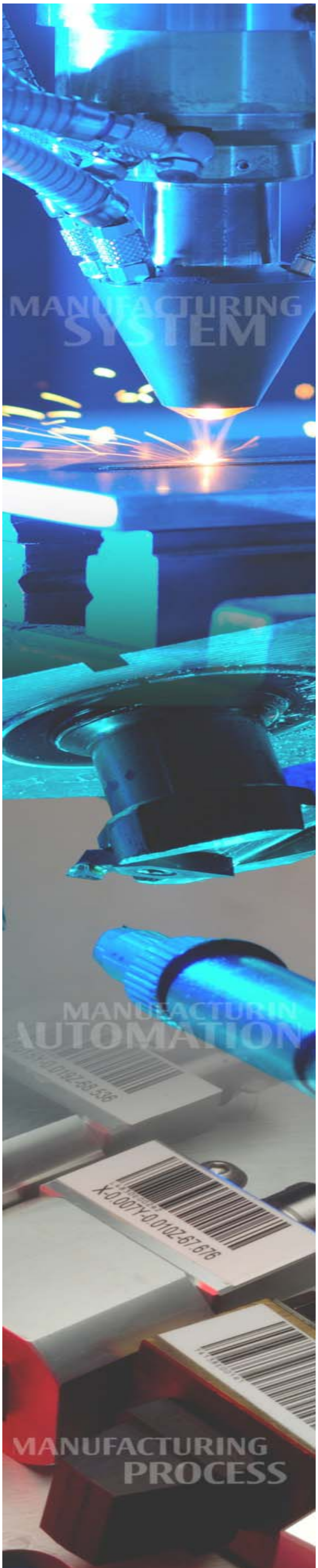

Project Report

Project Title:

Energy Efficiency Assessment of Innovative Polymers DeCalon (DCI) System for SIMTech Valley Block Water Cooling Tower System by E2MAPS

CONFIDENTIAL

Control No. (by KTO):__________________

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Date: 20/01/2016 (Updated on 11/02/2016)
Project Title: Energy Efficiency Monitoring, Analysis and Planning for Solutions (E2MAPS) for Innovative Polymers Pte Ltd
Project Code: I15-E-125W

Title of Case Study

Energy Efficiency Assessment of Innovative Polymers DeCalon (DCI) System for SIMTech Valley Block Water Cooling System by E2MAPS

Singapore Institute of Manufacturing Technology (SIMTech) is a member of the Agency for Science, Technology and Research (A*STAR). www.SIMTech.a-star.edu.sg

V 2.1 15 February 2016

1 EXECUTIVE SUMMARY

Important Note: This section should not disclose any technical detail, know-how of the solutions, or any confidential information.

Innovative Polymers engaged SIMTech as their independent consultants to provide performance assessments on energy monitoring and efficiency analysis for the high energy consumption cooling water systems.

SIMTech has developed an Energy Efficiency Monitoring and Analysis System (E2MAS) which is able to monitor energy consumption of equipment, provide energy consumption statistical analysis, identify and report energy usage patterns. Therefore it is able to provide a comprehensive energy consumption comparison before and after installation of the DCI system.

Innovative Polymers has an eco-sustainable approach and technology – the DeCaIon (DCI) system that can improve energy efficiency of water cooling tower systems by ensuring the heat exchanger system performed at its designed peak efficiency at all time. It is capable of reducing energy consumption by removing the scales and biofouling of cooling tower/water systems. Concrete proof in energy savings after using the DCI system is important for Innovative Polymers to promote its energy saving solution to industry.

The analysis results show that there is **17.5%** increase in energy efficiency with use of the DCI system in SIMTech VB cooling tower system. An average consumption comparison for without-using vs. with-using of the DCI system is **52.62kW vs 43.41kW**, which is about **80,680kWh** annual energy saving or **S$16,418** annual cost saving (rate: $0.2035/kWh). In addition, the measured temperature and humidity has a narrower variance, are much closer to the set points and are much more stable. This energy saving will translate to a carbon footprint reduction of **34,950 kgCO_2** per annum (Source: EMA Emission Factor 0.4332kgCO_2/kWh).

2 CASE BACKGROUND

The context and background of the case study; purpose of the report; objectives, definition of the problem or issue to be examined; explanation of the parameters; limitation of the situation; organisation of the report.

There is a huge market in energy efficiency improvement for cooling tower/water systems and for industrial process applications where temperature and humidity control is vital to ensure better product quality and yield. Innovative Polymers has an eco-sustainable approach and technology – the DeCaIon (DCI) system that can improve energy efficiency of cooling tower/water systems by ensuring the heat exchanger system performed at its designed peak efficiency at ALL time. It is capable of reducing energy consumption by removing the scales and biofouling of cooling tower/water systems. Concrete proof in energy savings after using the DCI system is important for Innovative Polymers to promote its energy saving solution to industry.

This will be beneficial not only to Innovative Polymers but also to SIMTech (as a neutral party) which provides E2MAS if both parties could collaborate in penetrating the market by sharing the customer base in Singapore and abroad.

3 PROBLEM OR ISSUE TO BE ADDRESSED

Document the problem or issue faced by the organisation with regards to the overall objective that is desired. Try to highlight one major problem per case study.

The issue or objective to be addressed in this project is to determine whether the DCI system can improve the energy efficiency of the cooling tower/water system and the percentage improvement that can be achieved after deploying the DCI system.

The desired tangible results could be in energy savings (kWh) or annual cost savings (S$) or % energy efficiency improvement after deploying the DCI system.

4 THEORY / FUNDAMENTAL INFORMATION FOR READING

List some theoretical and fundamental information or reference for the readers to learn more about key aspects of the case.

DCI working Principle:

The patented DCI works by basic electrochemistry principle.

What differentiates DCI is its unique ability to remove scale just sufficient to maintain good heat transfer efficiency but not excessively to cause corrosion. This is achieved by our state of the art DCI Intelligence Controller.

The electrolytic process removes the scale and disturbs the chemical balance of cooling water. The concentration gradient created will dissolve the existing scale as a means to restore the equilibrium according to the Le Chatelier 's Principle.

Reactions at the cathode surface

Two types of processes occur :

1) Cathodic Reduction Process
2) Precipitation Process

The alkaline environment induces precipitation of the Calcium Hardness in the form of $CaCO_3$ and of the Magnesium Hardness, in the form of $Mg(OH)_2$ .as follows:

$Ca^{2+} + HCO_3^- + OH^- = CaCO_3 + H_2O$
$Mg^{2+} + 2OH^- = Mg(OH)_2$

Reactions at the Anode surface

Two types of processes occur :

1) Anodic Oxidation Reaction
2) Acidic Catalyzation Reaction

Anode oxidation reactions, which are a whole series of reactions result in the formation of gases and biocides. The quantity of biocides will depend on the water chemistry. The biocides will disinfect the water

$2Cl^- - 2e = Cl_2$ (chlorine)
$2OH\cdot = H_2O_2$ (Hydrogen Peroxide)
$HCO_3^- + H^+ = CO_2 + H_2O$

5 APPROACHES

Outline the material used, testing environment, tools needed, alternative courses of action available to solve the problem, list the advantages and disadvantages of each course of action, and justify why this approach is selected.

The approaches adopted in this case study are described from different aspects as follows:

- Test-bed: SIMTech Valley Block (VB) Cooling Tower System including Cooling Tower 1 (CT1), CT2, Refrigerant Water Cooling Package 1 (RWCP1) and RWCP2 supplying cool air for MMP/LAP Cleanroom. Figure 1 shows a schematic diagram of the VB Cooling Tower System. The Figure 2 shows the CT1 & CT2 with DCI installation and RWCP1 and RWCP2.

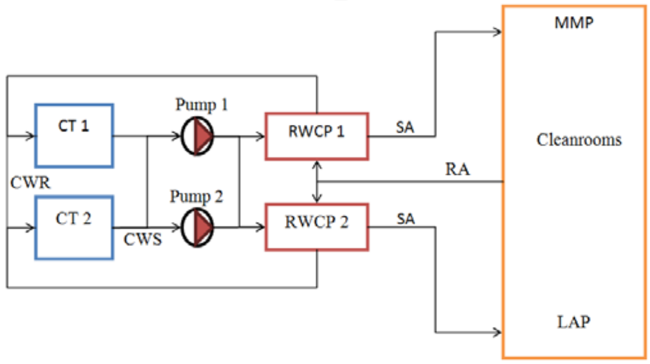


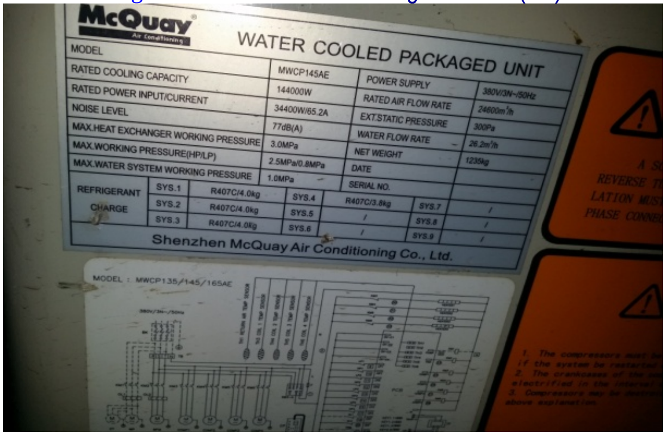
Figure 1. SIMTech Valley Block Cooling Tower System

Figure 2. Valley Block CT1 & CT2 with DCI installation and RWCP1 & RWCP2

- Device used:
  - DCI system to improve the energy efficiency of the cooling tower system; See Figure 3 (left)
  - Portable power meters to monitor and collect the power consumption data hourly; See Figure 3(right)

Figure 3. DCI system and portable power meters

- Combined cooling capacity: The combined cooling capacity of RWCP1 and RWCP2 is 2 X 144 kW = 288 kW based on the specification of RWCP label in Figure 4 below. The total Refrigerant Ton (RT) = 288kW/3.516= 82 RT.



McQuay Air Conditioning

WATER COOLED PACKAGED UNIT

MODEL	MWCP145AE	POWER SUPPLY	380V/3N~/50Hz
RATED COOLING CAPACITY	144000W	RATED AIR FLOW RATE	24600m³/h
RATED POWER INPUT/CURRENT	34400W/65.2A	EXT.STATIC PRESSURE	300Pa
NOISE LEVEL	77dB(A)	WATER FLOW RATE	26.2m³/h
MAX.HEAT EXCHANGER WORKING PRESSURE	3.0MPa	NET WEIGHT	1235kg
MAX.WORKING PRESSURE(HP/LP)	2.5MPa/0.8MPa	DATE	
MAX.WATER SYSTEM WORKING PRESSURE	1.0MPa	SERIAL NO.	

REFRIGERANT CHARGE	SYS.1	R407C/4.0kg	SYS.4	R407C/3.8kg	SYS.7	/
	SYS.2	R407C/4.0kg	SYS.5	/	SYS.8	/
	SYS.3	R407C/4.0kg	SYS.6	/	SYS.9	/

Shenzhen McQuay Air Conditioning Co., Ltd.

MODEL : MWCP135/145/165AE

Figure 4: Cooling Capacity of RWCP Unit

- Data collection:
  - Power usage data of the cooling tower system (including $P_{pre\text{-}DCI}$ and $P_{post\text{-}DCI}$);
  - Cooling temperature setting (Tc);
  - Cleanroom loading data: reflected by the temperature (T_l) and humidity (H_l) in the cleanroom;
  - Ambient temperature data

- Analysis approach:
    - Energy efficiency improvement = ($P_{pre\text{-}DCI}$ – $P_{post\text{-}DCI}$) / $P_{pre\text{-}DCI}$ * 100%
    - Correlation analysis between the $P_{pre\text{-}DCI}$, $P_{post\text{-}DCI}$ and Cleanroom loading data
    - Correlation analysis between the $P_{pre\text{-}DCI}$, $P_{post\text{-}DCI}$ and ambient temperature
    - Noise data filtering: power consumption data under special cooling temperature settings are ruled out of the energy efficiency analysis due to the exceptional requirements in the cleanroom.

6 RESULT AND DISCUSSION

Document the result, including relevant theories, assumptions, detailed analyses, justifications of the result, implementations for consideration, and benefits to customer.

The assessment to the DCI solution is performed mainly from the three aspects and their correlation as described below.

- Power consumption comparison between Before-DCI and After-DCI: this shows whether energy efficiency improves after using the DCI solution.
- Ambient temperatures: The smaller the difference between the period of Before-DCI and After-DCI, the lesser impact it has on the assessment to energy efficiency improvement of DCI.
- Cleanroom Loadings: Cleanroom loadings are reflected by the daily average temperature and humidity. The smaller the difference between the period of Before-DCI and After-DCI, the lesser impact it has on the assessment to energy efficiency improvement of DCI.
- Correlation coefficient analysis: we performed correlation coefficient analysis for power consumption against ambient temperatures, power consumption against cleanroom temperature and power consumption against delta temperature.

6.1 Power Consumption Reduction Analysis

From the daily average power consumption chart in Figure 5, we can see that after deploying the DCI system at the cooling tower, the Refrigerant Water Cooling Package 1 (RWCP1) and RWCP2 first went through few weeks' stabilisation and cleaning period (from 16/Oct to 27/Nov) with fluctuating power consumption. After that, the power consumption of the two cooling packages started to show an overall declining trend.

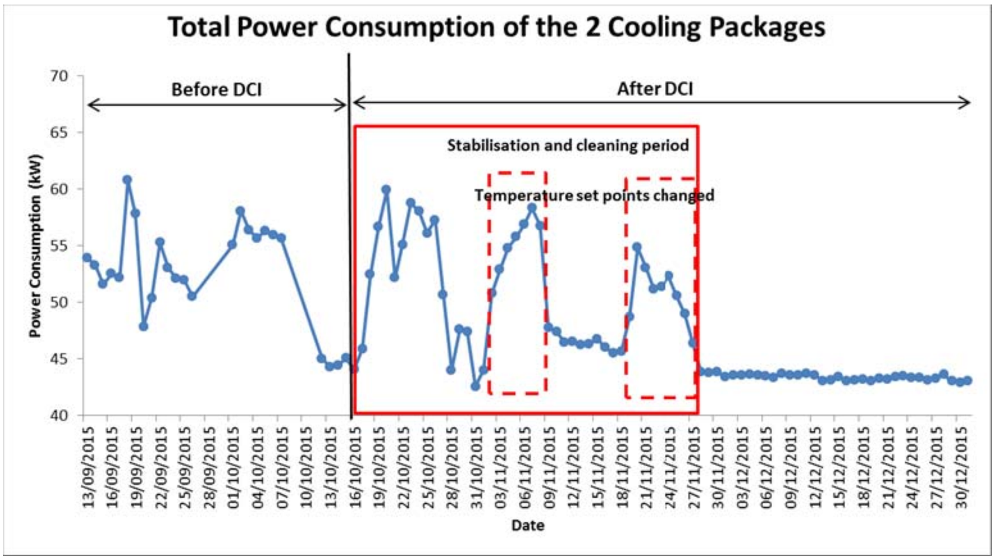


Figure 5. The total power consumption of the 2 cooling packages. The area surrounded by the solid red square indicates the stabilisation period after deploying the DCI system. The areas highlighted by dotted red boxes are the periods the temperature set points were changed from 19 degree Celsius to 16 degree Celsius.

From Figure 5, we observed that during the periods of 02/Nov to 08/Nov and 19/Nov to 27/Nov, the power consumption of the two cooling packages surged to a high level between 50 kW and 60 kW. The sudden increase of power consumption was caused by the fact that the temperature set points of the two cooling packages were set to a lower value (from 19 degree Celsius to 16 degree Celsius) due to insufficient cooling gas in one of the two units, which are the abnormal cases. The reduction of temperature set points caused the increased power consumption of cooling packages. If we remove the data of these two short periods and re-plot the chart as shown in Figure 5, we will get a normal power consumption case which shows more obvious gradual decreasing pattern as shown in Figure 6.

For the power consumption points during 12/Oct ~ 15/Oct which are 18% lower than the average power consumption Before-DCI, we assume that there was temperature set points increase and/or cleanroom loading drop that caused the lower power consumption.

In the beginning of the stabilisation and cleaning period, the DCI started working by removing the hard scales in the cooling tower/chiller (from 16/Oct to 27/Oct). After the hard scale was removed, the power consumption of the RWCPs dropped to a range between 43 kW and 48 kW, and the DCI system started to remove the soft scales. During the soft scale removal process, the power consumption level of the RWCPs showed a continuous declining trend until it reached the fully cleaned state on 28/Nov. After that, the DCI worked to maintain a fully cleaned state and the power consumption of the RWCPs was stabilised at 43 kW to 43.41 kW. So the above power consumption analysis shows that the DCI reduces the power consumption after using it.

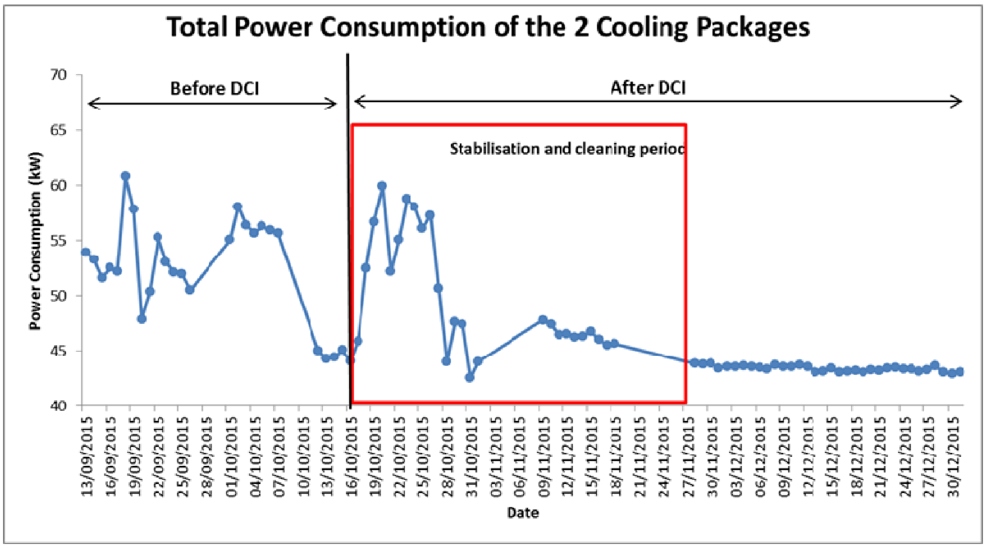


Figure 6. The total power consumption of the 2 cooling packages after removing the periods when the temperature set points were changed to 16 degree Celsius. The chart shows a more obvious declining trend for the total power consumption after deploying the DCI system.

Table 1 summarises the power consumption of the two cooling packages RWCP1 and RWCP2 for period of Before-DCI and After-DCI. By comparing the Before-DCI with the After-DCI excluding the stabilisation period and the periods when the temperature set points were changed, we can see that the power consumption reduced from 52.62 kW to 43.41 kW. In other words, the deployment of the DCI system brought a 9.21 kW reduction in average power consumption or a 17.5% improvement in energy efficiency. In terms of the maximum daily energy consumption during the period of the experiment, we can also see a significant improvement after deploying the DCI system.

Table 1: The power consumption comparison of the two cooling packages before and after deploying DCI system.

	Before DCI	After DCI (exclude stabilisation period and the periods when temperature set points were changed)
Average power consumption	52.62 kW	43.41 kW
Maximum power consumption	60.80 kW	43.86 kW

The total combined RT of the two RWCPs is 82 RT. Based on RWCPs' RT and their power consumption, we can compute their efficiency for Before-DCI and After-DCI periods respectively for different running capacity as shown in **Table 2.**

Table 2: RWCPs' Efficiency improvement for different running capacities

Capacity	2 RWCP Power (kW)	RT	Before-DCI Power (kW)	After-DCI Power (kW)	Before-DCI kW/RT	After-DCI kW/RT
25%	72	20.48	52.62	43.41	2.57	2.12
50%	144	40.96	52.62	43.41	1.28	1.06
75%	216	61.43	52.62	43.41	0.86	0.71
100%	288	81.91	52.62	43.41	0.64	0.53

This means that when RWCPs run in full capacity, the RWCPs' efficiency improves from 0.64 kW/RT to 0.53 kW/RT, while RWCPs run in 75% capacity, the RWCPs' efficiency improves from 0.86 kW/RT to 0.71 kW/RT. Since the RWCPs' running capacity dynamically adjusts according to the cooling temperature set point and clearnroom temperature, we can see a range of the RWCPs' efficiency improvement. More specifically, the maximum power consumption decreased from 60.8 kW to 43.86 kW.

6.2 Ambient Temperatures Impact Analysis

We downloaded the average daily temperature of the Jurong West district from the Meteorological Service Singapore website [1] (At the time when this report is compiled and updated, the January 2016 temperature data was not available yet from the website) [1]. From the data plotted in Figure 7 we observed that the ambient temperatures of Before-DCI and After-DCI were not significantly different. The average daily temperatures in the area were 27.98°C and 26.96°C respectively in the Before-DCI and After-DCI fully cleaned periods (28/Nov. onward) which is 1°C difference.

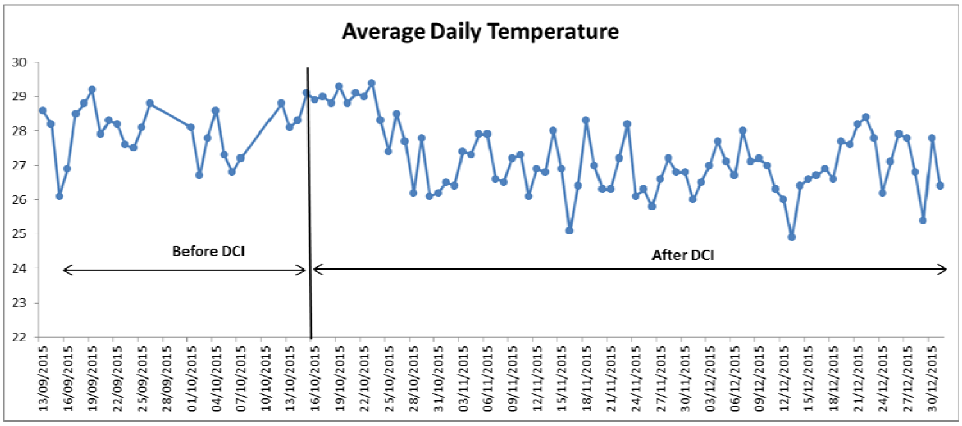


Figure 7. The average daily temperature at the Jurong West area. The data indicate that the difference in ambient temperatures before and after deploying the DCI system were not significant.

To analyse the effect of the 1°C temperature difference of the Before-DCI and After-DCI on the power consumption, we use the Pearson's correlation coefficient (Equation 1) to calculate the correlation between the power consumption and the ambient temperature. The Pearson's correlation coefficient ($\mathrm{r_{PT}}$) denotes the linear correlation between two variables. It uses a real number from -1 (perfect negative correlation) through 0 (no correlation) to +1 (perfect positive correlation). In this case, if the power consumption increased with the increase of the ambient temperature, the coefficient $\mathrm{r_{PT}}$ would give a value that is close to 1.

$$r_{PT} = \frac{\sum_1^n (P_i - \bar{P})(T_i - \bar{T})}{\sqrt{\sum_1^n (P_i - \bar{P})^2}\,\sqrt{\sum_1^n (T_i - \bar{T})^2}} \tag{1}$$

Where $\mathrm{P_i}$ and $\mathrm{T_i}$ are the average power consumption and ambient temperature of day i; and $\mathrm{\bar{P}}$ and $\mathrm{\bar{T}}$ are the average power

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[1] Meteorological Service Singapore website: http://www.weather.gov.sg/climate-historical-daily/

consumption and ambient temperature over the entire course of our experiment period.

The scatter plot in Figure 8 shows the correlation between the power consumption of the RWCPs and the ambient temperature. From the plot we can see that the increase of the ambient temperature did not introduce significant influence on the changes of the power consumption. When the ambient temperature falls between 26 and 27 degree Celsius, the power consumption varied between 40 and 60 kW; On the other hand, when the ambient temperature falls in the higher end from 28 to 29.5 degree Celsius, the power consumption remained in the range between 40 and 60 kW, without showing any increasing trends.

The computed Pearson's correlation coefficient r_{PT} between the power consumption and ambient temperature is 0.367, which shows a very week positive correlation. If we squared the r_{PT} to calculate the coefficient of determination r-squared, we would get the r-square = 0.367 x 0.367 = 0.134. R-square is an estimate of the proportion of variance in the dependent variable that is accounted for by the independent variable. It is used commonly to interpret the strength of the relationship between variables. And the value of 0.134 in this case indicates that only 13.4% of the variance in power consumption can be explained by variation in ambient temperature, which is a very low correlation.

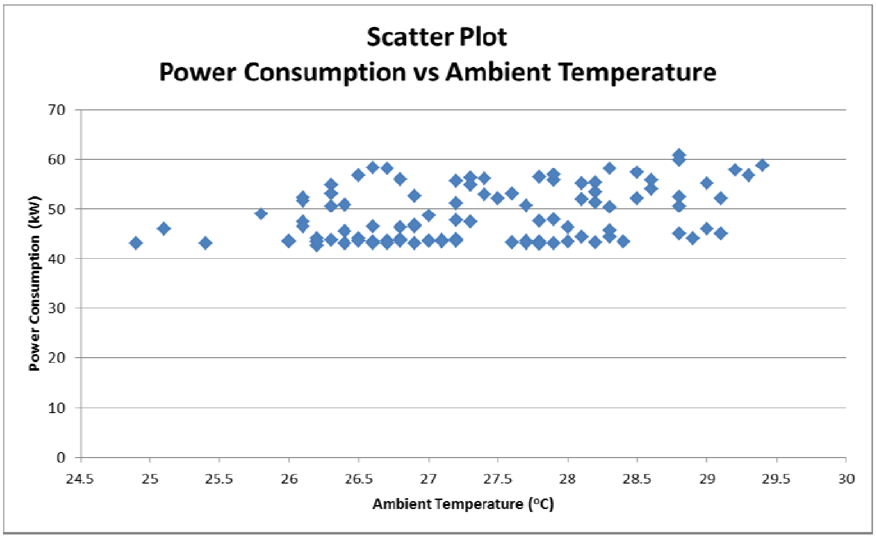

Figure 8. The scatter plot of the power consumption against the ambient temperature. The Pearson's correlation coefficient between these two variables is 0.367, and the coefficient of determination is 0.134.

6.3 Cleanroom Loading Data Analysis

Figure 9 shows the set temperature and measured temperature of the cleanrooms. We can see from Figure 9 that before DCI system was installed, the measured temperature fluctuated in an irregular pattern and deviated substantially from the set point. DCI system was installed on 16 Oct 2015. The DCI System usually takes a few days to stabilize (in this case from 16/Oct to 27/Oct as mentioned in section 7.1 with fluctuating power consumption).But, since the temperature set point was changed from 19°C to 16°C twice during the periods of 02/Nov to 08/Nov and 19/Nov to 27/Nov due to insufficient cooling gas in one of the two units, the stabilization process took a longer time than expected. Thus the measured temperature stabilised from 20 Nov 2015 to 8 Dec 2015 and was much closer to the set temperature.

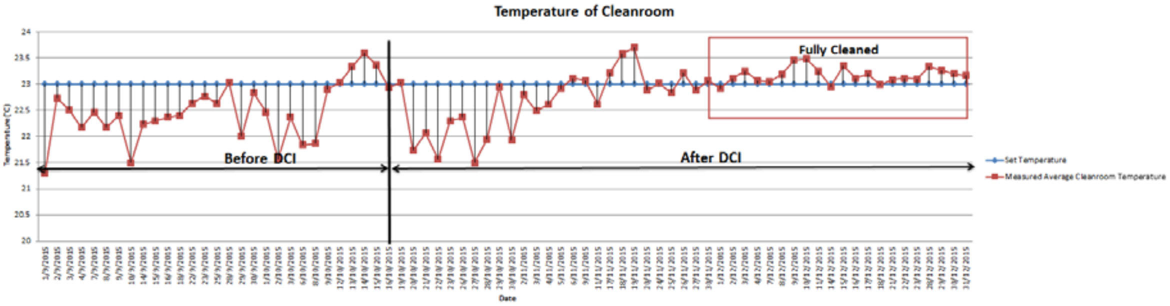

Figure 9. Temperature of cleanroom

Figure 10 shows the set humidity and measured humidity of the cleanrooms. We can see from the chart that before the DCI system was installed, the measured humidity deviated from the set temperature in an irregular pattern. After the DCI system was installed, the measured humidity was much stabilised and closer to the set humidity.

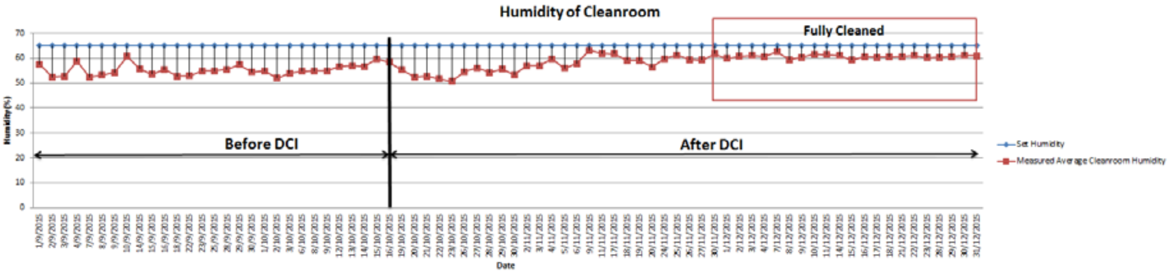

Figure 10. Humidity of cleanroom

Table 3 summarises the temperature and humidity of the cleanrooms before/after deploying the DCI system. The set temperature and humidity are fixed at 23°C and 65% respectively. Before the DCI system was installed, the average difference of measured temperature and humidity was 0.54°C and 9.84% respectively from the settings. After the DCI system was installed, the average difference of the measured temperature and humidity was 0.10°C and 6.28% respectively from the settings. After the DCI system had fully cleaned the cooling water system, the average difference of the measured temperature and humidity was 0.17°C and 4.29% respectively from the settings. So we can see that after deploying the DCI system, the measured temperature and humidity are closer to the temperature and humidity set points. This can be reflected by the Standard Deviation of temperature and humidity in Table 3, especially for the period of after cooling water system is fully cleaned.

Table 3: The temperature and humidity comparison of the cleanrooms before/after deploying the DCI system.

Measurement	Set Temperature	Set Humidity	Average Temperature	Average Humidity	Average Difference from Set		Standard Deviation	
Time Period					Temperature	Humidity	Temperature	Humidity
Before DCI	23	65	22.46	55.16	0.54	9.84	0.56	2.28
After DCI	23	65	22.90	58.72	0.10	6.28	0.51	3.11
After DCI fully cleaned	23	65	23.17	60.71	0.17	4.29	0.17	1.13

Similar to Section 7.2, we also carried out the analysis of the correlation of the power consumption with the cleanroom temperature by replacing the ambient temperature T in Equation (1) with the cleamroom temperature. We plotted that scatter plot of the power consumption against the cleanroom temperature (**Figure 11**) and calculated the Pearson's correlation coefficient (r_{PT} = -0.637) as well as the coefficient of determination (r-squared = 0.405) to analyse the relationship between the two variables. From the calculated result, we can observe a moderate negative correlation between the power consumption and the cleanroom temperature. The correlation coefficient of -0.637 implies that after deploying the DCI system, the increase of the cleanroom temperature had moderate influence on the reduction of the power consumption of the RWCPs, however the temperature was closer to the set point and has less fluctuation, which offers a better production environment. The coefficient of determination indicates that about 40.5% of the variance of the power consumption can be explained by the changes of the cleanroom temperature.

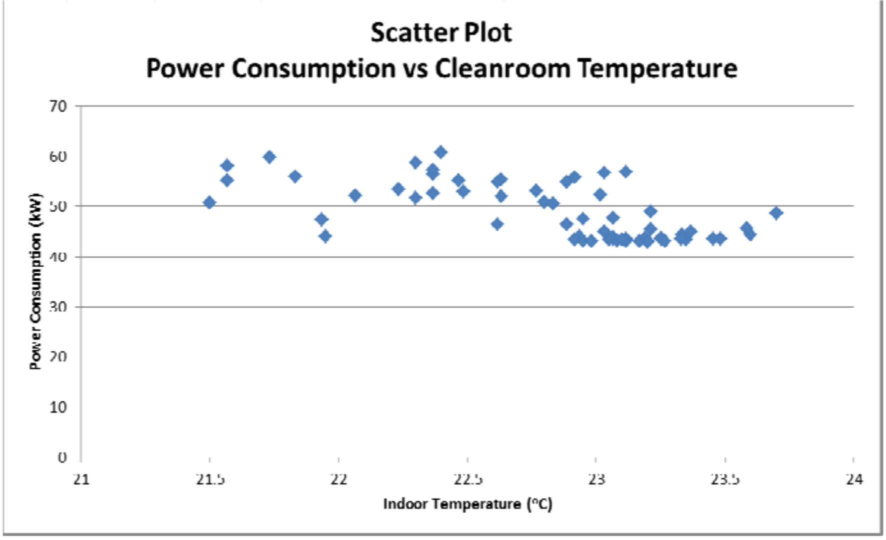

Figure 11. The scatter plot of the power consumption against the cleanroom temperature. The Pearson's correlation coefficient between these two variables is -0.637, and the coefficient of determination is 0.405.

6.4 Delta Temperature Analysis

Intuitively, without the influence of any external factors, the electric power of the RWCPs is consumed only to bring the temperature from the outdoor level down to the indoor level. In other words, the changes in the power consumption of the RWCPs were supposed to be proportional to the changes of the delta temperature (the difference between the ambient temperature and the cleanroom temperature). To analyse the correlation of the power consumption with the delta temperature, we again followed the same approach in Section 7.2 and 7.3 to plot the scatter plot (**Figure 12**) and calculate the Pearson's correlation coefficient between the power consumption and the delta temperature, as well as the coefficient of determination. In this case, the ambient temperature T in Equation (1) is replaced with the delta temperature.

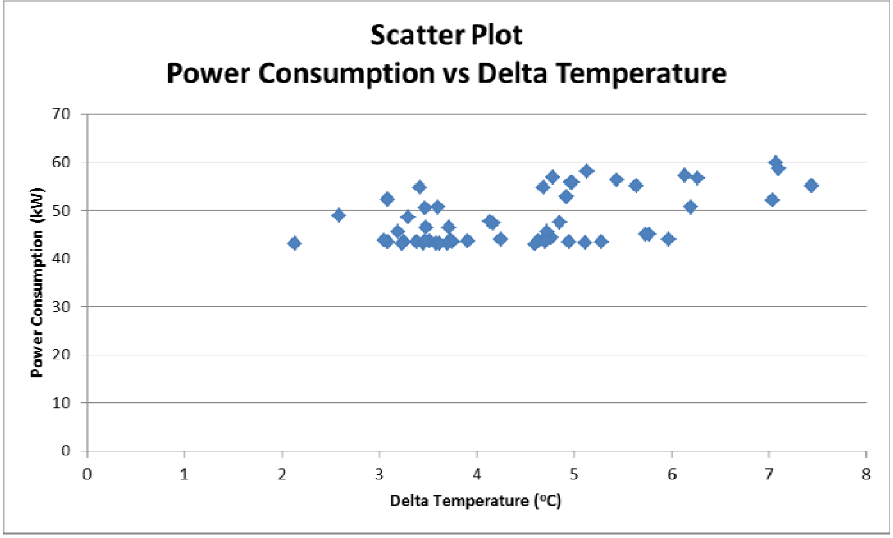

Figure 12. The scatter plot of the power consumption against the delta temperature. The Pearson's correlation coefficient between these two variables is 0.578, and the coefficient of determination is 0.334.

The calculated Pearson's correlation coefficient of 0.578 indicates a moderate positive correlation of the power consumption with the delta temperature. In other words, the changes in the difference between the ambient temperature and the cleanroom contributed partially to the reduction of the power consumption. The coefficient of determination of 0.334 quantifies the contribution as 33.4% of the variance of power consumption can be explained by the changes in the outdoor-indoor delta temperature. From this result, we may derive that the reduction of the power consumption is not fully due to the reduction of the outdoor-indoor delta temperature. There are some other factors that contribute to the saving of power consumption – it can be either the cleaning effect of the DCI system, or the unmeasured indoor loading conditions like number of people in the cleanroom and number of hours that the machines were operating, or both.

6.5 Blow-down Water Analysis

To ensure the cooling water conductivity meeting the Environmental Public Health (Cooling Towers and Fountains) Regulations [4], a conductivity control system is used to monitor/control the conductivity of CT1 and CT2. When the conductivity of the cooling tower water exceeds the pre-set limit of 800μS/cm, it will blow down the water and supplement with fresh water. In this way, Total Dissolved Solids (TDS) build-up due to evaporation can be prevented. Accumulated solids like Calcium and Magnesium hardness which cause scaling need to be bled off frequently. Thus huge amount of water is wasted considering 24/7 operation.

Prior to installing the DCI system, we observed that the blow-down valve was open most of the time because the conductivity was above the set point, thus, resulting in water wastage.

The DCI system reduces the Total Hardness and thus reduces the conductivity. It comes with its built-in auto blow-down mechanism and operates at a much higher Cycle of Concentration (COC), it helps to reduce water wastage. This means the cooling tower/water system will save a substantial amount of water.

However, at the time of testing, there was no dedicated water meter in SIMTech VB cooling tower to record the daily water consumption. Therefore, we were not able to estimate the savings in water. In addition, Condenser Approach Temperature (CAT) is another important parameter for a chiller/condenser system. However, in the course of this testing, due to the inherent design of the chillers, we were not able to monitor and measure this parameter as well.

6.6 Summary of Analysis

We observe from the analysis in section 7.1 ~ section 7.5 that after deploying the DCI system, power consumption reduced by 17.5%, that equates to annual cost savings of S$16,410; and at the same time, the measured temperature and humidity are closer to the set points and become much more stable; the RWCPs' efficiency improves for the different running capacities.

Through the analysis of the correlation of power consumption with the ambient, cleanroom and outdoor-indoor delta temperatures, we observe that the temperatures impose weak or moderate influences on the variance of the power consumption. There are some other factors that contribute to the saving of power consumption – it can be either the cleaning effect of the DCI system, or the unmeasured indoor loading conditions like number of people in the cleanroom and number of hours that the machines were operating, or both.

1 CONCLUSION

Summary of the result, recommendation, limitations and future research direction.

SIMTech has successfully completed a Pre- and Post-DCI system performance assessment in term of energy efficiency improvement based on SIMTech VB cooling tower system. The Energy Assessment Report delivered shows

- Energy efficiency improves by 17.5% that equates to annual cost savings of S$16,410, which is significant in the long run.

- The ambient, cleanroom and outdoor-indoor delta temperatures impose weak or moderate influences on the variance of the power consumption. There are some other factors that contribute to the saving of power consumption – it can be either the cleaning effect of the DCI system, or the unmeasured indoor loading conditions like number of people in the cleanroom and number of hours that the machines were operating, or both.

- The measured temperature and humidity are closer to the set points and become much more stable. This is important for industries where the production yield and quality is contingent upon these factors.

- The RWCPs' **efficiency improves** for the different running capacities. The energy efficiency improvement will be able to help most buildings, both existing and new, to meet Green Mark Label. (Platinum category <500RT : 0.7kW/RT and >500RT : 0.65kW/RT) [2].

With this technology that is substantiated by the above evidence, Innovative Polymers and SIMTech could collaborate, to effectively penetrate the Energy Efficiency Management market.

By leveraging on innovative ideas and technologies, DCI can help companies to save significant operating cost. This helps to cushion the impact of ever rising energy costs and also helps Singapore as a whole to meet its Sustainable Energy Program (60% of energy used in Singapore are for Air Conditioning and Chiller Systems [3].

2 REFERENCE

List all external references mentioned in the report.

References:

[1]. Meteorological Service Singapore website: http://www.weather.gov.sg/climate-historical-daily/
[2]. Green Mark Scheme http://bca.gov.sg/GreenMark/green_mark_buildings.html
[3]. National Climate Change Strategy (NCCS 2012) document in NEA website http://www.nea.gov.sg/energy-waste/climate-change
[4]. Environmental Public Health (Cooling Towers and Water Fountains) Regulations http://statutes.agc.gov.sg/aol/search/display/view.w3p;page=0;query=Id%3A%22558fa860-cd88-40c2-a78b-67d178295864%22%20Status%3Ainforce;rec=0;whole=yes

3 APPENDICES

Include appendices like exhibit copies of documents, charts, technical specifications, theatrical foundations, etc. to ensure that readers can understand the case scenario and have the necessary information to find solutions to the case problems.

4 CLASSIFICATION

Include classifications that are related to the case study

I. Industrial sector:

☐ Precision Engineering
☐ Electronics
☐ Automotive
☐ Bio-/ Medical
☐ Aerospace
☐ Construction
☐ Marine
☑ Others:

Energy efficiency management

II. Technology theme :

☐ Metal Forming
☐ Polymer Processing
☐ Powder Processing
☐ Abrasive Processes
☐ Laser Precision Machining
☐ Mechanical Precision Machining
☐ Microfluidics Research Foundry
☐ Others
☐ Metal Joining
☐ Polymer Joining
☐ Electro-chemical Engineering
☐ Sol-gel Processing and Particle Engineering
☐ Vapour Deposition and Plasma Processing
☐ Large Area Processing
☐ Robotic Automation
☐ Electromechanical Modules
☐ Ultra-Precision Systems
☐ Nano-scale Optical Measurements and Characterisation by Scanning Near-field Optical Microscopy (SNOM)
☐ Diagnostic Measurements and Analysis
☐ Image Processing
☐ Optical Inspection
☑ Manufacturing Execution
☑ Shop-floor Health Management
☐ Manufacturing Operations Management
☐ Manufacturing System Analyses
☑ Sustainability and Life Cycle Management

III. Technology readiness band:

☐ Band A
☐ Band B
☑ Band C

IV. Clearance of confidentiality :

☐ Clearance form from company attached, Date: ________________________

☐ Patent status: _N/A____

☐ Paper publication status:_ N/A____

☑ Non-confidential

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