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IMPROVING THE ENERGY USE AT THE SPIC FACTORY

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ABSTRACT
The production of non-woven material is an energy intensive process. The current work is focused at reducing the energy bill of the production process in order to increase the profitability of the factory. There are two main forms of energy used in the factory: electricity and Liquid Petroleum Gas (LPG).

The electricity bill is made-up of two components: the total kWh used as well as a peak demand penalty. These two components will be addressed in different ways. The electricity consumption is divided into the following main categories: lighting, HVAC and production line machinery. Several energy peak-shifting and energy conservation proposals have been suggested. Some have been put in place while others are waiting to be implemented. The implementation of these methods is expected to results in a significant reduction in the factory's electricity bill.

On the LPG front, the study showed that the current conditions do not favour the switch from LPG to Natural Gas (NG). The conditions needed for this switch were identified. A new design for the storage and delivery of LPG was made. The new design can be easily modified for use with NG once the conditions are right.

KEY WORDS
Energy management, peak-shifting, conversion to natural gas and non-woven production.

1. Introduction

Energy conservation and management has become a very important issue in industrial [1] as well as developing countries [2,3]. The importance of this issue is due to its economical as well as environmental [4] implications. The reduction in energy use in industry enables it to become more efficient, competitive and profitable [5]. Since most of the world's energy is produced using non-renewable greenhouse producing fossil fuels, the reduction in energy used helps conserve these precious resources and reduce the damage to the environment. Given this, there as been a lot of work in the area of demand side energy management [6]. This includes using alternative sources of energy [7], enhancing the efficiency of the energy used [8] and changing the patterns of energy use [9]. The current work focuses on changing the energy sources and use patterns in a Jordanian factory that produces non-woven fabrics. Non-woven fabrics are used mainly in sanitary products, e.g. baby diapers. Thus the use of such fabrics is wide spread and is expected to continue to increase due to the rise in the standards of living worldwide and the overall growth in the world's population.

Specialized Industries Co (SPIC) is the successor of Advanced Industries Co. which was established in Jordan in 1988 as the first producer of non-woven fabric in the Middle East. In August 2005 the company went through major transformation in technology and facilities to become one of the most advanced non-woven producers specialized in producing the cover stock for baby diapers, feminine sanitary napkins, adult briefs, as well as various medical applications. SPIC is a key player in the non-woven industry in the Middle East and is committed to providing the best available products and services. The factory is equipped with state-of-the-art machinery utilizing spun bond and melt blown technology, and is supported by an advanced laboratory to ensure consistent quality. SPIC exports most of its production to converters of baby diapers and feminine sanitary napkins in the Middle East.

The manufacturing process is energy intensive. Any reduction in the energy bill will be of significant importance to the competitiveness and profitability of the factory. The use of alternative cheap energy sources, e.g. natural gas, to replace the current sources used will also reduce the manufacturing cost.

The whole manufacturing process needs to be scrutinized by an expert in energy auditing/management in order to identify possible energy saving practices and possible conversion to natural gas. Optimizing the environmental conditions within the factory is essential for specific stages of the manufacturing process. These conditions should be maintained at the local level rather than the global level, i.e. throughout the whole of the factory. Dividing the factory into zones should improve the control of the environmental conditions as well as reduce the energy consumed to maintain the required conditions.

Currently the factory's energy bill is very high and suffers for a high peak-demand penalty. The factory is still undergoing teething problems but the current energy use is too high compared with similar plants. There is minimal attention to energy saving techniques as people are focused on getting the factory up and running smoothly. The factory's management recognizes that there is a waste in energy used but needs a specialist to pinpoint the problems issues and provide practical remedies.

The detailed objectives of this study are:

- Identification of sources and causes of wasted energy.
- Identification of processes which can be converted to use natural gas.
- Proposing, and testing if time permits, of energy conservation techniques.
- Economic analysis of the feasibility of applying the proposed techniques.
- Complete energy auditing of the factory.
- Categorization of the energy used vs. actual requirements.
- Identification of the specific environmental conditions required throughout the factory and the creation of specific zones in order to reduce the energy required to maintain these conditions.

2. Electricity Use

The electricity bill is made-up of two components: the total kWh used as well as a peak demand penalty. These two components will be addressed in different ways. Another way to look at the electricity consumption is for what it is being used. The main categories are: lighting, Heating Ventilating and Air Conditioning system (HVAC) and production line machinery. The second perspective is more logical and easier to follow.

2.1 Lighting

From the first walkthrough in the factory it was evident that it was excessively over light. Over lighting increases both the average as well as the peak electricity use of the factory. Over lighting also results in a significant increase in the cooling load that the HVAC/split units have to deal with which in turn will further increase the electricity usage within the factory. Over lighting also has a negative effect of the workers as it causes eye fatigue and a general feel of exhaustion. In order to rectify this, the lighting intensity needs to be measured and adjusted in each section in accordance with the Illuminating Engineering Society of North America (IESNA) standards [10]. Also proper control of when lights are turned on and off is important, especially for lights outside the factory. The following steps needed to be taken to achieve the goal of reducing the lighting's peak and total electricity use:

- Use a luxmeter to be used to measure the light intensity within the factory.
- Determine the required lighting intensity within each factory section in accordance with the international standards (IESNA).
- Reduce the light intensity within the factory using the luxmeter readings in conjunction with the IESNA recommendations for each section.
- Install automatic controller for the outside lights (photovoltaic cells or timer).

The luxmeter readings in the offices were more than 300 lux at the office desk level. According to IESNA standards, this level can be reduced to 200 lux for the type of work being done at these offices [10]. The levels can be reduced even further when considering that most of the office work is done on PCs and thus there are lower lighting requirements in such situations [10]. The reduction in light intensity is to be achieved by selective de-lamping that will maintain the required level of light intensity and uniformity in the office work areas. This process is expected to result in more than 35% reduction in the electricity used for office lighting which.

The luxmeter readings on the factory floor showed an even bigger potential for light-electricity savings. The factory floor has large windows to provide natural light during the day and a large number of flood lights along the inside walls of the factory floor. The workers had a tendency of turning the flood lights on even when there was sufficient natural light. Figure 1 below shows the right factory wall's flood lights are on the even though there is enough natural light coming from the large windows in the same wall. Luxmeter readings as high as 600 lux were recorded in such areas when the flood lights were on and around 240 lux with the flood lights on the right wall turned off. The internal flood lights, seen in the back of Fig. (1), were kept on as there were no windows in the roof of the factory floor that can allow natural light into the interior regions.

Figure 1. Flood lights in the factory floor.

2.2 HVAC

The manufacturing process has specific environmental conditions that need to be met. It also produces large quantities of heat that needs to be disposed of. The improper zoning of the plant and the lack of a formal operational strategy of using the available HVAC equipment leads to significant cooling loses and high/unregulated electricity consumption. The most important part of the manufacturing process which had the strictest environmental condition requirements was that in which the plastic particles were melted, transformed into thin fibres then heat treated to bond the fibres together to form the non-woven sheets. The machine that performs this task is called the RT machine and it is the heart of the factory. The RT machine can be seen in the background of Fig. (1), behind the internal wall with the flood lights. This internal wall actually separates the RT machine from the winding machine, forefront in Fig. (1). The winder is used to wind the non-woven sheets into large jumbo rolls which under go further processing on a separate machine later on. The fact that the RT machine's bay is open to the rest of the factory floor makes it difficult to control the temperature needed for the production of the non-woven sheets. Currently the factory employs three chillers that feed into a single large air handling unit (AHU) with a cooling capacity of 540 tone refrigeration (TR). The AHU is enough for the RT zone but not the whole factory. In the factory floor layout, the AHU and chillers combination is on almost continuously. This is a major contributor to the electricity bill of the plant. In order to reduce the HVAC electricity bill steps were needed to separate the RT production zone from the rest of the factory's floor area in order to focus the cooling load where it is needed and not dissipate the cold air all over the factory. This separation should be done using plastic curtains "bat wings" in order to allow free movement to and from the RT zone while containing the cooling load. This separation will also allow the AUH to provide positive pressure in the RT zone, as per the manufacturers process requirements. The proper plastic curtains have been located and will be installed shortly.

There were other issues in the use of A/C units in other regions of the factory, mainly the offices. The current practice is to install split units in each office. There is no master control and no temperature setting guidelines. Furthermore, it was noticed that people tend to forget to close their office doors when they step out of them even for short or even long periods. This result in loss of the offices' cool air which results in the A/C unit working more that needed. It was recommended to the factory management to have a factory wide policy on the operation and temperature settings for the split units in the offices. This includes when the units are to be turned on, what is the temperature set point and making sure that the units are turned off during peak demand hours and when people leave the room. The installation of an automatic door-closing mechanics can help in reducing the loss of cool air from the offices to the factory floor. This will reduce the electricity used by these split units.

2.3 Peak Demand Shifting:

SPIC pays an additional 3.05 JD/kWh, approximately 4.3 USD/kWh, for the maximum electricity demand during the peak demand hours (7 PM-10 PM in winter and 8 PM-11 PM during summer). Reducing the factory's maximum electricity demand during these hours can significantly reduce this "penalty". Peak demand shifting can be achieved by shutting or powering down any machine that does not "need" to work 24 hrs/day and does not cause irresolvable backlog in the process. This effect does not reduce the total kWh electricity usage but shifts the maximum electricity use away from the peak demand hours. Figure 2 shows the average and maximum demand in the factory. The utilization factor, average demand/maximum demand, ranges between 40%-75%. It is clear that there is great potential to increase the utilization factor thus reducing the peak demand penalty.

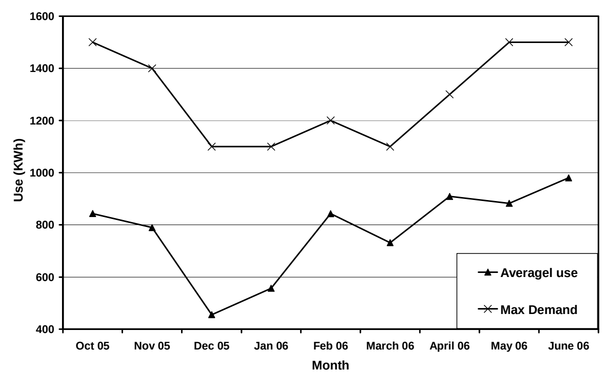

Figure 2. Average and Maximum electricity demand.

To achieve this, a list of the major electricity consuming items in the factory was drawn. Determining which of these items can be shut/powered down during the peak demand hours followed. The following list shows the main electricity consuming items in the factory and the potential for reducing peak demand:

- The RT machine: This machine cannot be shut down but can be slowed down during peak demand hours, depending in the production requirements. The RT machine is the bottleneck of the whole production process thus the machine that determines the factory's production rate. In addition, the starting of the machine after a short turnoff is time and energy consuming and/or might not be practical.
- The re-winder machine: This has great potential for reducing peak demand but requires more detailed analysis and coordination. Theoretically, the re-winder requires two hours to process a full jumbo reel compared to the RT's production rate of five hours/full jumbo reel. With the available 2-3 spare shafts, the RT machine can continue to work while

the re-winder is off. The extra shafts can buffer the jumbo(s) produced while the re-winder is off and the re-winder should easily handle these jumbo(s) after it is started. Doing this requires that all spare shafts be free before the re-winder shutdown. Also the RT's speed can be lowered if a backlog arises. This requires coordination between the production manager and the section & shift chiefs.

- The startup and operation of the chillers: It was recommended that the control panels of the chillers be connected to a PC in order to monitor and control the operation of the chillers. This will allow the implementation of a startup-shutdown strategy that avoids or minimizes the use of the chillers during the peak demand period. The current electricity bills show a large difference between the factory's peak and average electricity demands. This indicates high potential for savings in the electricity bill using peak shaving and/or shifting techniques. Turning one or more of the chillers off depends on the cooling storage capacity of the cold water storage tank used with the current HVAC configuration. Since the peak demand penalty is during night time, these is great potential to turnoff one or more of the chillers during the peak demand period without compromising the conditions in the RT zone. This recommendation is currently being implemented. Its effectiveness will determined based on future data collected from the monitoring system and future electricity bills.
- There are several other auxiliary/complementary machines in the factory that can be turned off without casing any slowdown to the factory's production rate. This includes: the PCMC machine, the Munchy along with its dedicated chiller, the Carton Core making machine, the water treatment line and the silos loading motors.

2.4 LPG use and replacement:

The current practice of using 50kg LPG tanks is being replaced by a system of two underground LPG storage tanks. Figure 3 shows the old arrangement of connecting 20 50kg LPG tanks to a common header and piping the LPG to the factory. The new arrangement should be safer as well as more reliable. As part of this work, the piping design proposed by the LPG supplier was reviewed and changes were recommendations in order to improve the reliability of the piping system and enhance the LPG supply. This recommendation resulted in the installation if a dual-pipe supply system at no extra cost to SPIC.

The second issue with LPG was to see if we could switch to cheaper natural gas (NG). This proved not feasible under the current conditions but had potential should future conditions change. The main issue here is the transport and storage of NG. In its gaseous forum, NG can only be transported by a dedicated piping system. Special tanker trucks can be used to transport gaseous NG but not in an economical fashion. Also the amount of NG to be used at SPIC cannot justify the building of a dedicated pipeline to the factory. Only when Liquefied Natural Gas (LNG) becomes available will the option of switching from LPG to LNG become feasible. The good news is that all of the infrastructure built for new LPG system can be used for LNG with little or no modification once LNG is available.

Figure 3. Old LPG piping system.

3. Conclusion

The energy use at the SPIC factory was studied and analyzed. The factory's energy bill is composed of two main items: electricity and LPG. Steps to reduce the overall electricity consumption of the factory were proposed. Some of which have been implemented while others are in the process of being implemented. Peak-demand shifting techniques were also proposed in order to reduce the maximum demand penalty which is independent of the total electricity use. The possible switch from LPG to the cheaper NG was discussed but proved not feasible under the current conditions. A new LPG storage and piping system was suggested and implemented which should reduce the cost and enhance the reliability of using LPG in the factory. The new storage and piping system was also designed to be compatible with LNG once it becomes available in Jordan.

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