

Minimization of LPG Consumption in the Heating Process and Aqueous Acid Solution Used in the Separating Process in a Chemical Factory

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This work indicates the need to integrate scientific research with the concept of cleaner technology to solve environmental problems and to utilize raw materials. Emphasis on the role of academic scientific research acts as a way to propose and support specific solutions for a company's problems. This work also concerns in the minimization of LPG (Liquid Petroleum Gas) consumption, and of aqueous acid solution used, together with the reduction of broken components. The minimization of LPG consumption can be achieved by introducing only 30% excess of air to the reactor in order to minimize the thermal energy loss. The aqueous acid solution used in the salvage section is drained with every 8,000 pieces of defect products fed to the process. This leads to minimization of acid solution used. With increasing injection time of aqueous acid solution from 1.6 s to 2 s, the number of broken components is then reduced from 27% to 7%.

Keywords: Cleaner technology, Resource minimization, Cleaner products.

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การลดการใช้ปริมาณแอลพีจีในกระบวนการความร้อนและการลดการใช้ปริมาณสารละลายกรดในกระบวนการแยกของโรงงานเคมี

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งานวิจัยนี้ชี้ให้เห็นความจำเป็นในการผนวกรงานวิจัยตามหลักวิทยาศาสตร์กับแนวความคิดทางเทคโนโลยีสะอาดเข้าด้วยกันเพื่อแก้ปัญหาสิ่งแวดล้อมและใช้วัตถุดิบอย่างคุ้มค่า การนำหลักงานวิจัยตามหลักวิทยาศาสตร์จะเป็นตัวที่มีบทบาทสำคัญต่อการแก้ปัญหาของทางบริษัท งานวิจัยนี้เกี่ยวข้องกับการลดปริมาณการใช้แอลพีจี การลดปริมาณการใช้สารละลายกรด และการลดปริมาณชิ้นส่วนที่แตกหัก การลดปริมาณการใช้แอลพีจีสามารถกระทำได้โดยการใช้ปริมาณอากาศที่มากเกินไปเพียง 30 เปอร์เซ็นต์ ในเครื่องปฏิกรณ์เพื่อลดปริมาณการสูญเสียความร้อน ขณะเดียวกันสารละลายกรดที่ใช้ในแผนกแยกชิ้นส่วนถูกถ่ายออกเมื่อใช้งานกับผลิตภัณฑ์ที่มีค่าจนถึง 8000 ผลิตภัณฑ์ ทำให้สามารถลดปริมาณการใช้สารละลายกรด และเมื่อเพิ่มเวลาในการฉีดสารละลายกรดจาก 1.6 วินาที เป็น 2 วินาที จำนวนชิ้นส่วนที่แตกหัก ลดลงจาก 27 เปอร์เซ็นต์ เป็น 7 เปอร์เซ็นต์

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INTRODUCTION

The development of global products and technology is causing major challenges to industrial initiatives, particularly in developing countries. It is necessary to find a new role of a product in an integrated form with development and the environment. There is a need for more effective use of resources and more efficient management of the waste produced by industries.^(1, 2) Thus, in this research, cleaner technology will be introduced to a company to produce cleaner products. Cleaner technology is used as a green slogan associated to products or processes that are supposed environmentally friendly.^(3, 4)

Description of company and use of LPG

It is known that LPG has been considered as a non-renewable resource. Moreover, it was believed that the resource in the natural environment was

limited. That is the reason why the economic cost of LPG was important relative to the total cost of the industrial activities. Thus, it is necessary to optimize its utilization and it is also necessary to consider distributing the energy loss and discharging flue gas to the atmosphere with the minimum gaseous pollutants. On the other hand, the competition between companies is increasing every day and environmental legislation is being enforced more strictly. This means that industrial leaders must make a huge effort to incorporate cleaner technology into their productive processes with less consumption of raw materials and energy resources and with less generation of waste. Thus it must strike a balance between the increasing efficiency of operation without exhausting the resources, while generating less waste and recovering and reusing materials as much as possible, as shown in Figure 1.

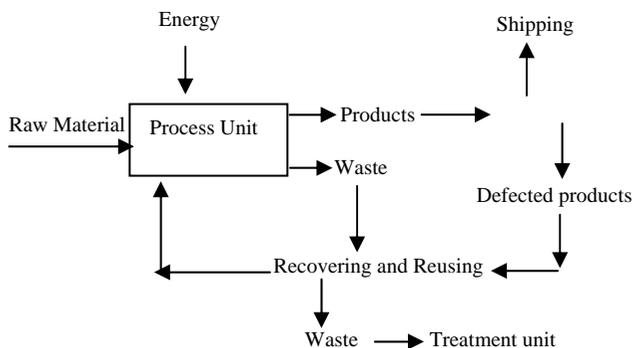


Figure 1. Applying cleaner technology to the process to produce cleaner products.

The studied company uses LPG as a fuel for heating masks of color televisions in the mask forming process only. The total amount of LPG consumption is around 350 to 380 tons per month. The mask is conveyed to an

anneal (stabilized Lehr) reactor at high temperature. The temperature in the stabilized Lehr range is divided into 4 zones. Each zone has its own upper and lower limiting temperature, as shown in Figure 2.

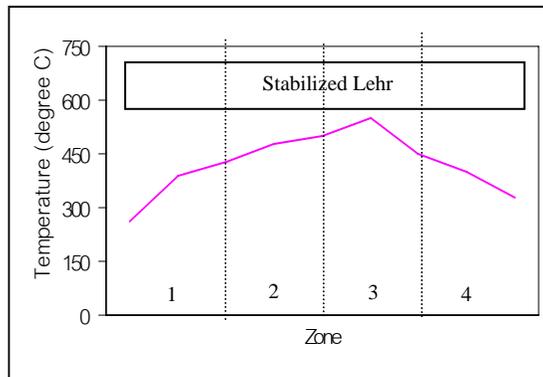


Figure 2. Temperature in each zone of the anneal reactor.

The configuration of the mask forming process is shown in Figure 3. The company needs to minimize the LPG consumption. Cleaner technology was applied by auditing the major cause of LPG consumption considering materials used, operation, efficiency of the reactor, and effectiveness of

workers. It is found that the percentage of excess oxygen in the flue gas was not suitable. This lead to the thermal energy loss from the reactor to the atmosphere. After analyzing the major cause of LPG consumption, the process was then studied in depth.

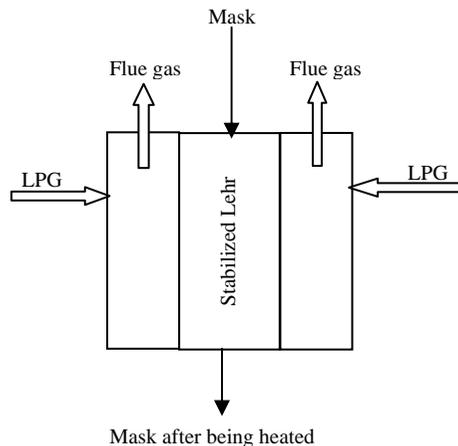


Figure 3. Schematic diagram of the use of LPG in an anneal reactor.

What is done in the salvage section?

In the case of defective products, this company reprocesses them in a salvage sector. The defect products are going to be separated to each element by using an aqueous acid solution, as shown in Figure 4. The aqueous acid solution is pumped from a storage tank into a pipeline to inject directly to the position between panel and funnel. After that the aqueous acid solution is then pumped back to the tank for reuse. All aqueous acid solution is drained out every week. A fresh acid solution is then introduced to the process. Each element is then cleaned and inspected for quality before being reprocessed in me

manufacturing section. The studied company uses 91 tons per year of formic acid, 760 tons per year of nitric acid, and 120 tons per year of acetic acid in the salvage section. The company observes that even though a large amount of aqueous acid solution is used, only a small amount of each element is in good condition. Then cleaner technology is also applied to minimize the acid solution used and to reduce broken elements. After considering the process in the salvage section, the amount of acid solution in relation to that of the broken element was then investigated in detail.

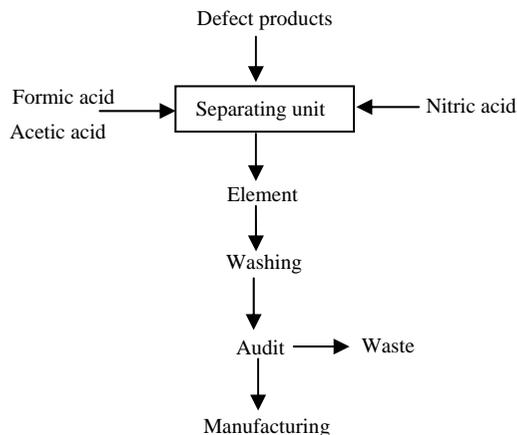


Figure 4. Schematic diagram of processes in the salvage section.

By doing this, the company follows the basic cleaner technology guideline of utilizations to generate less waste and it has also improved its competitiveness in the industrial sector because of cleaner products.

Approach to the company's target: *Minimization of the LPG consumption*

The company has not corrected data about the ambient temperature around the reactor and about the flue gas, such as temperature of flue gas, percentage of carbon dioxide, excess

oxygen, and carbon monoxide in flue gas. This also means that LPG consumption has not been studied in this company. Then the data are corrected at the both sides of the reactor in each zone, as shown in Figure 5.

All data were collected at least six times to ensure reproducibility of the data. Then the data presented in this research are always the average values obtained from the replicated experiments, as shown in Table 1.

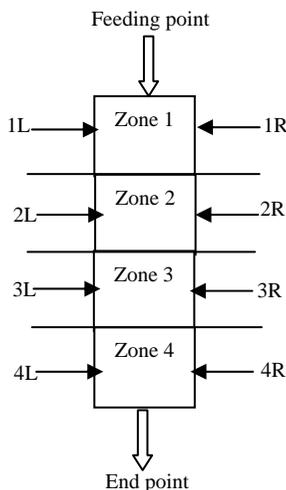


Figure 5. Reactor with sampling ports.

Table 1. Data obtained from each zone at both sides of the reactor.

SECTION	1L	1R	2L	2R	3L	3R	4L	4R
Temperature of flue gas (°C)	404	362	481	428	519	433	389	369
Ambient Temperature (°C)	29	31	29	26	29	29	29	30
% CO ₂	5	5	6	2	6	4	3	3
% excess O ₂	11	11	10	18	10	14	16	16
% excess air	121	122	104	439	101	214	304	302
CO (ppm)	836	44	501	452	98	124	12	14
Net efficiency of heating (%)	70	74	65	39	63	56	66	52
Gross efficiency of heating (%)	64	67	59	36	57	54	60	48

It is obvious from the ambient temperature around the reactor that there is no convection or radiation of the thermal energy loss from the reactor to the surroundings of the reactor due to a good insulation around the reactor preventing the loss. In addition, it can be seen that percentage of excess air in flue gas obtained from the reactor is

greater than the standard value, which should be about 30%. The temperature of flue gas is quite high, which leads to loss of the thermal energy to the atmosphere via the flue gas. Figure 6 shows the relationship between the temperature in the reactor and the excess air.

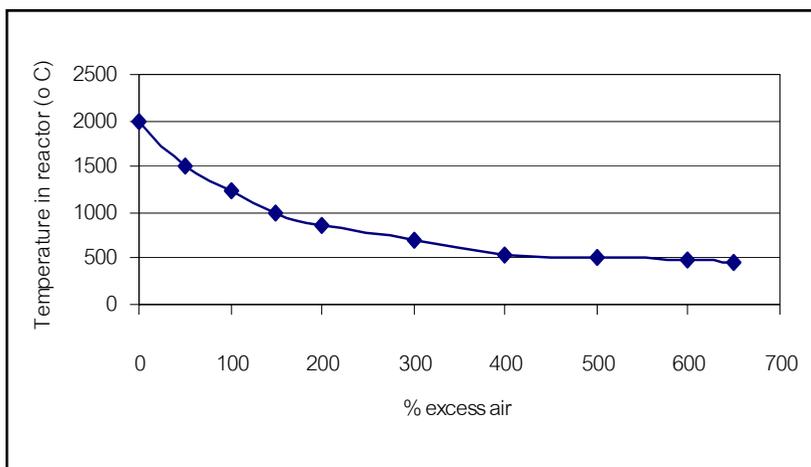


Figure 6. Relationship between percentage of excess air and temperature in the reactor.

The temperature in the reactor drops significantly with the amount of excess air. This implies that the thermal energy has been lost with the outgoing of flue gas. The LPG has been fed continuously to the reactor in order to reach the setting temperature. This is the reason why a huge amount of LPG is needed. To minimize the LPG consumption, 30% of excess air is set for the reactor.

Minimization of the aqueous acid solution used

The company has not considered the utilization of the aqueous acid solution. The acid solution might

be drained even though it can be still reused. Then the relationship between the number of defective products and the number of broken components within one week was investigated, as shown in Figure 7. It can be seen that the aqueous acid solution should be drained after injecting 8,000 pieces of defective product. If more than 8,000 pieces of defective products have been processed with the same aqueous acid solution, the percentage of broken components increases dramatically. In addition, the injection time is increased from 1.6 to 2.0 seconds in order to increase the contact time. It is found that the percentage of broken elements

is then reduced from 27 to 7%. The acid solution dissolves more joints between panel and funnel from 0.92 mm to 1.34 mm when increasing the

contact time. Therefore a counter and a sensor should be installed in the process.

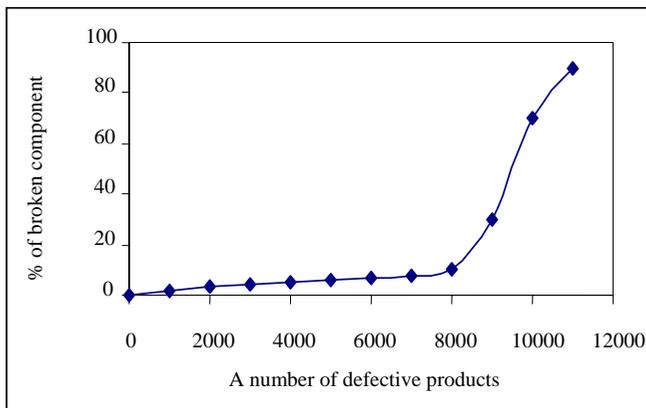


Figure 7. Relation between the number of defective products and the percentage of broken components.

Evaluation and implementation

Minimization of LPG consumption

By means of controlling excess air in the reactor, 1.02×10^6 kcal of thermal energy obtained from LPG can be recovered. This also implies that the thermal energy can be saved

when controlling the excess air in the reactor. The company can save on operating costs. Table 2 shows the savings achieved by using 30% excess air.

Table 2. Economical saving per one kg of LPG used when using 30% excess air.

Section	1L	1R	2L	2R	3L	3R	4L	4R
Thermal energy recovering (kcal)	66986	59643	65656	283127	67973	149125	13913	184600
Amount of LPG saved (kg)	0.13	0.12	0.13	0.56	0.14	0.30	0.28	0.37
Cost saved (baht)	1.47	1.31	1.47	6.30	1.51	3.31	3.09	4.09

The company can save the expenses and thermal energy by following the above solution without

installing any additional of equipment to minimize the LPG consumption.

Minimization of aqueous acid solution used

By installing a counter and a sensor in the salvage section, less acid solution is used. This means that it is not necessary to replace the acid solution every week but it should be replaced after contact with 8,000 pieces

of defective products. Table 3 shows the savings achieved when changing the injection time to 2 seconds and when replacing with a fresh solution after every 8,000 pieces of defective products processed.

Table 3. Savings achieved when changing the injection time to 2 seconds and when replacing with a fresh solution after every 8,000 pieces of defect products processed.

Installing a counter	
Nitric acid saved (kg/month)	2607
Formic acid saved (kg/month)	996
Acetic acid saved (kg/month)	35
Economic cost for acid solution (baht)	931,698
Expense for installing a counter and a sensor (baht)	15,400
Payback period (months)	0.2
Installing a sensor	
Electric cost in changing the injection time from 1.6 to 2 seconds (baht)	5,325
Economic cost of unbroken components recovered (baht)	1,144,800
Payback period (months)	0.05

CONCLUSIONS

When applying cleaner technology to the manufacturing process, it can be concluded that

- A decrease of LPG consumption can be achieved by controlling excess air at 30%.
- This study has a benefit of preventing the release of some thermal energy to the atmosphere.
- Draining after every 8,000 pieces of defect products processed can reduce the aqueous acid solution used.

- The number of broken elements decreased with increasing injection time from 1.6 to 2 seconds.

- From the economical point of view, low investment with adjustment causes a short-term pay back
- The company produces cleaner products.

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