# Analysis and Improvement of Damage to a 1200-Amper Rectifier Causing Current Surges During the Anodizing Process

## Final Project

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**2026**

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Batam, 29 juni 2026

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**The Final Project is structured to fulfill one of the requirements for obtaining a degree**
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## Abstract

Study this aim for analyze reason occurrence surge current in the rectifier system in the production process as well as evaluate effectiveness action improvements made for increase stability system. The method used is approach analysis cause and effect using a fishbone diagram that identifies four factor main reason disturbance, namely factor environment, factors operational factors machines, and factors human. Research results show that instability current caused by temperature high environmental conditions, less than optimal ventilation, use of system in a way continuously, and existence damage to components critical like capacitor in the circuit rectifier, IGBT, and module rectifier control, accompanied by weakness implementation maintenance periodically. After it is done improvement actions in the form of replacement damaged components, optimization system cooling, increase ventilation of the work area, as well as implementation of preventive maintenance and inspection periodically, occurs improvement performance significant rectifier system. Research results show level stability current increase up to ±85%, marked with decrease surge current in a way drastically and achieving greater output stable, so that system become more reliable and supportive smooth production process.



Keywords: Rectifier, Current Surge, Anodizing, Fishbone Diagram, Preventive Maintenance.

# Foreword

This section contains the author's introduction and acknowledgments to individuals and institutions that support this thesis.

Batam,29 juli 2026

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# Analysis and Improvement of Damage to a 1200-Amper Rectifier Causing Current Surges During the Anodizing Process

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Study this aim for identify and analyze factors reason surge current in the rectifier and determine action appropriate repairs. The method used is a fishbone for grouping factor reason to in a number of categories, namely machine, man, method, material, environment, and measurement. Research data obtained through observation field, measurement of main parameters of rectifier, inspection condition module control, busbar, cable, terminal, panel temperature, and anodizing reject data. Research results this expected can show factor reason dominant influencing surge current in the rectifier, so that can determine action proper repair for increase stability current, lowering number of rejects, and fix quality anodizing results[1][2].

***Keywords: Charger Connector Assembly, Fishbone Diagram, Semi-Automatic System***

## I. INTRODUCTION

Rectifier is one of the device electronics lots of power used in various sector industry for change current alternating current (AC) becomes current direct current (DC)[3]. In the system industry, stability current the rectifier output is very important factor because influential direct to reliability equipment and continuity of the production process. Rectifiers that work in a way stable will produce output appropriate current and voltage with process requirements, whereas output instability can cause disturbance operation, decrease performance system, as well as increase risk damage to connected equipment.

Various study show that the performance and reliability of the rectifier are affected by the conditions internal components as well system supporting components. like capacitor electrolyte, module controls, busbars, terminals, cables, and components electronics Power other can experience degradation consequence continuous use, temperature high operations, as well as factor environment. Decline performance component the can cause occurrence fluctuations current, surge current surge, increased ripple, and instability voltage output that has an impact on decreasing rectifier performance.

Besides factor components, conditions environment operations also have an effect to rectifier stability. Temperature high temperature environment, high humidity, poor ventilation adequate, and exposure steam chemistry can accelerate the corrosion and degradation process component electronics. Condition the can increase resistance on the path delivery person current, disturbing system cooling, and ultimately causes the rectifier to work outside normal conditions.

Based on results observation field on the 24 volt 1200 amper rectifier at PT ENNOVI integrated engineering services batam, found problem in the form of surge current and output of the rectifier that is not stable during the operation process ongoing[4]. Inspection results beginning show a number of indication causes, including damage to the module control, loose busbar connections, oxidized terminals, system suboptimal cooling, as well as not yet monitoring of parameters is carried out routine. Condition the show that stability rectifier current is affected by various factors interrelated factors related so that required comprehensive analysis for determine root reason problem.

Effectiveness action repair evaluated through comparison rectifier performance before and after improvements were made, including stability output current, condition components, as well as operating parameters others. Research results this expected can increase reliability rectifier system, reduces occurrence surge current, and support operation more systems stable and efficient.

Figure 1 Improved rectifier 12volt 1200A.

Figure 1 Rectifier or rectifier wave is one of the media that works for change signal AC (Alternating Current) voltage becomes DC (Direct Current) voltage. Circuit rectifier can made with utilise diode. Rectifier half wave use one diode, whereas rectifier wave full using 2-4 diodes or can use bridge diode. In addition diode, needed component in the form of resistors and capacitors[5].

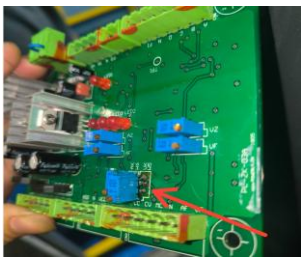


**Figure 2 rectifier control modul.**

Figure 2 illustrates rectifier module that is experiencing damage to parts component his that is functioning potentiometer for regulates the voltage and amperage of the rectifier. Damage to the module control can cause surge current, output instability, or system no can controlled. Therefore, the module control be one of focus main in study This.

Besides cause fluctuations current, damage to the module control also has the potential bother overall rectifier system. In conditions certain, rectifier can experience error parameter reading, difficulty maintain current according to set point, even no can controlled optimally. If condition the left alone in a way continuously, then can speed up degradation component others, improve amount reject products, and reduce reliability anodizing system.

## II. Method

Fishbone method or cause-effect diagram used in study this for identify and group various potential factors cause occurrence surge current in the rectifier is 24 volt 1200 ampere during the anodizing process. Analysis done based on results observation directly in the field, interviews with technicians and operators, as well as inspection document maintenance. Factors identified causes then grouped to in six categories, namely machine, man, method, material, environment, and measurement[6].

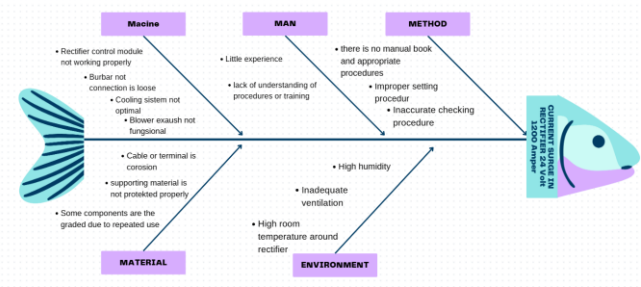



**Figure 3Fishbone Diagram Analysis**

In the category machine, identified factors covering fault in rectifier control module, connection loose busbar, and system suboptimal cooling. Disturbances in the module control can cause instability output current and voltage so that trigger occurrence surge current. Besides that is, a loose busbar connection can increase resistance contact, whereas system suboptimal cooling can cause increase lowering temperature performance rectify.

In the category man, the cause main is lack of operator experience as well lack of understanding to procedure work and training. Conditions this make it difficult for operators detect symptom beginning disturbance like fluctuations current, increase panel temperature, or decline quality connection electricity, as well as potential happen error in parameter settings and handling rectifier fault.

In the category method, cause main is no availability of clear manuals or sop, errors setting curren, voltage and process time parameters, as well as procedure insufficient inspection routine and accurate. Condition this can causing the operator not to own reference uniform work, system working outside normal limits, as well as damage small no detected until develop become disturbance serious.

In the category material, cause main is corrosion on cables /terminals, insufficient material protection good, and decline performance component consequence use term long. Condition this can increase resistance, disturbing stability current, and speed up damage component like capacitors, connectors, and modules rectifier control due to humid and corrosive anodizing environment.

In the category environment, factors reason is humidity high, poor ventilation good, and temperature high room. Condition this can trigger corrosion on components, causing accumulation hot or overheating, as well as lower performance and speed up damage module rectifier control.

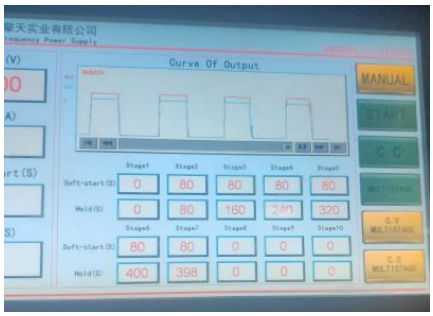
In the category measurement, reason main is no existence inspection routine current and voltage, no availability monitoring temperature, and no he did calibration tool measuring in a way periodically. This is can cause parameter changes do not detected since early and taking decision technical become not enough accurate.

Based on fishbone analysis, category machine is the most dominant factor reason surge current in the rectifier. Root problem main originate from disturbance in the functioning rectifier control module arrange stability current and voltage. Therefore that, research this focused on improvement and enhancement performance module control for increase stability current and quality of the anodizing process.

## III. Result

This chapter serve results analysis conducted for identify reason occurrence surge current and output instability on the rectifier used in the anodizing process. Purpose main analysis This is for identify in a way comprehensive contributing factors to occurrence disturbance as well as determine root reason problem. The Fishbone method is used for identify and group various factor reason in a way systematic based on six categori, namely machine, man, method, material, environment, and measurement. For validate results analysi, carried out visual inspection and measurement directly on the rectifier system, especially on the module controls and components electronic related. Visual inspection is carried out for identify damage physical, whereas measurement electricity done for evaluate condition and performance component critical. Analysis

results the become base in determine action improvements to the module rectifier control function increase stability current.




**Figures 4. Before Graphic Rectifier.**

Based on appearance curve of output, pattern rectifier output shows existence instability in the output level. This indicated by the amplitude pulses that are not uniform and existence decrease in output levels during hold period. Conditions the indicates that the rectifier does not capable maintain current output in a way constant, so that potential cause surge current and reduce quality of the anodizing process[3]. Instability this can affected bay degradation component electronics, such as capacitor electrolyte, module rectifier control, as well as system less than optimal cooling. Based on results observation to curve rectifier output, found existence fluctuations current at each cycle operation. Current value current no can maintenant at a target value of 940 A, but fluctuates in the range of 850–1150 A. Conditions this show that the rectifier system is experiencing potential output instability cause surge current (current surge) during the anodizing process.

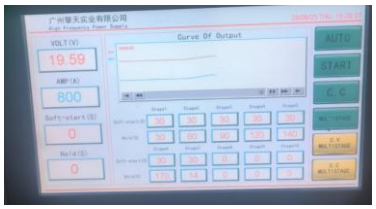



**Figure 5 Rectifier graph after improvement.**

Figure 5 shows multi-stage voltage and current regulation on the 24 volt 1200 ampere rectifier used in the anodizing process. This rectifier operated use system multi-stage control for increase voltage and current in a way gradually use guard process stability and reduce occurrence surge current. Settings voltage programmed in five stages active, namely of 3 V, 6 V, 7 V, 8 V, and 10 V. Each stage own soft-start time of 90 seconds so that increase voltage ongoing in a way gradually. Meanwhile that, the settings current is also divided into five stages, name 184 A, 368 A, 552 A, 736 A, and 940 A, with soft-start time of 45 seconds on each different stages and hold times in accordance with anodizing process requirements.

Improvement voltage and current in a way gradually aim for prevent occurrence surge current that can give burden shock on the rectifier components as well ensure formation layer uniform oxide during the anodizing process. However, based on results observation field, although multi-stage system has applied, still found condition surge current and output instability during the operating process. Conditions the show that instability no only caused by the operating parameter settings, but also influenced by other factors others, such as damage to the module control, loose busbar connections, degradation component electronics, systems suboptimal cooling, as well as condition the environment around the rectifier panel. Therefore that, multi-stage voltage and current regulation data used as one of the main parameters in study This for analyze root reason surge current use fishbone method and determine action proper repair use increase rectifier stability results.

He table below shows the results of a comparison before and after the improvements were made.

TABLE I
Perbandingan Kondisi Rectifier Sebelum dan

| Parameter | Before improvment | | After improvment | |
|---|---|---|---|---|
| Potentiometer condition | The voltage control potentiometer is malfunctioning, resulting in suboptimal output settings. |  | The potentiometer is functioning normally and can adjust the voltage properly |  |
| Condition of the dioda | Subject to degradation due to long-term use and high operating temperatures |  | The dioda functions normally, helping to maintain output stability. |  |
| IGBT/Transistor Condition | There are signs of overheating in the module |  | The components are in normal condition and the system is functioning properly |  |
| Condition of the busbars and terminals | There are loose connections and discoloration caused by excessive heat |  | The connection is better after inspection and tightening |  |
| Cooling system | Cooling is not optimal, causing the panel temperature to rise |  | The cooling system operates more efficiently |  |
| Output voltage | Unstable |  | Stable at 23,63 dan 19,59 V |  |
| Output current | Fluctuating | | Stable within the range 940 amper and 3-10 volt, according to the configured current setting |  Amper Volt |
| Current fluctuations | ±15% from the target value | | ±3% from the target value | |
| Curve of output | It is unstable and frequently experiences current surges | | More stable and with reduced current surges | |
| Anodizing Process Conditions | Has the potential to cause product defects | | The process is more stable and quality has improved | |

## A. Assembly Method Evaluation

Study this evaluate rectifier stability based on operating parameters voltage and current applied to the system control. Settings voltage done in a way gradually through five stages, namely 3 V, 6 V, 7 V, 8 V, and 10 V with soft-start time of 90 seconds on each stage. Meanwhile that, the settings current done in five stages, namely 184 A, 368 A, 552 A, 736 A, and 940 amper with soft-start time of 45 seconds as well as different hold times in accordance anodizing process requirements. Settings gradually the aim for guard rectifier output stability and reduce occurrence surge current in a way suddenly during the process.

Evaluation rectifier stability is carried out through observation field, measurement of output parameters, and inspection to condition module control, busbar, cable, terminal, and system cooler. The stability of the rectifier is determined based on ability system in maintain current and voltage output in accordance with the parameters that have been set without happen excessive fluctuations. Result data observation then used for identify reason dominant output instability using fishbone method. Analysis results This expected can become base in determine action proper repair for increase rectifier stability and maintain consistency quality of the anodizing process.

## B. Bone diagram analysis

Based on the Fishbone diagram that has been mapped, analysis focused on identification potential factors cause surge current in the rectifier during the anodizing process. Analysis results show that factor reason originate from category man, machine, method, material, environment, and measurement. From the results said, category machine identified as the most dominant factor[6]. The results of the analysis presented in Table X

TABLE I
FISHBONE TABLE ANALYSIS RESULTS

| Category | Potential cause | Current Control | Action Required |
|---|---|---|---|
| Man | Lack of understanding to procedure Work | No existence book a guide that explains procedure rectifier repair and adjustment . | √ |
| Machine | Damage to the rectifier control module, loose busbar connection | The examination was carried out moment happen disturbance, busbar check is carried out in a way periodically. | √ |
| Machine | System cooler No work optimally | Cleaning and inspection fan and AC are done in a way periodic | √ |
| Method | No availability of adequate SOP/manual books | The process is still ongoing referring to experience technician | √ |
| Method | Error process parameter settings | Parameter settings are done manually by technician | |
| Material | Corrosion on cables and terminals, Decrease performance component electronic | Inspection condition cable done in a way maintenance, replacement component done after happen damage | √ |
| Environment | Humidity high in the anodizing area, coolant insufficient panel space adequate | Not yet there is system control humidity special, Cooling using less AC maximum. | √ |
| Measurement | No existence inspection routine current and voltage, no done calibration tool measuring in a way periodic, no availability tool indicator panel temperature | Measurement done moment happen disturbance, no existence calibration tool work. Monitoring temperature still being done manually | √ |

Based on results Fishbone analysis, several factor reason surge the current on the anodizing rectifier is successful identified. From all over factors found, the machine category is the most dominant factor, especially fault in the rectifier

control module. This module functioning for organize and maintain stability current as well as voltage supplied output to anodizing tank. Disturbance or decline performance on the module control will in a way direct influence stability of the rectifier output so that cause fluctuations and spikes current during the anodizing process.

Verification results show that the rectifier control module has operate in a way continuously in condition current tall in term long time. Operation continuous the potential speed up degradation component electronics inside series control, such as capacitor electrolyte, component semiconductor power, and driver circuit. Decline performance components the can reduce ability module in arrange corner ignition (firing angle) and maintaining stability of DC output, so trigger occurrence fluctuations and surge current during the anodizing process.

Besides module control, system the cooler is also identified as factor support occurrence disturbance. Fan performance cooling and ventilation on the rectifier panel are assessed less than optimal in throw away heat generated during operation current high, then lack of system cooler maximum panel space. As a result, there is accumulation heat inside the panel which increases temperature work component electronics. Improvement temperature This can speed up aging components, lowering reliability system, and ultimately cause module error control.

Anodizing area environment has humidity height and exposure steam chemistry also participates contribute to decline performance system. Condition the can speed up occurrence corrosion on busbars, terminals, connectors and joints electricity others. Connections that experience corrosion or leniency will increase resistance contact so that cause hot excessive and causes flow current become no stable. Condition this the more make things worse rectifier performance in general

From the side factor human man, lack of operator experience and lack of understanding to procedure operation and rectifier maintenance can cause error in process parameter settings as well as delay in detect symptom beginning disturbance. The operator's inability to identify indication like fluctuations current, increase panel temperature, or decline quality connection electricity can cause disturbance develop become surge more current serious. Therefore that, combination between temperature high environment, the use of rectifiers is continuous, and factors man allegedly become reason main occurrence surge current in the rectifier system

## IV. Discussion

This chapter serve discussion results analysis reason occurrence surge current in the rectifier system obtained by Fishbone. The main focus discussion this is, discussion This explain about function from Analysis fish bones provide base theoretical for reason potential from damage, provide supporting evidence findings the.

### A. Fishbone Diagram Analysis

Fishbone diagram analysis identifies three category main reason occurrence surge current in the rectifier system, namely factor environment temperature, factors operational use continuously, and factors human (man). Factors the then described more carry on become more causes specific, such as poor ventilation, temperature high environmental exposure steam chemical properties corrosive in the panel space area, as well as lack of operator experience and understanding of procedure rectifier operation.

Analysis results show that temperature is the most dominant factor because the rectifier is operating in a way continuous on current tall during the anodizing process. Conditions this cause accumulation heat inside the panel, especially when system ventilation no work optimally. Improvement temperature in a way continously can speed up degradation component electronics, such as capacitor electrolyte, semiconductor power, and modules rectifier control, so that lower ability system in guard stability current output.

Besides that, the use of rectifiers in continously without period rest is also potential speed up decline performance components. Operation in term long time cause component experience pressure thermal in a way repeatedly, which in the end can reduce reliability system and improve possibility occurrence surge current. Condition environment in the anodizing area which has humidity height and exposure steam chemistry can also speed up occurrence corrosion on terminals, busbars and connectors electricity. Corrosion on the connection electricity can increase resistance contact, produce hot excessive, and causes flow current become no stable.

From the side factor human (man), lack of operator experience and lack of understanding to procedure operation and rectifier maintenance can cause error in process parameter settings as well as delay in detect symptom beginning disturbance. The operator's inability to identify indication like fluctuations current, increase panel temperature, or decline quality connection electricity can cause disturbance develop become surge more current serious. Therefore that, combination between temperature high environment, the use of rectifiers is continuous, and factors man allegedly become reason main occurrence surge current in the rectifier system.

## V. Conclusion and Suggestions

Based on results research that has been done about analysis and improvement damage to the 24 volt 1200 almpere rectifier which causes occurrence surge current during the anodizing process, it can concluded that fishbone method is successful identify various factor reason occurrence surge grouped currents to in six categories, namely machine, man, method, material, environment, and measurement. Of the six categori in this case, the machine factor is the most dominant factor, especially damage to the rectifier control module, system the cooler is not work optimally, as well as loose busbar connection. Besides that, factor environment in the form of temperature high humidity

high, poor panel ventilation good, and exposure steam the chemistry in the anodizing area also contributes to acceleration degradation components and reduction performance rectifier system.

Observation result show that before done repair, making it unable to maintain the current at the target value of 940 amperes. Condition the potential causing current surges which can lower quality anodizing results. In addition factor technical, lack of operator understanding of procedure operation and maintenance of rectifiers is also one of the reason occurrence disturbance. Therefore that, action repair in the form of repair module control, improvement system cooler, as well as implementation maintenance and monitoring of parameters on an ongoing basis periodically can increase rectifier output stability and support better quality anodizing process good.

Based on results research that has been done, it is recommended that the company implementing preventive maintenance programs periodically to all over component critical rectifier, especially on the rectifier control module, busbar, terminal, cable, and system cooler. Besides that, it is necessary done monitoring routine to operating parameters like current, voltage, and panel temperature as well do calibration tool measuring in a way periodically so that changes condition system can detected since early before develop become more disturbances Serious.

Companies are also advised for increase system ventilation and cooling on the rectifier panel as well provide system control moisture in the anodizing area to reduce impact environment to performance component electronics. In addition that, the arrangement clear SOP and manual book about operation, adjustment and maintenance of the rectifier is necessary done for increase understanding of operators and technicians. For study next, it is recommended do more analysis deep to characteristics and degradation component electronics on the module rectifier control so that root reason damage can identified in a way more specific and accurate

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# Attachment

Please enter the required attachments. If necessary, attachments can be split into Appendix A, Appendix B, and so on