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Waste Heat Recovery from Printing Lehr of Glass Manufacturing Process

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ABSTRACT

Sri Lanka glass industry is mainly engaged in glass container production from the year of Second World War. Energy efficiency improvement is an important way to reduce the production cost and to increase predictable earnings, especially in times of high energy price volatility. The Glass Company selected for this study is the leader in container glass manufacturing in Sri Lanka, mainly facing at high energy cost as other countries in the world. Previous study was carried out to find the way of reducing the gas consumption of glass printing lehr by adjusting the temperature profile.

This study was carried out to reduce the gas consumption of glass printing lehr by heating the bottles at the entry of the printing lehr using flue gas through a heat exchanger. According to the feasibility study and the literature survey, plate fin type heat exchanger was selected as the most appropriate type and the required heat exchanger parameters were calculated.

It was estimated that bottle entry temperature could be increased from 40°C to 210°C by introducing a heat recovery system. Thereby gas consumption can be considerably reduced. According to the specimen calculation for 300 ml Coca-Cola bottle, it was found that the gas consumption of 0.00184 m^3/kg of glassper hour can be saved. Therefore, depending on the tonnage per day considerable amount of gas consumption can be reduced.

Key words: Printing Lehr, gas consumption, Heat exchanger, Glass Company, Heat recovery

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INTRODUCTION

In Glass bottle manufacturing process, after producing the bottles, some types of bottles are sending to the printing department to print the bottles as per the customer requirement. When the printing is done by the machine, those labels can be easily removed as it is not stick to the bottle surface. Therefore, subsequent heating is needed to paint get adhere to the glass permanently. Glass printing lehr which is called the 'Decorating Lehr' in printing department is a heating tunnel consists of several zones with different temperature profiles. In printing process, LP gas is used as the main fuel that provides the heat requirement for the decorating lehr. It was estimated that considerable amount of cost out of the total production cost carries the printing process due to high consumption of LP gas. Therefore, the objective of this study was to introduce a heat recovery system to minimize the gas consumption of the Decorating lehr.

RATIONALE FOR STUDY

Feasibility studies were carried out to find out the method of minimizing the gas consumption in glass printing lehr. It was found that the heat of flue gas of the decorating lehr can be used for preheating the bottles before entering the Zone 1 of the printing lehr. Therefore, literature survey was carried out about the printing lehr which is used in glass industry and possible heat recovery systems. According to the literature, it was found that the best methods to recover the heat of the flue gas was designing a heat exchanger and heat-up an air volume from the flue gas. According to the feasibility and the literature survey, plate fin type heat exchanger was selected and the necessary dimensions were calculated.

METHODOLOGY

According to the temperature profile, Zone 1 temperature of the Decorating Lehr is 240 °C. But the bottle entry temperature of the Lehr is about 40 °C. So, it consumes more LP gas to raise the temperature to Zone1 temperature of

240 °C. Temperature of the flue gas in decorating lehr is 270 °C. Therefore, there is a possibility of using waste heat of flue gas to heat up the bottle entry area and so, it will be useful to save part of LP gas usage.
There are two options to use this heat of flue gas as follows.

1. Direct heating the bottle entry area using flue gas.
2. Heating the bottle entry area by flue gas via heat exchanger.

There are few limitations to use the flue gas directly to increase the bottle entry temperature as follows.

1. If the flue gas is touching the glass bottle, its outer surface can be discolored.
2. Glass printing ink consists with Titanium dioxide and Led oxide.

Because printed ink is heating at the Lehr, flue gas can be contaminated with above chemical compounds. If the flue gas is touch the glass bottle, hazardous chemicals are deposits on bottles and it is not accepted for food containers. Because of these reasons direct heating the Lehr from flue gas is not accepted. Therefore, heating the bottle entry area by flue gas using a heat exchanger was considered, because there is enough space to install a heat exchanger.
Flue gas properties were found as follows [1].

- Flue gas temperature - 270 °C
- Flue gas density - 0.656 kg/m^3
- Flue gas flow rate - 1.9 m3/s = 1.25 kg/s
- Heat value - 1.114 kJ/kgk
- Flue gas pressure - 125 kPa

Ambient air properties are as follows [2]

- Air temperature - 40 °C
- Air density(at avg. Temperature) - 1.129 kg/m^3
- Heat value(at avg. Temperature) - 1.005 kJ/kgk

Plate -Fin Heat Exchanger was selected as the suitable one as shown below [3]

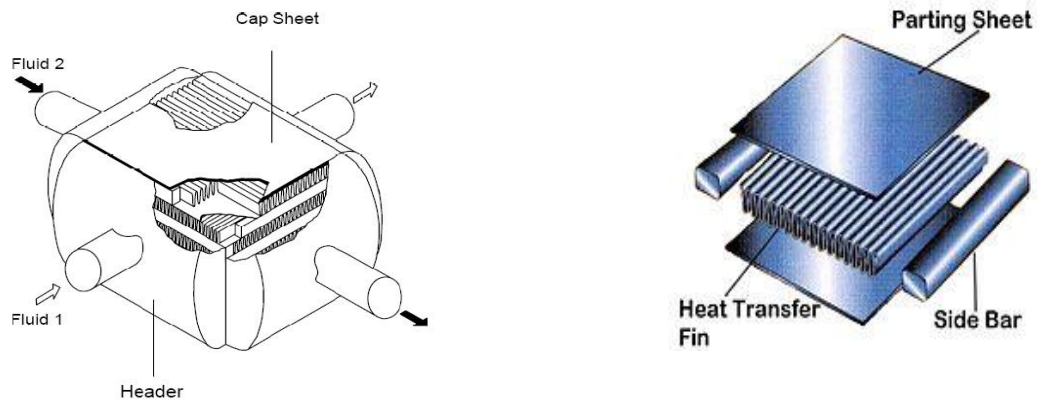

Fig. 1 Plate-Fin Heat Exchanger (PFHX)

The following Figure 2 shows the arrangement of the heat exchanger on the Lehr.

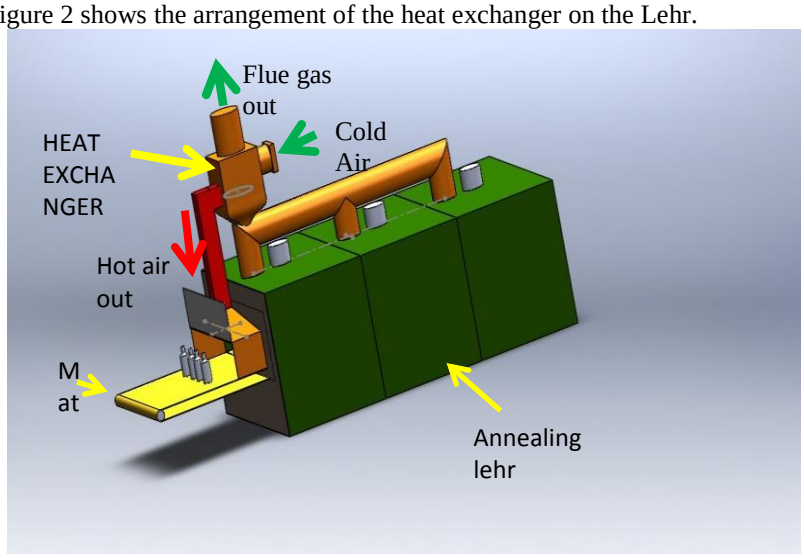

Fig. 2 Heat exchanger arrangement on the Decorating Lehr

Using design calculations [4], it was found the dimensions of the heat exchanger as given in the Fig. 3 below.

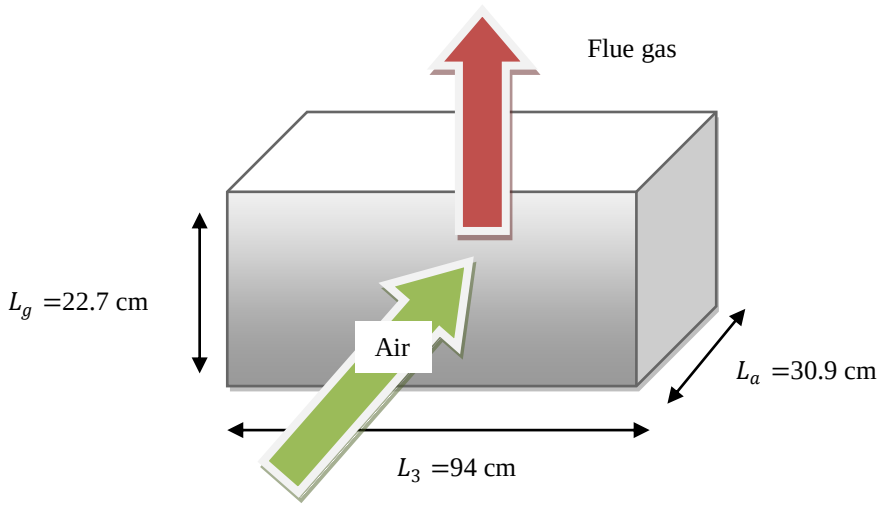

Fig. 3 Dimensions of the heat exchanger

The hot air flow extracted through the heat exchanger can be applied to two different areas to heat up the bottle entry temperature as follows.

1. By introducing a new zone before the existing zone-01
2. By applying the heated air to the existing zone-01

With these both methods, zone-01 burners operating time can be reduced or completely cut-off.

No of burners in Zone-01 = 02
Bottle entry temperature = 30 °C
Existing temperature of Zone 01 = 240 °C
Flue gas temperature = 210 °C
(Assuming 25 % temperature loss due to heat losses at new Zone)
New Zone temperature = 157 °C

Considering 300 ml Coca-Cola bottle [5] & [6]

Gas consumption per hour = 11.5 m^3/h
Burners running pattern (duration) during one hour period.

Table -1 Measured time data of burners

Zone	**01**	**02**	**03**	**04**	**05**	**06**	**07**
No of burners	02	02	04	04	04	02	02
Total working time per hour	41 min	40 min	48 min	27 min	24 min	18 min	15 min

Total running time of 20 burners = 213 min
Without the heat exchanger-bottle heating range = (30-240) °C =210 °C
Zone -01 burners operating time = 41 min
Therefore, Zone-1, for two burners gas consumption $= \frac{41}{213} \times 12.25 \times 2$
= 4.716 m^3/h
With heat exchanger-bottle heating range at Zone-01 = (157-240) °C = 83 °C
Assuming leaner temperature increment,
Zone-01 burners operating time = $\frac{41}{210} \times 83$ = 16 min

Therefore, after applying the new pre-heating Zone with heat exchanger, Zone -01 both burners will be energized only 16 minutes.

Therefore, gas saving with heat exchanger $= \frac{4.716}{60} \times (41 - 16)$ m^3/h
= 1.965 m^3
New gas consumption with heat exchanger = 12.25-1.965 = 10.285 m^3/h
Drawn bottle quantity = 2478 bottles/h
Drawn weight per hour = 2478 x 0.425 = 1053.15 kg/h
Specific gas consumption with heat exchanger = 10.285 /1053.15
= 0.00976 m^3/kg of glass / h
Saving of specific gas consumption with heat exchanger = 0.0116-0.00976
= 0.00184 m^3/kg of glass / h

DISCUSSION AND CONCLUSION

As per the rationale form the study it was found that the heat of flue gas of the decorating lehr can be used for preheating the bottles before entering the Zone 1 of the printing lehr. Installing a heat exchanger as shown in Fig. 1, entering temperature of the bottles to the decorating lehr can be increased. Thereby reasonable amount of gas required to pre-heat the bottles can be minimized.

According to the specimen calculation for 300 ml Coca-Cola bottle, it was found that the 0.00184 m^3 of LP gas / kg of glass per hour can be saved. Therefore, depending on the tonnageper day considerable amount of gas consumption can be saved.

ACKNOWLEDGEMENT

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[5]. Article card PGC/300 ml coca-cola bottle, Winchester 200ml, 175ml Coca-cola, 1L sprite, 300ml lion soda.
[6]. Job change set-up card PGC for Decorating Lehr-300 ml coca-cola bottle, Winchester 200ml, 175ml Coca-cola, 1L sprite, 300ml lion soda.