

Power Generation

TURBINE BLADE ADJUSTMENT FOR PERFORMANCE RECOVERY

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Abstract: The issue of sudden vibration disturbance occurred at the Dieng Geothermal Power Plant Unit 1 during full load operation. An investigation was conducted by reviewing the trends in the Distributed Control System and performing a startup trial using vibration monitoring equipment. Based on the analysis, the vibration was identified to be caused by rotor unbalance. However, during the balancing process, it was found that a 1300-gram balance weight was required. With a mass weight like that, it is not possible to continue the balancing process, therefore, a deeper investigation was undertaken by opening the upper casing to determine the root cause of the issue. Upon opening the upper casing, a broken turbine blade was found at stage #5 on the generator side. As there were no spare blades available at the Dieng Geothermal Power Plant, a corrective action was required. It was decided to cut the turbine blade at stage #5 using a plasma cutting method. With this method, the highest vibration level observed remained below the maximum allowable standard. Considering that the procurement of a new blade would take approximately one year, the blades cutting for turbine vibration recovery as a solution to expedite the repair process to approximately less than 2 months. This approach allows the power plant to continue supplying electricity to meet public demand and enables the company to maintain economic gains, rather than facing a total shutdown while waiting for the new blades.

Keywords: Cutting Blade, Vibration, Adjustment, Blade repair, Turbine blade, Geothermal, Power Plant, API 687

1. Introduction

While Power Plant was operating normally full load, the unit suddenly tripped due to a High-High Vibration Alarm on Bearing #2. During the rundown process, two vibration anomalies occurred—once at 3000 rpm and once at the critical speed of 1527 rpm. Vibration parameters showed 246 microns on Bearing #1 and 254 microns on Bearing #2, which led to the unit trip. During the trip, the lubrication system functioned normally; the jacking pump activated according to the proper sequence, and the turning gear engaged at 2 rpm. Startup trial was performed using a vibration monitoring device (ADRE 408), and the unit was found unable to pass through the critical speed range (1000 to 2000 rpm). Vibration spectrum analysis at 1000 rpm (below operational speed) indicated the highest vibration amplitude occurred at 1X RPM frequency. Orbit analysis showed an elliptical shape with a bush spot pattern, indicating that high vibration only occurred at 1X RPM frequency. The waveform displayed a pure sinusoidal shape with flattened peaks. From this, it was concluded that the high vibration was likely

caused by rotor bow, rotor resonance, or mechanical unbalance. A 24-hour turning gear operation was conducted to eliminate the possibility of rotor bow.

Balancing trial was then conducted by adding trial weights at hole numbers 9 and 11 on plane 2 (generator side). However, calculations indicated that a balance weight of 1262 grams was required to counteract the unbalance an unusually large amount for Dieng Geothermal Power Plant Unit 1's turbine. With a mass weight like that, it is not possible to continue the balancing process. Therefore, a deeper investigation was undertaken by opening the upper casing to determine the root cause of the issue. Upon inspection, a broken turbine blade was discovered on stage #5, generator side, resulting in significant mass loss and rotor unbalance (as shown in Figure 1).

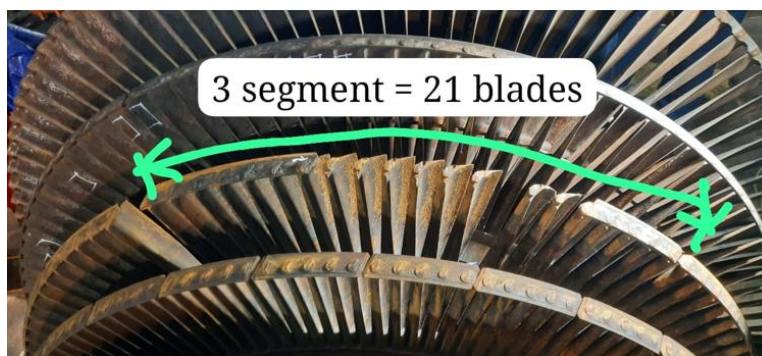


Figure 1. Broken Blade Finding

Corrective Action Plan for Turbine Repair and Unit Reoperation According to standard procedures, reblading is required. However, no spare blades were available at Dieng Geothermal Power Plant. According to OEM standards, reblading must be performed. However, ordering new OEM blades would take approximately eight months (exclude delivery time), during which the unit would be inoperable. An option to remove the stage #5 turbine blades was considered. However, this carried the risk of damaging the blade platform's "Christmas tree" structure, potentially preventing future blade installation. The final decision was to cut the stage #5 turbine blades for short-term recovery, it was decided to proceed with cutting the stage #5 blades, accepting the risk of reduced efficiency or output derating with the aim of accelerating the recovery to resume operation while awaiting the delivery of new blades. The Problems is how to establish a proper procedure for turbine blade cutting and the impact of blade cutting on vibration and operating pattern.

2. Materials and methods

The turbine blade removal and cutting process at Power Plant was conducted during the vibration recovery program from March 1 to April 15, 2025. This work was conducted following the API Recommended Practice 687 – Rotor Repair Guidelines. The The blades were cut along the platform section that connects to the blade housing. According to Figure 2 from API RP 687, the airfoil begins approximately 30% above the platform. To ensure the blade no longer functions within the steam flow path, the cutting was executed at that location

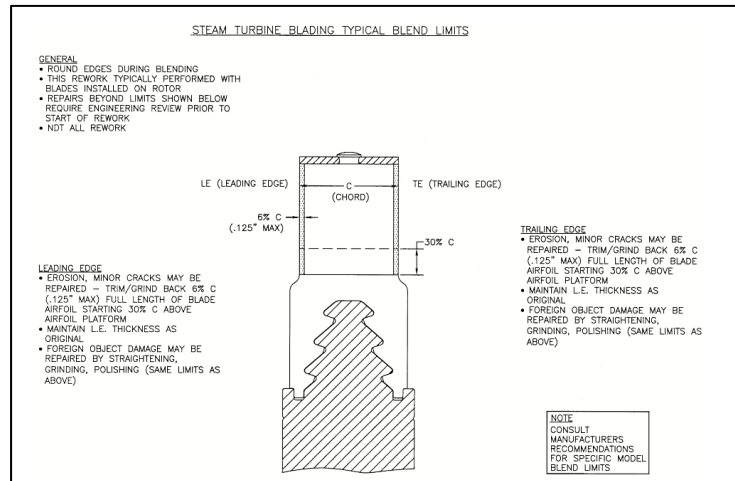


Figure 2. Blade Rotor Typical

Work Plan schedule for On-Site Service for cutting of Stage #5 Turbine Blades less than 2 months. The first procedure to be implemented is preparation of manpower and tools. Mobilization of qualified personnel, including turbine specialists and safety officers. Preparation and inspection of necessary tools and equipment, including plasma cutting machines, lifting tools, and safety apparatus. Visual Inspection and Position Mapping are necessary. Conduct a thorough visual inspection of the turbine rotor and surrounding components. Map and document the exact position and condition of each blade on stage #5, including recording damage indicators. Protection of Adjacent Stages (Stage 4 and Stage 6). Cover stage #4 and stage #6 using protective plates or heat-resistant glass wool insulation. Ensure all adjacent components are shielded from potential thermal or mechanical impact during the cutting process.

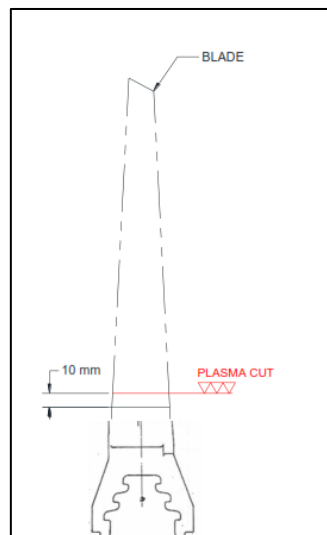


Figure 3. Finishing Cutting Blade Diameter

According to Figure 3, Cutting of Stage #5 Turbine Blades Using Plasma Cutting Method. Perform blade cutting operations in accordance with the standard procedure outlined in API RP 687, cut the blades precisely at the designated location above the platform to ensure removal from the steam path without damaging the blade housing or platform structure. Conduct post-cutting inspection to verify clean cuts and absence of collateral damage

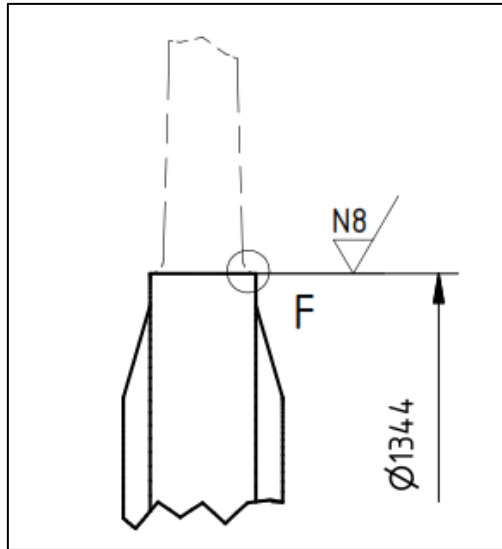


Figure 4. Final Diameter and Roughness

The drawing of Figure 4 smoothing using hand grinding and adjusting the final diameter and et the surface roughness and performing final machining using a lathe machine.

3. Results and discussion

3.1. Cutting Result

Sl. No	Manufacturing Process	R_a in μm														
		0.012	0.025	0.050	0.10	0.20	0.40	0.80	1.6	3.2	6.3	12.5	25	50	100	200
1	Sand casting										5				50	
2	Permanent mould casting						0.8					6.3				
3	Die casting						0.8				3.2					
4	High pressure casting				0.32						2					
5	Hot rolling								2.5						50	
6	Forging								1.6						28	
7	Extrusion				0.16										5	
8	Flame cutting, sawing & Chipping											6.3				100

Figure 5. Standard roughness relative to manufacturing processes

The final surface condition (as shown in figure 5) of the turbine blade cutting at Power Plant meets the standard roughness values associated with flame cutting, sawing, and chipping processes, which typically fall within the range of 6.3 – 100 μm (Roughness Grade Number N9). However, post-operation inspection showed that the achieved surface roughness improved to one level higher, equivalent to Roughness Grade Number N8, indicating a smoother finish than initially expected. Figure 6 shown the result from cutting blade using plasma cutting method.



Figure 6. Result of the Blade Cutting Process

3.2. Flow Characteristics Stator

An important consideration during the blade cutting and removal process was whether the turbine stator (diaphragms) located between the turbine blades should be retained or removed. This question arose particularly during the reassembly phase of the turbine. Based on a technical presentation by MHPS (Mitsubishi Hitachi Power Systems) titled "*Tentative Correction Action for L-2 Stage Blade Damage – Suralaya Unit 1*", guidance was provided through a detailed flow diagram, which clarified the role and configuration of the diaphragms under similar damage scenarios.

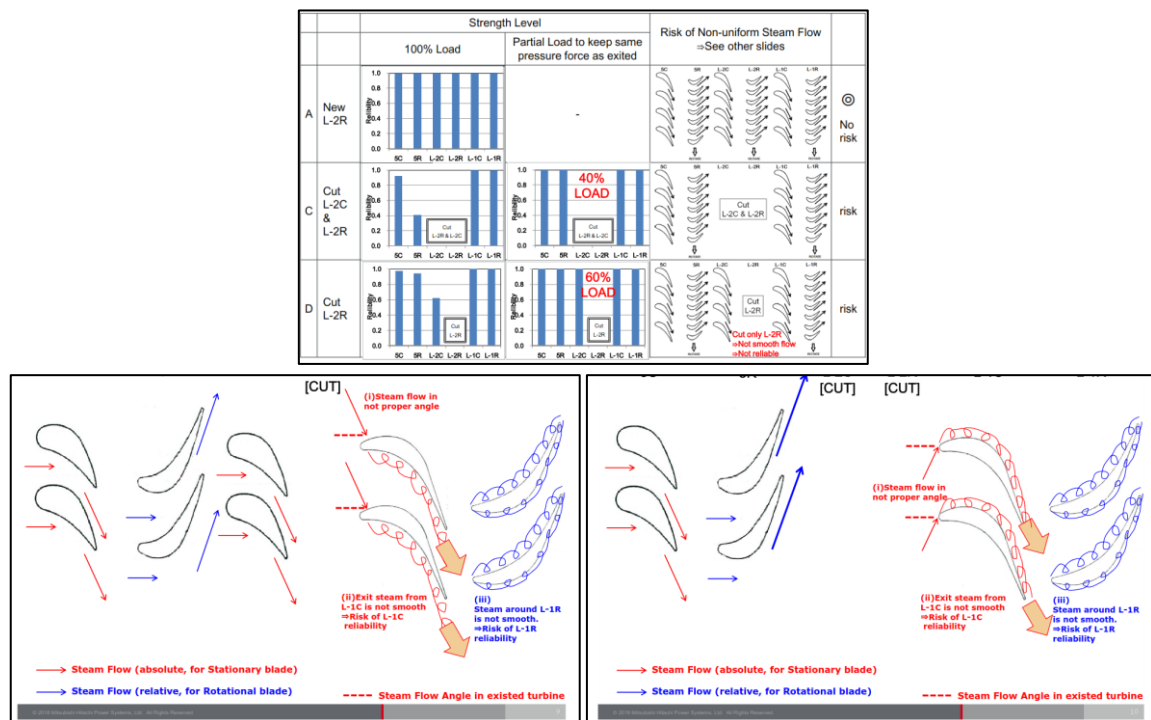


Figure 7. Turbine Steam Flow Characteristics

The referenced diagram on Figure 7 illustrates the steam flow characteristics and mechanical configuration when a blade stage is removed. It indicates that, in such cases, the diaphragms can remain in place to help maintain flow direction and minimize disruption to downstream stages, provided that no damage or obstruction exists. This solution aims to preserve turbine efficiency while mitigating mechanical imbalance risks after stage removal.

3.3. Vibration And Operation

The vibration results during turbine operation, the unit demonstrated stable performance within acceptable vibration limits, indicating that the corrective action—cutting the stage #5 turbine blades—was effective in mitigating the imbalance and enabling safe turbine operation. The operation of Power Plant Unit 1 was operating normally, the highest recorded vibration was observed at Bearing #2, with a peak value of 57 microns. This value remains within acceptable limits when compared to the vibration standard recommended by the turbine manufacturer. According to the Manufacturing guidelines, the vibration limit for radial bearings during steady-state operation is typically categorized as follows:

- Normal: ≤ 60 microns
- Alarm/Trip > 80 microns

Therefore, the measured vibration value of 57 microns at Bearing #2 indicates that the turbine continues to operate safely following the corrective action involving the cutting of the stage #5 blades.

3.4. Impacts and Benefits

Based on the overall analysis and discussion, it can be concluded that removal or cutting of turbine blades can be performed as a corrective action if conducted in accordance with established procedures. This method has been previously implemented on several units within PT PLN Indonesia Power such as PLTU Asam Asam (South Kalimantan), PLTU Suralaya (Banten), PLTU Pangkalan Susu (North Sumatra), etc. The effects of blade cutting may vary depending on the turbine's design and characteristics, potentially impacting primary energy efficiency or resulting in power derating. However, since geothermal power plants utilize geothermal heat as their energy source—a renewable energy form—the fuel efficiency value can be disregarded. Considering that the procurement of a new blade would take approximately one year, the blades cutting for turbine vibration recovery as a solution to expedite the repair process to approximately less than 2 months. This approach allows the power plant to continue supplying electricity to meet public demand and enables the company to maintain economic gains, rather than facing a total shutdown while waiting for the new blades.

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