Journal of Mechanical Design and Testing 5(1), (2023), 45-51
DOI: http://dx.doi.org/10.22146/jmdt.85644
e-ISSN: 2685-8029, ISSN: 2716-1293

Modification of The Oil Cooler to Avoid Oil Leaking in Generator Transformer PLTU Labuan "Moderator"*

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Abstract
The Main Generator Transformer for PLTU Labuan is a transformer with a power capacity of 350 MVA and a cooling system of 6 pcs OFAF (Oil Force Air Force) type. During operation, a disturbance to the Main Generator Transformer (GT) was caused by an oil cooler leak. This is caused by the corrosive expand tube caused by the constituent material consisting of 2 different types of materials. The oil leak caused environmental pollution, decreased oil level, and increased winding temperature and oil temperature on GT. During the decade of operation of the PLTU Labuan, GT oil cooler leaks almost always occur every year, both in unit 1 and unit 2. To anticipate this, we made modifications to the end tube design by changing the type of material on the expanded tube from initially using iron to aluminum such as tube material outside the expanded position. The next design change is to increase the length of the end tube which is equipped with the knock and glue with an expansion strength above normal operating temperature which makes the end tube more reliable by increasing the surface area attached to the body oil cooler. In addition to making changes to the design, this modification reuses used oil coolers that have good tube quality so that they can be reused with more reliable quality. By making these modifications, it can increase the readiness of generating unit production (EAF) by 3.33% in one MO event due to the replacement of the oil cooler generator transformer and lower maintenance costs for the required transformer oil cooler. The modified Oil Cooler was installed during the Maintenance Outage in Unit 1 and Overhaul unit 2 in 2021 and is still operating well for 20 months of operation.

Keywords: *Oil Cooler, Corrosive, Transformer, Modification, Expand Tube.*

Abstrak
Trafo Pembangkit Utama untuk PLTU Labuan adalah trafo dengan kapasitas daya 350 MVA dan sistem pendingin 6 buah tipe OFAF (*Oil Force Air Force*). Selama beroperasi, terjadi gangguan pada Main Generator Transformer (GT) yang disebabkan oleh kebocoran *oil cooler*. Hal ini disebabkan karena expand tube bersifat korosif yang disebabkan oleh bahan penyusunnya yang terdiri dari 2 jenis bahan yang berbeda. Kebocoran oli menyebabkan pencemaran lingkungan, penurunan level oli, dan peningkatan suhu belitan dan suhu oli pada GT. Selama dasawarsa beroperasinya PLTU Labuan, kebocoran GT *oil cooler* hampir selalu terjadi setiap tahunnya, baik di unit 1 maupun unit 2. Untuk mengantisipasi hal tersebut, kami melakukan modifikasi desain end tube dengan mengubah jenis material pada expand tube. dari yang awalnya menggunakan besi hingga alumunium seperti bahan tabung di luar posisi dilebarkan. Perubahan desain selanjutnya adalah penambahan panjang end tube yang dilengkapi dengan knock and glue dengan kekuatan ekspansi di atas suhu operasi normal yang membuat end tube lebih handal dengan menambah luas permukaan yang menempel pada body oil cooler. Selain melakukan perubahan desain, modifikasi ini menggunakan kembali oil cooler bekas yang memiliki kualitas tube yang baik sehingga dapat digunakan kembali dengan kualitas yang lebih handal. Dengan dilakukannya modifikasi tersebut dapat meningkatkan kesiapan produksi unit pembangkit (EAF) sebesar 3,33% dalam satu kejadian MO karena adanya penggantian *oil cooler* generator trafo dan biaya perawatan yang lebih rendah untuk kebutuhan oil cooler trafo. *Oil Cooler* yang telah dimodifikasi dipasang pada saat Maintenance *Outage* di Unit 1 dan *Overhaul* unit 2 di tahun 2021 dan masih beroperasi dengan baik selama 20 bulan beroperasi.

Kata kunci : *Oil Cooler, Corrosive, Trafo, Modifikasi, Expand Tube.*

*Best paper dalam Science Technology and Management (STeM) MeetUp, 22 November 2022 di Yogyakarta.

1. INTRODUCTION

PT Indonesia Power, especially PLTU Banten 2 Labuan, is responsible for the operation and maintenance of PLTU Banten 2 Labuan 2x300 MW. PLTU Banten 2 Labuan is located in Sukamaju Village, Kec. Labuan Kab. Pandeglang Banten contributed 2.1% to the supply of electrical energy for the Java-Madura-Bali interconnection network. To maintain the supply of electricity, careful planning is needed for the maintenance of generating equipment at PLTU Banten 2 Labuan (PLTU Banten 2 Labuan OMU, 2022).

The transformer is one of the main pieces of equipment of the power plant, so its reliability needs to be maintained because it affects the power production of the power plant (IEEE, 2010). The PLTU Labuan's Generator Transformer cooling system uses the OFAF (Oil Force Air Force) method through an oil cooler. Continuous operation without stopping leads to operational risk as well as increasing the probability of equipment failure (Nurhidayat, 2014). One of the downtimes that often occurs in generator transformers is an oil cooler leak caused by the expanding tube on the oil cooler being corrosive so that the expanded tube has a gap with the oil cooler body, resulting in a leak.

Figure 1. Oil cooler leak

Based on data on the number of oil cooler leaks in the last 3 years, they are as follows:

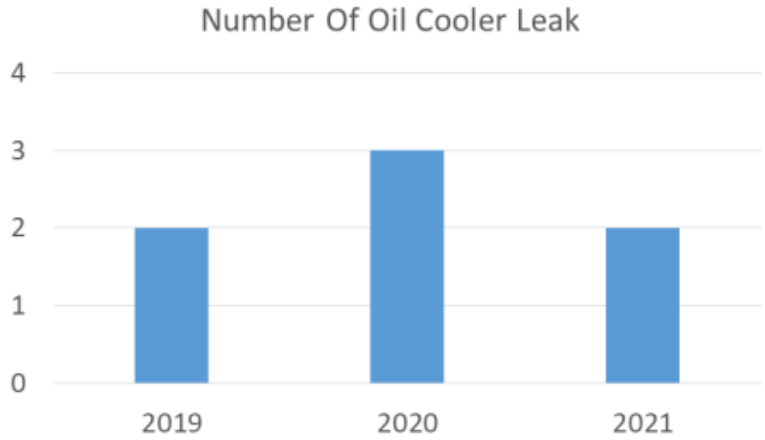

Figure 2. Oil Cooler Leakage Data 2019-2021

If there is a leak in the oil cooler, the previous mitigation carried out is to replace the new oil cooler. The procurement process that is carried out requires a long time for maintenance and costs. This will have an impact on greater leakage and affect the operating parameters of the generator transformer due to the cooling process not running optimally. In addition, the oil leak requires proper waste management to avoid pollution of the surrounding environment. In the process of replacing an oil cooler that has a leak, a stop unit is needed, resulting in a decrease in unit production and threatening the achievement of unit performance.

The need for modifications to minimize the potential for unit stops caused by repeated interruptions of oil cooler leaks is very necessary to increase the achievement of unit performance.

2. RESEARCH METHODOLOGY

The research methodology used in compiling this scientific work, the researcher uses several methods, including the following:

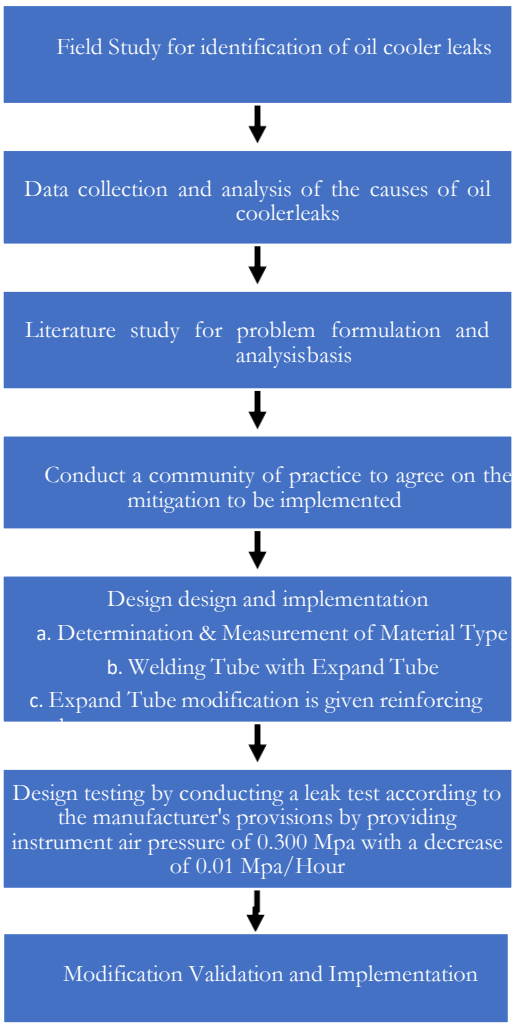

Figure 3. Research Methodology Flowchart

3. RESULTS AND DISCUSSION

3.1. Problem Identification

Oil cooler leaks at PLTU Labuan with type YFZL – 300 have almost occurred every year since PLTU Labuan was established. Based on the report data on the 2020-2021 Maximo application, there are several reports of disturbances in the transformer caused by the oil cooler tube leak, as follows:

Table 1. Summary of Transformer Oil Cooler Fault Work Orders for 2020 – 2021

No.	Work Order	Deskripsi
1	BLB20/32861	Inspeksi Radiator GT No.5 Unit 1 Kondisi Bocor
2	BLB20/24629	Kebocoran radiator cooling no. 3 GT #1
3	BLB20/14272	Perbaikan kebocoran di radiator cooling fan GT No 2 & 5 #2
4	BLB21/17185	Perbaikan rembesan oli di area pompa radiator GT no.6 #2

In the process of following up on the disturbance report, as a corrective step, it is necessary to stop the unit so that it can result in a decrease in production. If not handled immediately, it has the potential to cause excessive damage to the transformer and can pollute the environment due to less-than-optimal handling of waste oil.

3.2. Problem Solving Analysis

An overview of the background and root causes of oil leakage in the transformer oil cooler is described in the following Fishbone Diagram RCFA analysis:

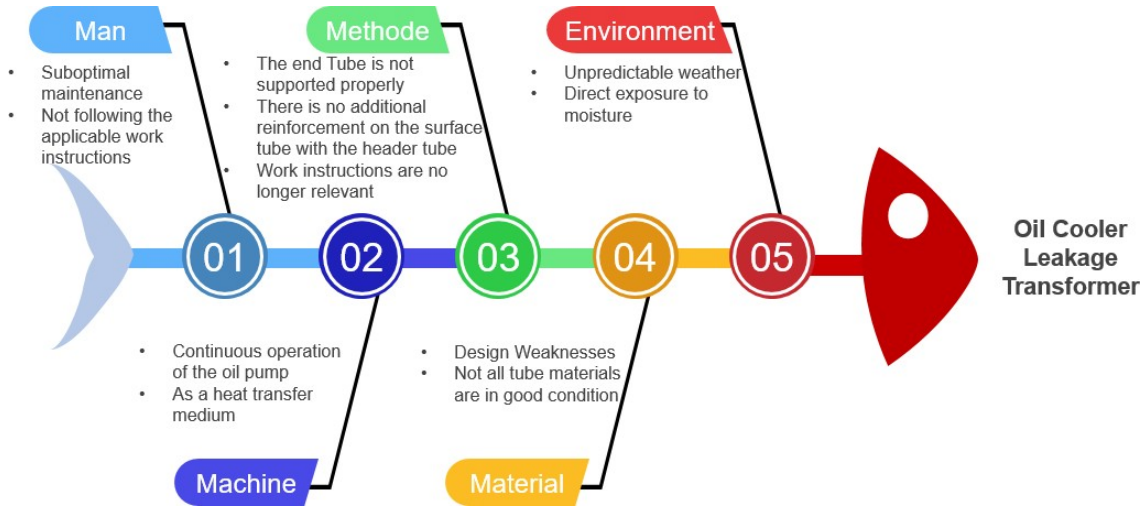

Figure 4. Fishbone Diagram RCFA

The root of the problem of oil leakage in the tube Oil Cooler transformer refers to the Material and Method factors. On the material factor, the tube oil cooler consists of 2 different materials, namely aluminum on the tube and for the expand tube using iron, so that it becomes one of the weaknesses that causes corrosion (Xi'an Xibian Components, 2008). Corrosion that occurs due to the presence of 2 different metals in one electrolyte so that the more anodic metal will be corroded, including the type of Galvaniscorrosion (Utomo, 2009). In addition, because the tube oil cooler works at varying working temperatures, if there is an expansion, then the tube consisting of 2 different materials will result in internal stress which has an impact on disturbances in the oil cooler. From this, if the tube is corroded due to material differences, there will be a decrease in the function of the equipment, resulting in leakage.

In Factor Method, based on a field study, it was found that the leak of the Oil Cooler tube came from the upper side of the end tube where at that point the existing Oil Cooler was not strong enough in the buffer system to the header tube. So if there is corrosive on the end tube and there is no strong support, of course the oil distribution process cannot run according to its proper function, because it causes the end tube position to not accommodate the entire flow of oil used as a transformer winding cooler.

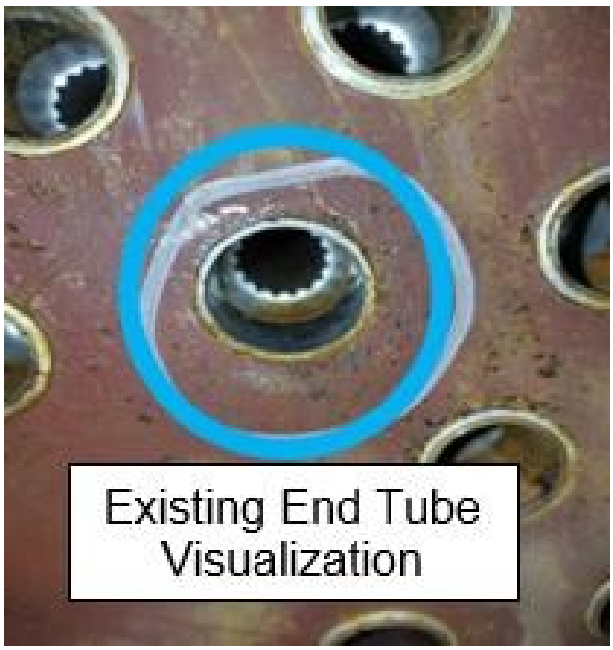

Figure 5. End Tube Design on Existing Oil Cooler

The picture above shows that in the existing oil cooler, the end tube only rests on the paired surface header. So when there is a corrosive part of the expanded tube and also the side effect of vibration caused by pressurized flow in the oil cooler tube, the end tube does not have sufficient support to be in its previous position.

3.3. Design

Based on the above problems, it is necessary to modify the Oil Cooler tube so that it can increase electricity production and also maintain the reliability of transformer equipment which is one of the main equipment in the power plant. From the modifications made, it can provide additional support strength to the end tube

Oil Cooler by changing the type of tube expansion material, which was originally iron replaced with the same material as the existing tube material in the form of aluminum so that the tube material as a whole will become homogeneous and suppress the potential corrosion rate produced be lower.

Figure 6.Realization of Existing and Modified End Tube Oil Cooler Design

In addition, modifications were also made by increasing the length of the expanded tube by ±2cm so that the cross- sectional area between the tube and the expanded tube is wider which increases the strength in supporting the position of the upper-end tube. The connection between the tube and expand tube is done by the welding method.

a b

Figure 7. Size of Existing Expand Tube

To test the welding results, the Dry Penetrant Test method is used to determine the presence or absence of cracks in the welds.

Modifications were also made to the end tube, by adding a ring per/knock at the end of the end tube with the aim that when an expansion tube occurs, the Oil Cooler can still return to its original position. To keep it from being corrosive and also as tube protection in this series of modifications, an anti-heat, and anti- corrosive layer was added to maintain the life time of the Oil Cooler tube, especially on the surface that became the expanded area.

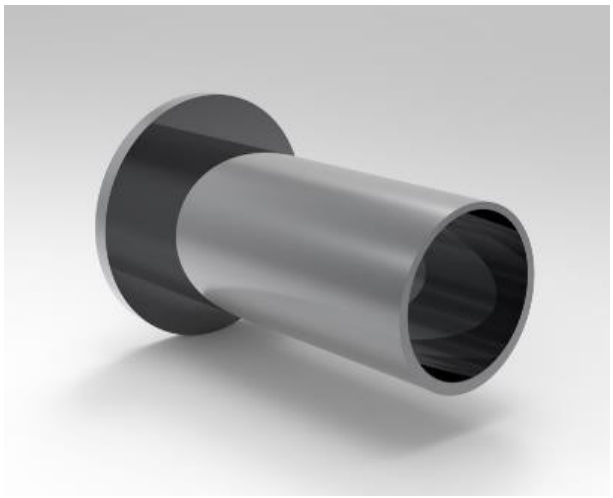

Figure 8. 3D Design of End Tube Oil Cooler Modification

3.4. Implementation

Before being implemented on the PLTU Labuan generator transformer, a leak test or leak test method was carried out using instrument air to determine whether there was a leak after modification. In this leak test, the instrument air pressure is 0.300 Mpa. The modification results are declared successful if the decrease is 0.01 Mpa/hour according to the operation's standard (PLTU Banten 2 Labuan OMU, 2022).

This modification of the transformer oil cooler tube has been applied during the periodic maintenance of the Serious Inspection Unit 2 and Maintenance Outage Unit 1 in 2021, by replacing the oil cooler that has experienced a leak and is also indicated to have a leak.

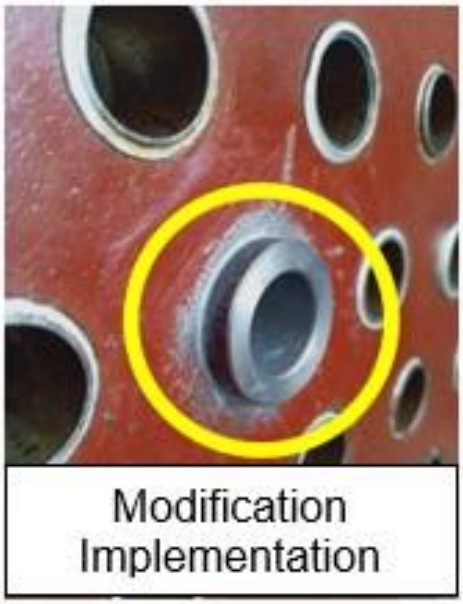

Figure 9. Implementation of Modifications on Oil Cooler GT PLTU Labuan

4. CONCLUSION

From the evaluation of the implementation of the Modified Oil Cooler Generator Transformer or abbreviated as "MODERATOR" at PLTU Banten 2 Labuan, the following conclusions are obtained:

a. Modification of the oil cooler is done by changing the material and increasing the length of the expanded tube dimensions.
b. Modification of the oil cooler resulted in an increase in EAF of 3.33% from the achievement of monthly performance.
c. There have been no reports of oil cooler leaks for 20 months of operation since the implementation of modifications to Maintenance Outage Unit 1 and Simple Inspection Unit 2 in 2021.

d. Modification of the oil cooler can increase the power production of the power plant by 6.72 GWh or 0.25% of the annual production of PLTU Labuan by minimizing the occurrence of oil leakage disturbances in the Oil Cooler transformer.
e. Modification of the Oil Cooler reduces the transformer maintenance costs of PLTU Banten 2 Labuan by 0.11%.
f. Utilizing a used oil cooler that has a tube that is still in good condition so that it can be reused after modifications are made.

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