Proceedings World Geothermal Congress 2015
Melbourne, Australia, 19-25 April 2015

Power Enhancement of Dieng Geothermal Installed Capacity

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Keywords: power enhancement, remaining life assessment, equipment & plant performance test, EPCC Tie In

ABSTRACT

Dieng geothermal field has proven reserves and is a very promising proposition. However, since continuous operation began in 2002, the power generation has tended to be not stable and has declined relatively rapidly. Several technical methods have been implemented in order to systematically increase the production capacity of this field. The first step was a general assessment to map the problem and find alternative solutions. Moving forward, it was necessary to determine the technical constraints of the solution in terms of production wells productivity, steam production process, brine injection scheme, and plant performance and reliability. The series of these methods has resulted in increased average power production of 10 MW to 52 MW by the end of the project in 2013.

1. DIENG GEOTHERMAL FIELD OVERVIEW

Dieng Geothermal Power Plant is located in the Dieng Plateau area in Central Java, which currently has one geothermal power plant with installed capacity of 60 MW.

The concession area of the Dieng Geothermal Field has been developed by Geo Dipa Energi ("GDE"). The area is 63 km^2 (9 km from north to south, 7 km from east to west), and extends over Batang District, Kendal District, Wonosobo District and Banjarnegara District, Central Java Province. The main area of the developing field is divided into two parts, northwestern part and southeastern part. The former is the Sileri area and the later is the Sikidang area. The Dieng Geothermal Power Station and the substation of PLN are situated in the Sikidang area, Sikunang Village, KejajarSubdistrict.

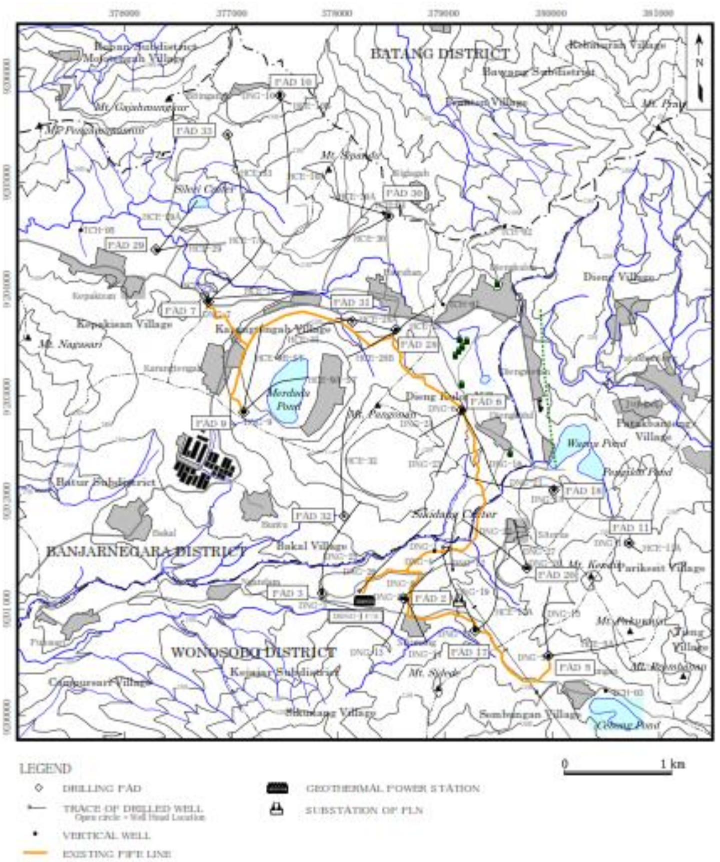

Figure 1. Dieng geothermal production facilities.

In the Dieng Geothermal field, 52 wells (including five slim holes for coring) have been drilled. In the Sileri area, corresponding output of 190.4 MW is examined through a production test for thirteen wells. Among these thirteen wells, the following eight wells are used as a production well for the Dieng power plant; their total corresponding initial output is 103.1 MW. For these wells, separators are installed individually nearby them. The produced geothermal fluid from these wells is separated steam from brine by separators in their drilling pads. Separated steam is transported to the power plant in the Sikidang area through steam pipelines.

Separated brine is transported to the Sikidang area through brine pipelines installed along the steam pipeline. Finally, transported brine is re-injected under the ground through DNG-17 and HCE-17A.

2. PRODUCTION HISTORIES

Dieng power plant was operated in 1998 in 72 hours, and after that the unit was shut down until 2002. The power plant was re-commissioned in 2002 and started continuous operation until now. Figure 2 explains the history of power generation from 2004 to 2011, where the contrast between the large-capacity wells and the power production of this field can be observed.

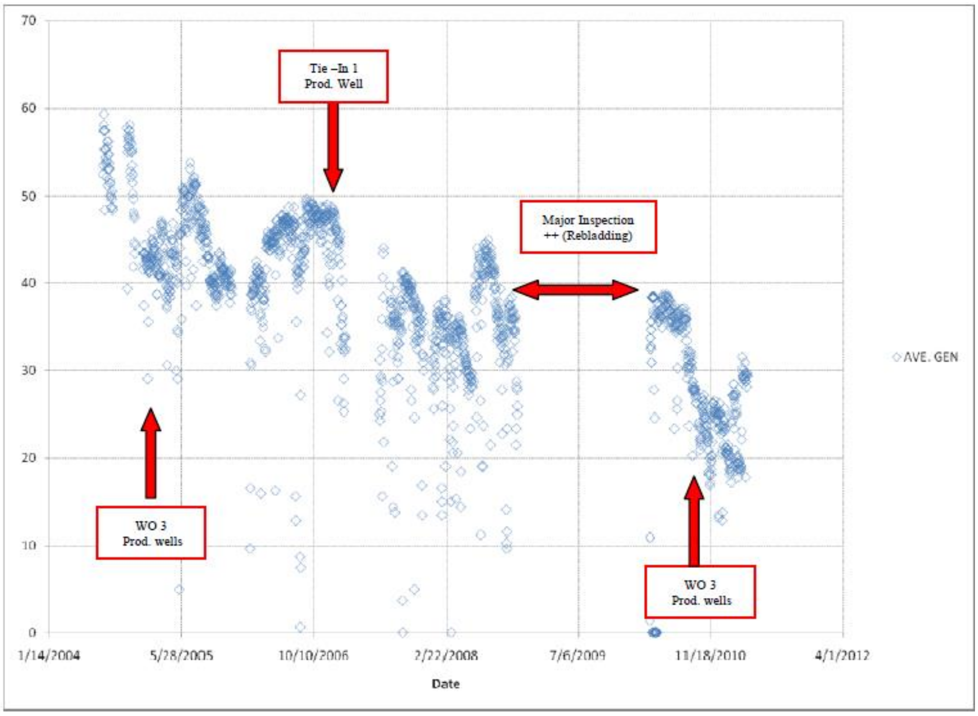

Figure 2. Production Histories 2002 – 2011.

Several technical obstacles that caused a decrease in the production of electricity have been identified. The first problem is scaling in production wells, production facilities, and steam injection wells. Another issue is the reliability and performance problems of steam production and brine injection equipment and power generation equipment.

3. POWER ENHANCEMENT

The technical approach to the power enhancement project was initiated by mapping the problems and determining alternative solutions. Execution of the following solutions were carried out in parallel: conduct investigations and work over well production and injection wells, perform Front End Engineering Design (FEED), Engineering Procurement and Construction Commissioning (EPCC), tie-in facilities and supporting equipment. In addition, a detailed technical approach was performed in the power plant: conduct performance tests and remaining life assessment of turbine equipment as the main equipment in the plant. The following section will explain the details of each execution solutions that have been done in order to provide power enhancement at Dieng Geothermal Field.

3.1 Problem Mapping

This work was done with an independent engineering consultant (SKM and ITB). The work was carried out for four months to perform the analysis. This stage of the project was divided into several works: 1) the collection of data, 2) survey field conditions, 3) analysis and conclusion. The study concluded that there were five major issues associated with power enhancement of Dieng Geothermal Field:

1. Production Well Blockages
2. Silica Deposition problem on 2- phase facility& brine reinjection system
3. Options to increase Unit 1 steam supply to full load
4. Assessment of Steam Field Surface Facilities
5. Constraints on monitoring program

3.2 Well Survey and Work Over Program

The solution of flow restriction on production wells and reinjection wells have been started well survey. The well survey method used in this program is exploratory hole depth and the inside diameter of the hole of wells, and conduct scale sampling using sample catcher. Well survey results show that all production wells and injection wells experienced flow restriction due to scale. In the production, it was determined that the type of scale that occurred was sulphide scale. The type of scale in the injection wells was silica scale. The results of this survey were used to plan the well work over jobs.

Well work overs were performed using mechanical cleaning combined with a jet pulsation. This program was implemented on three production wells and two injection wells with an average rig - operation time of six days. The production well work over program successfully restored the well capacity so that the implementation of this program has improved steam availability of 7 MW from only one production well (HCE 7C) (see Figure 3).

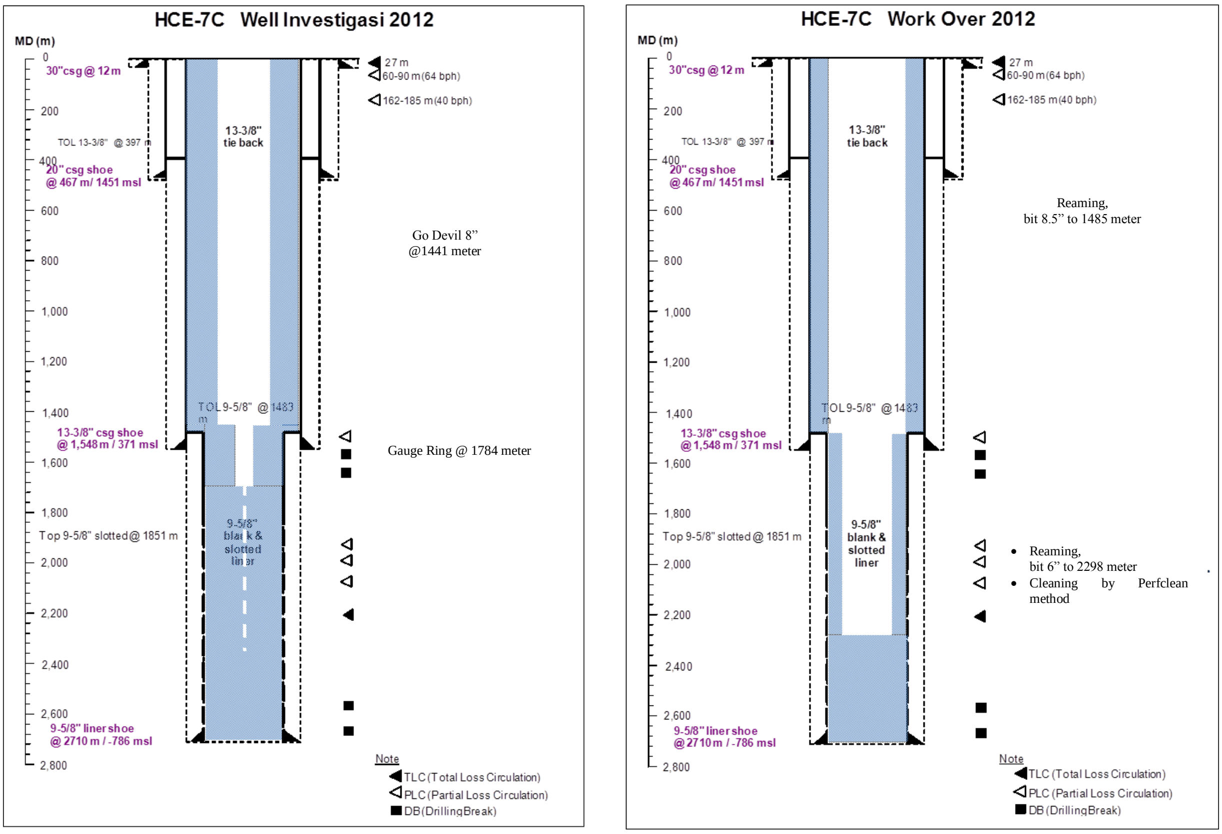

Figure 3. Well Investigation and Work Over Program HCE-7C.

3.3 FEED and EPCC Tie – In Project

For additional steam of new production wells, the surface equipment installation including the steam production system and brine injection system needs to be prepared properly. Work begins by looking at the effect of additional production wells to the existing system, and then continued with the EPC for several additional equipment required to accommodate the additional production of steam and brine. Four production wells HCE29/29A and HCE30/30A will be added to existing Steam Above Ground System(SAGS) as shown below (Figure 4 ang Figure 5). An isolated separator is used for this project with consideration of well capacity, location and cost. This project carried out by the EPCC contractor over duration of eight months at a total cost of $8,000,000 USD.

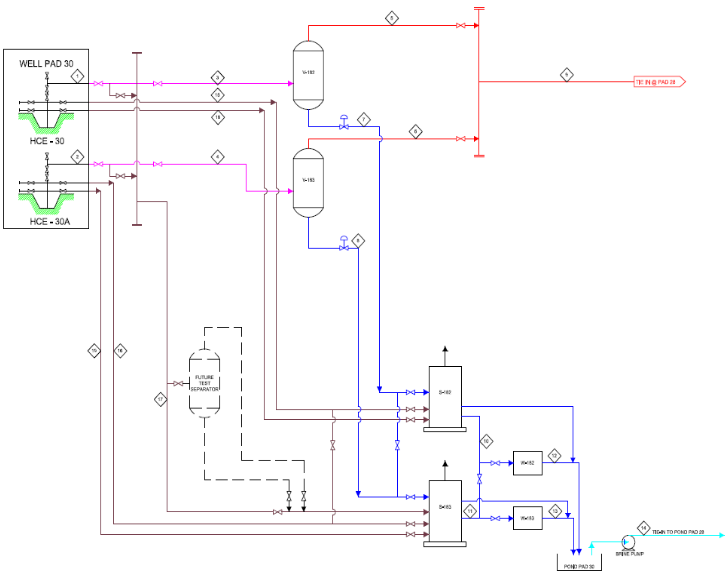

Figure 4. Typical process flow diagram of surface facilities.

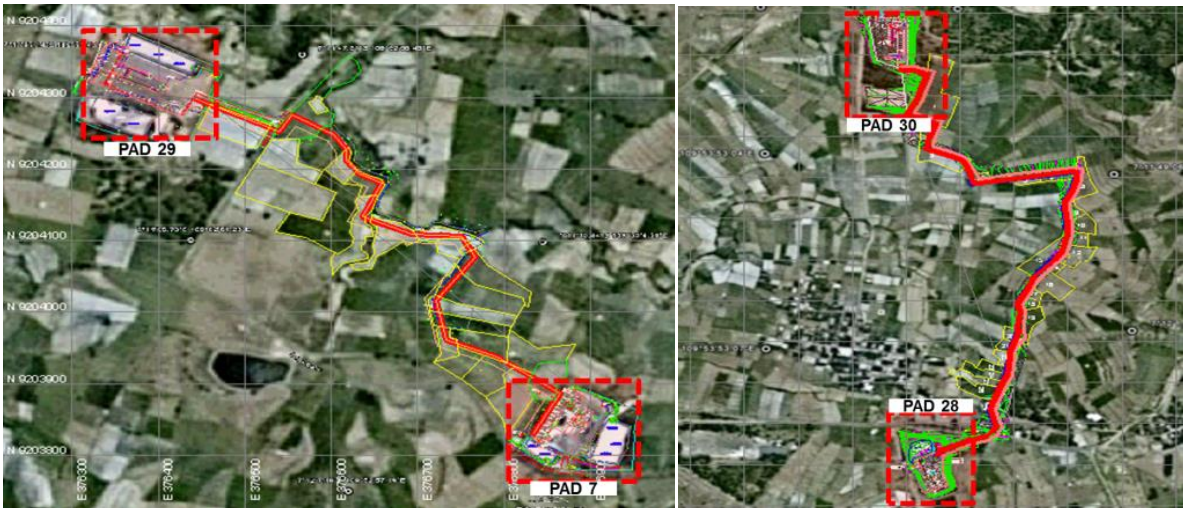

Figure 5. Pipeline route along 3 km connected tie-in wells to existing gathering system.

3.4 Performance Test of Dieng Geothermal Power Plant

A performance test was conducted on four variations of load generation, i.e: 17, 25, 28, and 35 MW. Retrieval of data is done to equipment-equipment, i.e., turbine, condenser, cooling tower, hot well pump (HWP), and gas removal system (GRS). Furthermore, these data are analyzed using heat and mass balance equations. The purpose of this test was to determine the performance of the main equipment and plant overall to obtain the operational limits prior to the increase in load generation. The results of the analysis of heat and mass balance in this test compare with the result of the study prior to commissioning of the 60 MW plant in 2002. Heat and mass balance in 2002 is shown in Figure 6.

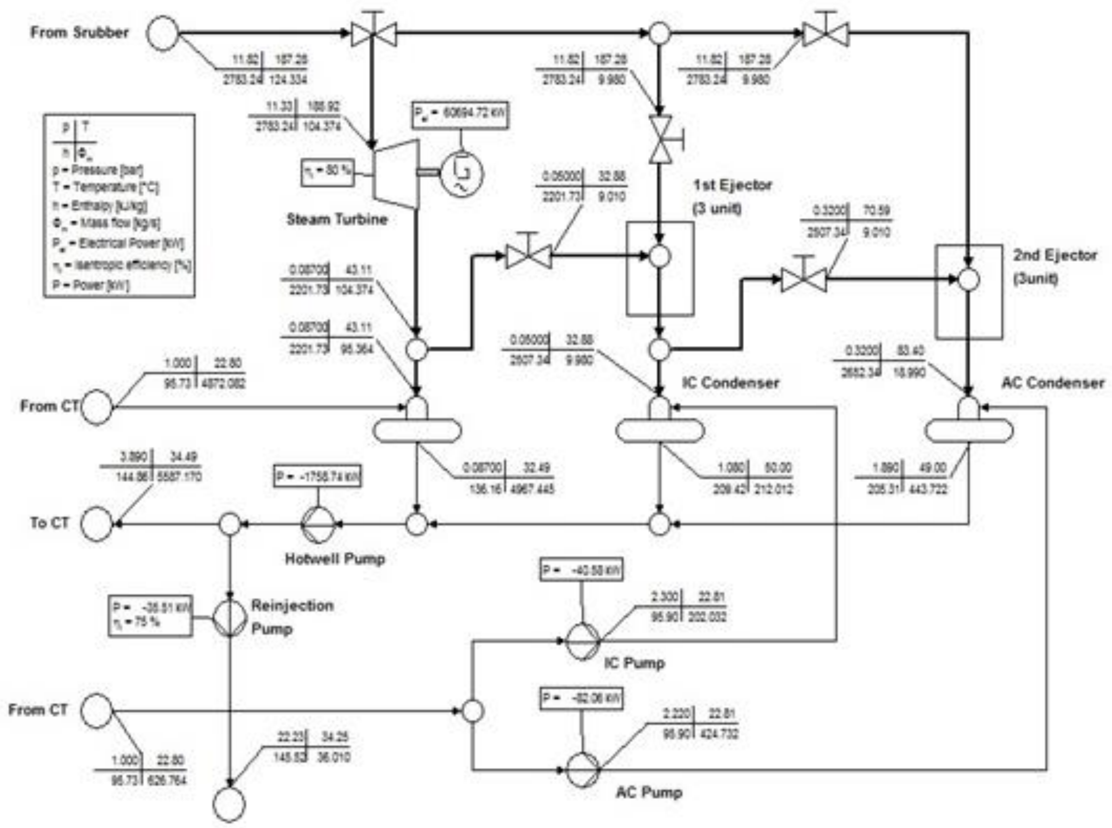

Figure 6. Heat and mass balance commissioning of 60 MW in 2002.

Turbine performance testing was conducted to ascertain the heat rate, steam rate, and isentropic efficiency turbine, with the results obtained that the operation in 2012 was much better than 2002. This is also true for the other major components, such as initial temperature differential (ITD) of condenser and effectiveness of the cooling tower. The efficiency of HWP did not change. Similar results were obtained for the entrainment ratio of GRS. For the GRS performance, the steam needed to evacuate Non-Condensable Gas (NCG) is relatively better in term of quantity when compared with the 2002 performance test results.

3.5 Remaining Life Assessment for Steam Turbine

Remaining life assessment (RLA) for the turbine was conducted to determine the limits of the remaining life of critical mechanical components that can be operated by the operation hour limit. The RLA was conducted for 14 days by applying the analytical methodology and the incorporation of non -estructive methods as shown in the diagram in Figure 7.

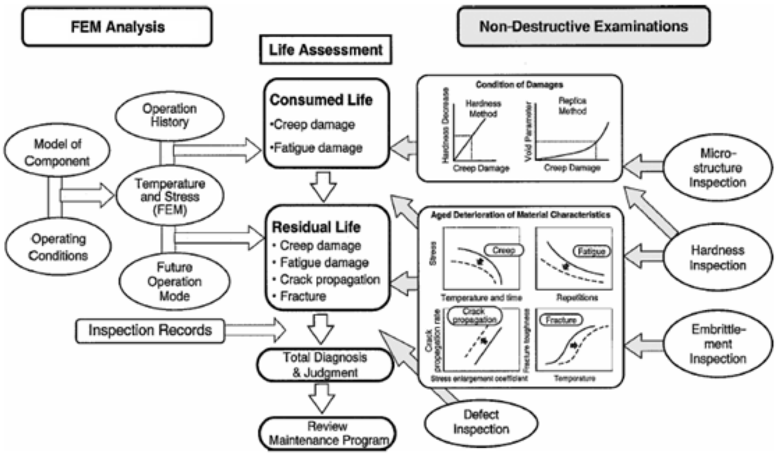

Figure 7. RLA methodology of steam turbine PLTP Dieng.

Data collection was done in visual observation, non-destructive test (NDT), replica metallographic and hardness test. The data found is the presence of pitting corrosion, dent, erosion, and crack, as shown in Figure 8. Pitting corrosion formed on rotating components and stationery. Dents occur in some components. Cracks only occurred in the rotating shroud components. Erosion happened to the last stage blade (LSB). The RLA analysis use equation of crack growth and stress corrosion cracking (SCC). The remaining life was determined by shortest life of the turbine component. The results of both equations can be compared in order to obtain material remaining life prediction. The result is turbine PLTP at Dieng of a minimum of about 5 years.

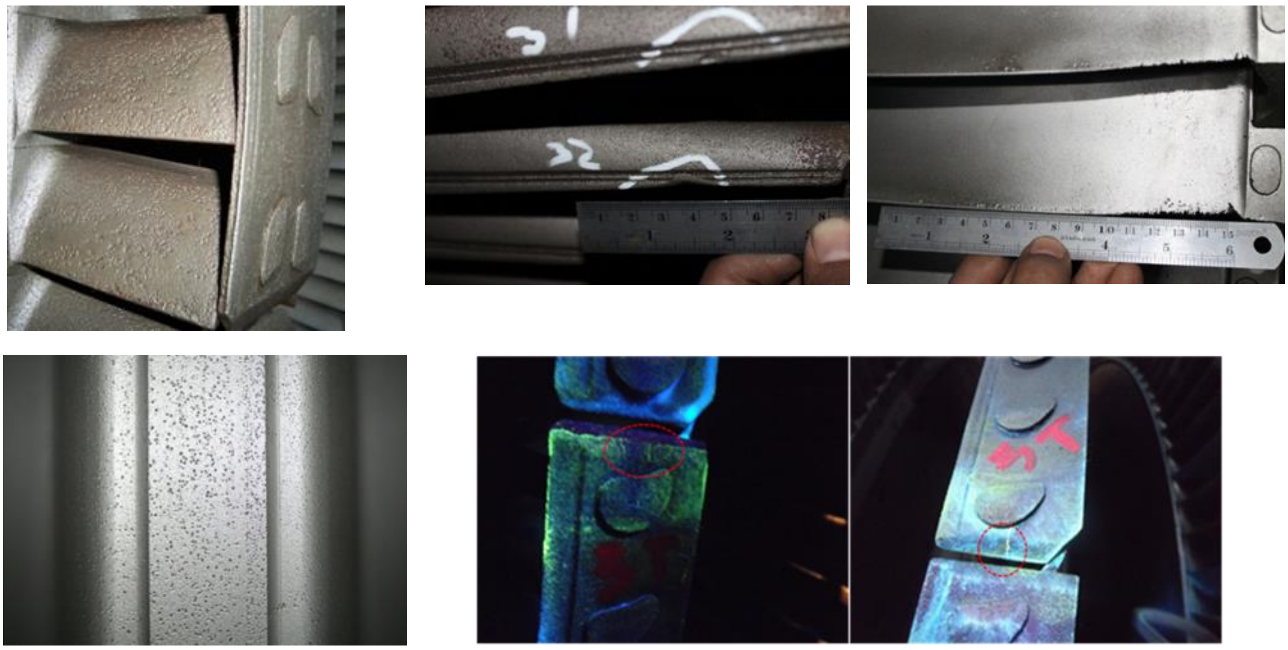

Figure 8. Phenomenon that occurs in steam turbine PLTP Dieng.

4. POWER ENHANCEMENT RESULTS

The preceding strategies have been implemented so that the target of 50 MW can be achieved. In February 2013, the gross power output of Dieng Geothermal Power Plant reached 52.56 MW (maximum load).

In July 2012, production has increased as a result of work over wells. Furthermore, in September 2012, production increased again as a result of the tie-in of one well into the SAGS. Finally, in January 2013, production increased again to reach 45.31 MW caused by the tie-in of two wells into the SAGS. In the same month, the gross power output strived to reach 50 MW. As a result, the production of electric of PLTP Dieng can operate approximately 52 MW as shown in Table 1. By using a heat and mass balance simulation, Dieng Geothermal Power Plant can be operated to reach 52.56 MW, according to Figure 9, with gross power output amounted to 52.55 MW. The final results of the analysis were proved in February 2014, when the maximum load reached approximately 52.56 MW.

Table 1. Gross power output records of PLTP Dieng.

Month	Ave. Gross (MW)	Max. Gross (MW)	Min. Gross (MW)
July 2012	24.20	27.70	14.50
August 2012	26.90	32.40	16.90
September 2012	28.59	38.50	17.49
October 2012	34.50	40,66	24.16
November 2012	31.34	35.89	25.20
December 2012	31.72	38.49	24.18
January 2013	41.06	48.47	29.19
February 2013	45.74	52.56	32.40

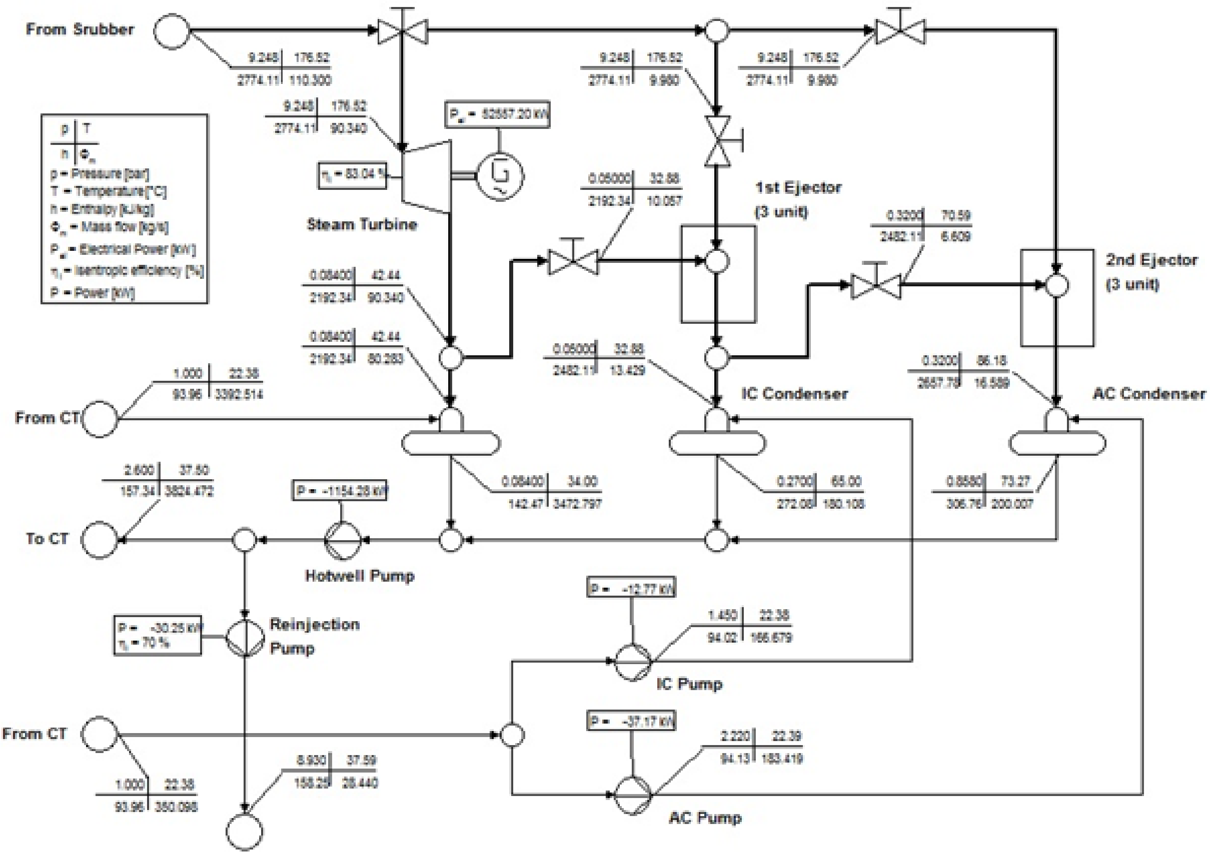

Figure 9. Heat and mass balance of gross power output 52.55 MW.

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