mentioned in the annual report of NPCIL.

Corruption in atomic energy industry of Russia and India.

India

There are lots of similarities between the atomic establishments of India and Russia.

In both the countries, there has not been any clear cut demarcation between the weapon and civil nuclear establishments. The power elite in India still believe that projects like KKNPP are linked to the nation's defence, though not a single gram of plutonium can be diverted from the imported reactors that will be under IAEA safeguard. The lack of transparency in the financial deals of NPCIL has been criticised by the Comptroller and Auditor General (CAG) of India. The NPCIL issued purchase order for 'end shields' for the Rajasthan Atomic Power Project to L&T on nomination basis without inviting competitive bids "though several firms/vendors were available in this field", violating CVC guidelines based on a Supreme Court judgement. CAG said this would amount to breach of the Constitutional guarantee of the right to equality. The audit rejected the stand of NPCIL that L&T was selected as other firms would not have been able to meet the demanding delivery schedule of June as the delivery date was subsequently extended to April, 2014 in favour of the company.[19] A pilot study of KKNPP tenders also reveals several instances of awarding contracts on nomination basis.

Russia

In Russia, Kirill Kabanov, a member of the Presidential Council for Civil Society and Human Rights and head of the National Anti-Corruption Committee (NAC) wrote to the Prime Minister and the Prosecutor General: “Recently, equipment purchases for NPPs have been conducted outside the tender procedure, which is contrary to the law. Preferences are afforded to such suppliers that offer equipment without a due guarantee of reliable operation, as well as that produced from fire-hazardous materials, which, in its turn, could affect the safety of power-producing sites. In a number of cases – and again outside the tender procedure – the choice has been made in favour of a foreign-based company, even though analogous equipment produced domestically is both up to quality standard and significantly cheaper in price (by two or three times). Russia's nuclear regulator Rostekhnadzor’s (RTN) report of 2009 says that new reactor construction is compromised by run-of-the-mill theft – perpetrators substitute cheaper, sub quality materials for the ones approved for construction. “Supervisory measures undertaken led to the discovery of 959 units of counterfeit concrete reinforcement supplied to Reactor Unit No. 2 of Rostov NPP.” In an analysis of 300 orders placed by the state corporation Rosatom, Transparency International Russia reported violation of purchasing standards in 27% cases.[20] Ecodefense!’s co-chair Vladimir Slivyak says “Corruption in the nuclear industry leads to an impaired safety culture, substandard construction quality, and, as a result, accidents at nuclear sites. With respect to Rosatom, there is no outside control, so there are truly gigantic opportunities there for corruption. There was corruption before, but with a new wave of NPP construction, that corruption processes may have reached a record high in the corporation’s history”.

Commenting on Rosatom's proposed nuclear deal with South Africa, Dirk De Vos, wrote in Daily Maverick, on 26 September 2014: "when there is no history of independent nuclear regulators standing at arm's length to the state, the processes and detailed assessments required to guarantee safety of any future facilities in the country where they are to be built are not necessarily top priority. Safety is not just about reactor design; the Rosatom reactors 1200 MWe VVER (AES-2006) appear up to standard. Safety in nuclear is about relentless quality control, which is harder when there is no regulatory background, or when there are questionable records on quality control and corruption.[21]

The construction of two reactors at KKNPP started in 2002. They were scheduled to be commissioned in 2007. The first reactor was loaded with enriched uranium in October 2012 and grid connected in October 2013. It did not pass the commissioning tests and has been lying idle since 26 September 2014. The study of the 14 trips of the reactor since grid connection shows that systems other than T-G also had serious problems.[4] Earlier, the Atomic Energy Regulatory Board (AERB) had revealed that the reactor pressure vessel have welds on the beltline, a feature of old vintage vessels. Gen-III reactor pressure vessels do not have such welds. An earlier study based on official documents from India and Russia had concluded that key equipment like polar crane, reactor pressure vessel etc are counterfeit/obsolete. Defects in valves supplied by the companies tainted with corruption like Zio Podolsk have been detected at KKNPP. Equipment and spares rendered surplus due to post-Chernobyl and post-Soviet cancellation of 25 VVER-1000 reactors are exported to Asian market and also incorporated in Rostov and Kalinin reactor plants in Russia.[22] The present study clearly shows that the serious defects of T-G system were known to the management some two years before the grid connection.

Conclusion

The KKNPP commissioning crew drawn from other reactor campuses and academic institutions have gone back to their respective institutions, feeling dejected as their dream of commissioning the first 1000 MW pressurized water, billed as the best and safest in the world, turned into a nightmare. Mean while, the top leadership of the NPCIL-Rosatom combine is busy negotiating the deal for the 5th and the 6th reactors, without proving that the reactors already built can be operated safely. The people from the peninsular India, who will be the immediate and proximate victims of a nuclear disaster at KKNPP and the experts and concerned citizens world-wide, who have been demanding an impartial safety audit of the reactors and a inquiry into *affair-la-kknpp* wonder why the new political leadership is on the silence mode!

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