Employment at Mercury

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Report Submitted : 2024-03-18 PASSED

Assigned Marks : 25 / 25 (Grade : A)
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Marker : [redacted]

Student : [redacted]
Specialisation : Chemical & Materials Engineering
Student Group : [redacted]

Uploaded Report
[redacted]

Scoring Rubric

Section One	**Passed Section** If you pass Section One you still need to pass Section Two.			**Failed Section** If you fail Section One you will be asked to resubmit the report.			5/5
Section Two	**Passed Section** If you pass Section Two you will still need to pass Section Three			**Failed Section** If you fail Section Two you will be asked to revise and resubmit the report.			5/5
Section Three Part A : Structure of the Report	Excellent	Above Average	Satisfactory	Room for Improvement	Below Average	No Marks	5/5
Section Three Part B : Quality of the Report	Excellent	Above Average	Satisfactory	Room for Improvement	Below Average	No Marks	5/5
Section Three Part C : Presentation of the Report.	Excellent	Above Average	Satisfactory	Room for Improvement	Below Average	No Marks	5/5

Existing Admin Verified hours

No additional time added.

Administrator Add Verified Hours

Administrator Details

[redacted]

Verified Hours Hours Type

Mercury NZ

Practical Work Report

Optimisation Engineering Intern

20th November 2023 – 16th February 2024

[redacted]
12.02.2024
Department of Chemical and Materials Engineering

SUMMARY

This report summarises my internship at Mercury Energy in Rotorua. Mercury is a leading NZ power company that generates electricity solely through renewable sources such as geothermal, hydropower and wind. This report includes an overview of the Rotorua office and an example of the Ngātamariki power plant, and work culture at Mercury, as well as an explanation of the various tasks I was involved in during my employment.

I was an Optimisation Engineering Intern, where I undertook several projects including collation of operating limits documents for the Rotokawa and Ngātamariki geothermal plants, and performance review of chemical cleaning on the preheaters at Ngātamariki.

I was able to obtain incredibly valuable insight into the power generation industry, specifically geothermal power, where I learned a lot about the process and operation, as well as having the opportunity to collaborate and learn from other staff members within the company and understand their roles to ensure the safe and smooth operation of a process plant.

ACKNOWLEDGMENTS

I want to extend a big thank you to Mercury NZ for allowing me the opportunity to experience an internship at the company. I am incredibly grateful for the exposure to the power generation industry, and it has enriched me with very valuable experiences and learnings and makes me excited for my future as a chemical/ process engineer. I also appreciate the effort that Mercury puts in to make the interns feel welcome by organising three intern gatherings to get to know the other students from the Rotorua, Hamilton and Auckland offices and allow everyone to get a taste of different roles within the company.

I also thank my supervisor, [redacted], for supporting me in this role. I am so grateful that he was always willing to help me by answering all my questions, assisting me in my projects and being someone to have banter or a good chat with. I truly appreciate the support that [redacted] gave me during the internship, and it was so valuable to have such a knowledgeable and dedicated supervisor who would put in effort to make sure that I am on track with my projects.

Next, I thank all the other staff at Mercury, both in the office and on site who made me, and the other interns feel welcome to the company and the town and imparting their knowledge through informative conversations about their roles, and suggestions for activities outside of work, especially mountain biking routes.

Finally, I thank the other interns in the office for their moral support and ability to have light-hearted conversations about all sorts of topics and coming up with some very questionable dad jokes.

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INTRODUCTION

Mercury is currently the only electricity and power company in New Zealand that generates electricity from 100% renewable sources including geothermal, hydro and wind power.

My role at Mercury was working as an Optimisation Engineering Intern in the Rotorua office, focussing entirely on the geothermal processes, and working on the operating limits project and caustic cleaning performance review on the preheaters at the Ngātamariki plant. I was able to gain a deeper understanding of how geothermal energy is harnessed to make electricity, as well as putting knowledge I had learned at university to real world applications, such as reading and understanding Piping & Instrument Diagrams (P&IDs) and calculating heat transfer coefficients of heat exchangers.

COMPANY INFORMATION

Power Generation

Mercury operates five geothermal power plants (Kawerau, Rotokawa, Ngā Awa Pūrua, Mōkai and Ngātamariki) located in the central North Island mostly between Rotorua and Taupō, except for the Kawerau plant. Mōkai and Rotokawa/ Ngā Awa Pūrua are run in partnerships with Tuaropaki and Tauhara North No.2 Trusts respectively, thus Mercury does not have full ownership of the sites. Geothermal generation provides baseload electricity for the consumers as it is a stable source of generation, whereas hydropower generation is more variable, and can be adjusted according to demand, by allowing varying amounts of water through the gates.

There are nine hydro stations along the Waikato River (Karāpiro, Maraetai I & II, Ōhakuri, Arapuni, Whakamaru, Aratiatia, Waipāpa, Ātiamuri) and the Taupō Control Gates which control the levels of Lake Taupō and the river. The lakes have strict restrictions on water levels which must be consistently adhered to preserve the environment and abide by consent rules.

Finally, Mercury has acquired five wind farms in the lower North Island and bottom of the South Island, with four development opportunities in progress to increase generation.

Office Layout

The office has an open plan layout with hot desks with several monitors which staff can connect to with their work laptop. This concept also allows people to go to any site and do the same work that they can in the office. There is around 100 staff members stationed to the Rotorua office, however, typically there is only half that number that come into the office. Mercury is a very flexible company that allows staff to work from home, which is convenient for myself as I could work from home in Auckland some days when driving down to Rotorua late on a Sunday night was not ideal.

There was also a full kitchen (with a pretty good coffee machine!) and comfortable seating, both inside and on the deck outside, where us interns would have lunch – it became known as the ‘Kids Table’. The

interior of the office was bright and colourful, with numerous collaboration spaces, and decorated with lots of plants, giving it a comfortable and casual vibe.

Ngātamariki Geothermal Power Plant

I had many opportunities to go onto the geothermal plants at least once, however, my regular jaunt was to the Ngātamariki station. This plant is Mercury's newest geothermal site, commissioned 10 years ago, it generates 96MW of power from four identical 24MW OEC (Ormat Energy Converter) units.

Figure 1: Aerial view of Ngātamariki plant, New Zealand in March 2013 (source: Mighty River Power)

At the site, there is a central office which also has hot desks for staff, making it seamless to carry out work from there. There is also the control room for the operators to monitor and adjust plant operations if needed, however, as of November 2023, Ngātamariki is now remotely controlled from the Ngā Awa Pūrua plant ~10km to the south. On site (excluding the office), it was compulsory to wear full coverage clothes (long sleeve shirts and long pants), hi-vis vests, as well as safety boots, hard hats, and safety glasses. This was imperative in the event of any accidents; everyone has the appropriate protection.

During my internship, I was predominantly focussed on the Ngātamariki plant, so I became quite familiar with the layout of the site and its process. It is a binary station, which uses both brine and steam as heat sources to vaporise pentane in a closed loop cycle, which is used to spin the turbines that generate the electricity. After passing through a series of vaporisers, preheaters and superheaters, the brine and steam (which is condensed to liquid condensate after the vaporiser) returns to the underground reservoirs through the reinjection wells, which allows the fluid to reheat over time to eventually be extracted again by the production wells.

The other type of plant is called a flash plant, where a two-phase fluid is extracted from the ground, then passes through a series of separators ranging in pressures to flash the liquid to steam, before passing through a turbine to generate electricity. This eliminates the need for pentane within the plant. Both Kawerau and Ngā Awa Pūrua are flash plants.

Work Culture & Environment

The office is in the Ōwhata suburb of Rotorua, near the entrance to the Redwoods, which makes it an ideal location for after work activities such as mountain biking, trail running or hiking. Such activities are common amongst the staff members and there are many social groups. There are also competitions throughout the office such as a mountain biking/ running competition to see who could complete the most trails around the area over the summer.

During the first week of my internship, the Rotorua office had their Christmas lunch at the Skyline Stratosfare restaurant near the luge, which was a great opportunity to bond with the other interns and permanent staff, as well as experience something I otherwise wouldn't have usually done. Additionally, the office has monthly drinks and nibbles evenings, which were a fun way to catch up with colleagues in a casual setting.

To make us interns feel welcome, Mercury organised three intern gatherings so we could get to know the other students in the Hamilton and Auckland offices. The first gathering was during my second week, where we travelled to the Hamilton office and listened to many presentations from staff amongst many different areas of the business such as intro to geothermal and hydro generation, how the trading and hydro control desks work (person who buys electricity from Transpower at set prices, and someone who controls all the dam levels as well as how much flow is going through each hydro station). Our second gathering was a site visit to Karāpiro and Ngātamariki stations, which was very interesting as I had little to do with the hydro stations, and it was fascinating to visit one. Finally, at the end of the internship, we presented individually to the other interns and supervisors about our internship experience. This was interesting as we could listen to the different projects that the other interns worked on during their time at Mercury and hear their experiences and learnings throughout the internship.

Figure 2: Group picture of the Rotorua office interns at Ngātamariki Geothermal Power Plant

It is also a tradition for the interns to make and decorate a cake to be judged by the other staff in the office. We made our cakes in the office on the last week of the internship and was judged by the office for the best design, through a poll vote on the office Teams chat. As it turned out, my design was the most voted, as I had decorated a jam-filled sponge cake with an original PFD that I had drawn over the course of the summer for one of the units. My cake is shown in in figure 3.

Figure 3: My winning cake, decorated with a PFD of the Rotokawa OEC11.

Finally, as part of the optimisation team, I was fortunate enough to be a part of their team building activity where the whole team went ziplining on my last day of the internship. This was such an awesome day out, and it was fun to get to know everyone in the team better, and I am very grateful that this event was organised to include me.

Overall, my experience of the work culture at Mercury was very positive and the environment was also a casual yet professional setting as everyone knew their role and would perform their tasks to a high standard.

WORK EXPERIENCE

I completed my internship at Mercury in Rotorua as an Optimisation Engineering Intern. I had two main projects during the three months of employment: collating operating limits for the Rotokawa and Ngātamariki plant, as well as performance review after caustic cleaning of the preheaters at Ngātamariki.

Operating Limits

I was tasked to collate and define the operating limits for the Rotokawa and Ngātamariki plants. As there was no defined process for tracking the limits, it was important to create documentation that would describe those limits for each unit on the plants. As part of this project, I had to create Process Flow Diagrams (PFDs) for each of the OEC (Ormat Energy Converter) units, which displayed the heat and

mass balance data, control valve locations, instrumentation, major pipelines, as well as maximum generation for each unit, and piping specifications showing maximum design pressure and temperatures.

I also had to collate all the control setpoints for the units which would sound alarms or trip the units if breached. This was displayed in both a document and an Excel register which collects live values for temperature, pressure and fluid level from the PI Processbook software and calculates the number of minutes that the unit breached the setpoint over the last three months.

Finally, I worked with process engineers to determine troubleshooting methods and actions for operators to conduct should they see on their control dashboard if the operating limits are breached.

During this project, I became very familiar with both the sites, especially Rotokawa which has a more complex layout – having four OEC units, two use the geothermal brine as the heat source to vaporise pentane, which is pressurised, then expanded in the turbine to generate the electricity. The other two OEC units are identical and are called ‘bottoming units’ which use the expanded steam from the large steam turbine generator, to vaporise the pentane for the turbine. The pentane is in a closed loop cycle, and is used due to its low boiling point, which makes it easy to vaporise. However, using pentane in large quantities makes the plant a ‘Major Hazard Facility’, thus there are more safety procedures to adhere by to ensure everyone on site goes home safely.

Through this task, I also completed a full plant diagram of the steam field and separator system at Rotokawa, which included information of the production and reinjection wells. The Rotokawa geothermal field is shared with the Ngā Awa Pūrua plant, therefore the production wells are also shared. On one day, two of the interns and I went for a ‘tiki tour’ around the Ngātamariki and Rotokawa sites to find all the wells – one of the interns was carrying out investigations for the rupture disk information on all the wells, and another had to measure the top of a well for their project, so we all decided to go together.

This was a fascinating experience to tour around the geothermal fields and find the wells, which I was surprised to see how underwhelming a well site is (shown in figure 4) – after all, it is just a hole in the ground!

Figure 4: One of the reinjection well pads from the Rotokawa field.

Caustic Cleaning

The preheaters at Ngātamariki exhibit pressure drops and decrease in heat transfer due to buildup of scale on the brine side (shell side) of the heat exchangers. Thus, a caustic cleaning regime was carried out by an external contractor to dissolve the scale to, theoretically, increase the performance of the exchangers. Caustic soda was used instead of acid due to an educated guess that the preheaters were fouled by stibnite (Antimony Sulfide, Sb_2S_3), which dissolves in caustic conditions. Over four days in December 2023, each of the identical OEC units were shut down for a day to conduct the cleaning, which involved pumping ~5m^3 of 98% caustic soda through the preheaters and allowing it to circulate for several hours.

Ideally, the preheaters were maintained at a temperature of 85°C and circulated for three hours, however, due to specific circumstances, this was not often the case. I was tasked to collate data from two weeks before and after the clean, to calculate the pressure drop and heat transfer coefficient over the preheater series and calculated the percentage change. I also carried this out for the two previous cleans in September 2019 and February 2022, and compared the results between the cleans. To analyse the efficiency of the cleaning, the unit with the most efficient clean had the lowest pressure drop and highest heat transfer coefficient, which I found interesting that it wasn't the unit with the greatest percent change.

It was important to conduct this performance review to determine how much of an effect the cleaning has on the generation of the plant. I also compared the past cleans to gain insight into the factors that influence the cleaning efficiency, such as the circulation time and temperature, which is beneficial to Mercury for the future cleans.

REFLECTIVE APPRAISAL

Reflecting on my internship experience, I acknowledge that I have learned a multitude of skills, both professionally and personally, including:

Process Safety

Despite having learnt about process safety during classes at university, it was valuable to understand how safety mechanisms play a part in geothermal operations. Maintaining a safe workplace for everyone is an integral part of any live plant, and process safety is paramount to achieving this. I learnt about safety critical elements within the plant, such as rupture discs, and pressure relief valves, and as part of my task creating the PFDs for the units, I had to identify the locations and set pressures/temperatures for these devices.

On one instance during my internship, a rupture disc connected to one of the high-pressure production pipelines had burst 30 minutes before I had arrived on site, spewing steam into the atmosphere. I got the opportunity to go with some of the maintenance staff to close the valve with the burst rupture disc and open one of the back-up valves. While I was near that vicinity, I could feel the immense amount of energy coming from the pipe, even standing 30 meters away, shown in figure 5. At a set pressure and temperature, the rupture discs are meant to pop open like a flower and allow for quick pressure relief, however, on this instance, several pieces of the rupture disc were found 20 meters away from the valve. This was an unnatural phenomenon, potentially due to corrosion on the metal, shown in figure 6.

Figure 5: Steam expelling from the pipe after the burst disc ruptured.

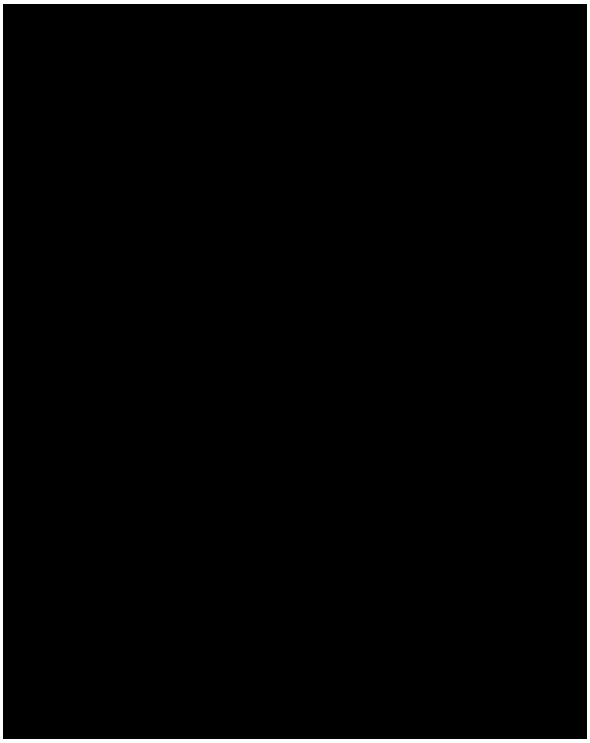

Figure 6: Burst rupture disc in two pieces.

Upon reflection, I understand the high importance of having regular maintenance procedures and inspections of the safety critical devices, to ensure that these events do not happen, and to protect the workers and equipment.

Communication

One thing I quickly learnt while carrying out my Operating Limits project was how limited documentation the older stations have. The Rotokawa plant was constructed almost 30 years ago, and

since then, upgrades have been undertaken to improve the power generation of the plant. However, due to its age, many of the original, as-built documentation was not readily available, thus I had to communicate with engineers responsible for the running of the plant to confirm any assumptions I had made, primarily with the heat and mass balances.

I also found that most of the people in the office were incredibly knowledgeable, and it was fascinating to talk with them and understand how their roles fit into electricity generation. For example, although my role had minimal contact with the process safety team, my natural curiosity led me to spark conversation with members of that team. I found it was interesting to learn about the safety critical devices and it helped me gain an insight into safe management of processes in a plant.

Problem Solving

Due to the lack of documentation for the plants, I would often encounter issues where there was no information for a particular unit operation/stream, or conflicting values. I had to problem solve how best to resolve those issues, typically by making educated assumptions about the design of the unit. I quickly began to reinforce the knowledge that the heat and mass balance is created based on near-ideal situations, so it was typically a correct assumption that the temperature of a pipe remained constant through a valve, for example.

I found that this problem solving honed both my technical and analytical knowledge, and although I had connections with any of the specialist engineers/ technicians that would help me solve it, I found it more valuable for myself to try work through the problem first by myself.

Impression on the Company

After three months at Mercury, I can confidently say that I am impressed with the company and especially the Rotorua office. From my first day, I was welcomed to the team by everyone and was made to feel like valued. During the internship, I worked on meaningful projects which enhanced my skills and knowledge as an aspiring process engineer, which was exciting as it didn't seem like the stereotypical 'intern project'. I felt that I had a sense of purpose within the company, and I am grateful for the assistance of my supervisor, [redacted], who undoubtedly helped my professional development throughout my internship. Overall, my time at Mercury has left a lasting and positive impression, and I am incredibly grateful for the insight and experience that I gained, and I would not hesitate to work there again.

CONCLUSIONS

In conclusion, my internship at Mercury was a valuable opportunity to gain real-world experience and insight into geothermal energy generation, and the power industry.

I now appreciate how much goes on behind the scenes of a geothermal power plant, from maintenance, process safety, optimisation, reservoir engineering, and other important roles that all fit together to produce electricity.

My internship has allowed me to have real-world experience in optimisation engineering, by working on a meaningful project, which I hope will benefit a variety of people in the future.

On a personal note, the internship has successfully honed the soft skills required to become an engineer. These included communication with all ranges of staff members and having the opportunity to problem-solve the challenges that arose.

I am very grateful for the opportunity to experience an internship at Mercury. The knowledge and skills gained will undoubtedly serve as a solid foundation for my future endeavours as a process engineer.