Solar Air Heating at the Linamar CAMTAC Facility in Guelph, Ontario

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Abstract. A transpired air collector (TAC) installation is designed and analyzed for the purpose of reducing energy costs at Linamar’s CAMTAC Manufacturing facility in Guelph, Ontario. Ventilation air preheating was targeted due to high annual costs. A variety of solar heating technologies were researched, and transpired air collectors were deemed the most applicable. A final detailed design was prepared and is presented herein. A number of design options were investigated. The most promising option offers annual renewable energy delivery of 240 MWh, and a 12 year payback period.

1 Introduction

TRN and Associates were retained by Linamar to perform an energy audit of the CAMTAC Linamar facility, to identify potential cost-saving solutions to improve energy efficiency, and provide a design for implementation [1].

To evaluate the design options, the following criteria were used: payback period, annual energy savings, return on investment, ease of implementation, maintenance requirements, design life, and building aesthetics. In addition, the design:

- Must improve the plants energy efficiency
- Must maintain facility floor temperature at or above 18°C throughout the year
- Must not affect existing ventilation rate inside plant
- Must be compatible with existing air handling units
- Must not negatively affect ventilation air quality
- Must be able to be safely supported by the existing building frame
- Must comply with municipal and provincial zoning and building codes
- Must provide return on investment within lifespan

A variety of solar-based technologies were investigated, and those focused on heating were deemed the most promising as CAMTAC’s annual natural heating bills exceeded $200,000 in 2007. Solar heating technologies including Trombe walls, passive solar devices, and transpired air collectors were researched. TACs were selected as the most promising option due to their ability to provide the large volumes of heated ventilation air required. Also, this technology has been successfully applied in the Greater Toronto Area [2].

2 Conceptual Design and Methodology

Currently, six rooftop-mounted natural gas make-up air (MUA) units provide ventilation air to the main floor area at the facility. Ventilation flow rates were found to be approximately 300,000 m³/hr and air is provided at a 15°C setpoint [1]. The TAC will be placed on the southeast (SE) facing wall of the existing facility. The TAC provides heated air by converting solar radiation into thermal energy. A steel wall with hundreds of tiny perforations warms up and transfers heat to ventilation air as it is drawn through the perforations in the wall.

After the air is drawn through the perforated face and passes up the wall, an inlet at the top of the wall directs the air into ducting which runs along the ceiling of the plant. The ducting feeds the existing Make-up Air (MUA) units found on the roof of the building. This air is then heated to the desired setpoint with natural gas heaters, and blown in to heat the plant area. Air is heated by the wall throughout the year, however bypass dampers ensure that heated air is not blown into the plant when it has been heated above the desired temperature within the plant.

Several design options were considered to determine the most suitable configuration for the CAMTAC facility. These feasibility results were prepared by altering wall size, and the number of MUA units connected to the TAC. Three ducting options were considered including rooftop-installed insulated steel ducting, interior steel ducting, and fabric ducting. Fabric ducting was deemed the most feasible. The results of this feasibility analysis are provided in Figure 1 below with a simple payback period.

<table>
<thead>
<tr>
<th>Option</th>
<th>Number of MUA (s)</th>
<th>Collector Area (m²)</th>
<th>Capital Cost (CAD)</th>
<th>Payback Period (yrs)</th>
<th>Annual Fuel Cost Savings (CAD)</th>
<th>Annual Energy Savings (MWh/Yr)</th>
<th>Net Savings over Project Lifespan (CAD)</th>
<th>Return on Investment (%)</th>
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<td>310</td>
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<td>10,300</td>
<td>390</td>
<td>149,000</td>
<td>87</td>
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</tbody>
</table>

Fig. 1. Feasibility Design Results

3 Discussion

The preceeding designs were evaluated against the criteria specified. Options 1 and 2 have the lowest payback period at 12 years, along with the greatest return on investment as analysed under simple payback. The amount
of renewable energy collected increases proportional to increasing wall size. All Options are relatively straightforward to install, and have the same design life. Service and maintenance requirements would increase slightly with increasing wall size, but likely will not amount to more than a few hours each month. Option 2 was chosen as the most practical option, as it provides the highest return on investment while providing more energy savings than Option 1. Options 3 and 4 offer greater energy savings, but the payback period is longer and the return on investment is not as high. Option 2 can be pursued, and should the system performance be as expected, Option 3 or 4 could be implemented.

The TAC will have minimal aesthetic impact in an industrial setting. Energy savings with a grey wall are \( \frac{3}{4} \) as much as an identical black wall design, and the payback period increases from 12 to 14 years. The project savings over the lifespan are also decreased. Therefore, a black wall is recommended as the payback and energy savings are the greatest.

4 Detailed Design

The final design consists of two 34m wide transpired air collectors spanning the entire 8.85m height of the facility. The TACs will be 20.5m apart, and symmetrical about the centre of the southeast wall. A structural analysis on the existing building should be performed prior to installation of the TACs by a qualified structural engineer to ensure the additional load of approximately 6 tonnes can be supported. The TAC is to be anchored to the existing wall using galvanized steel framing which is also used to create the desired 20cm air gap.

The transpired air collector cladding can be purchased in sheets 1m wide and 4.5m tall. The transpired air collector panels should be attached to the existing metal cladding through a grid of z-bars. Fifteen-cm vertical z-bars, 7.5m high, will be anchored at 1.25m spacing to the existing structural support beams. Five-cm horizontal z-bars will be fastened to the vertical z-bars at 1.25m intervals as well. A hat-bar should be installed midway up the wall where panels overlap [3]. At the ends of each transpired air collector, a 20-cm vertical j-bar will be installed and covered by a strip of prefinished metal cladding. At the base of the wall, a 30m long, 20cm wide z-bar will be laid flush to the ground and anchored to the existing foundation. An angled j-bar overlaid with a pre-finished cap at the top of the wall will provide structural support and prevent rain from draining into the TAC structure [3].

The TAC will be connected to the existing make-up air units through the use of fabric ducting. Two runs of ducting will be used. Each will be 1.2m in diameter, with a centre 1.6m below the top of the wall so it can be easily suspended from the existing ceiling trusses. Ducting with a diameter of 1.2m will be used to ensure the velocity in the ducting does not exceed 7m/s.

A damper will be inserted into the hole cut from the existing exterior wall to regulate flow and isolate the system. The fabric ducting will be fastened to this damper using a pinch-down duct belt and will run perpendicular to the SE wall until it reaches the MUA.

Non-permeable, lightweight, flame retardant, polyester fabric ducting will be used to supply the air from the transpired air collector to the make-up air units. Slightly porous ducting will be used to reduce the risk of bacterial growth as a result of condensation. Fabric ducting will be connected by cable supports to the existing ceiling trusses.

1.2m insulated steel ducting will be used to convey the TAC pre-heated air through the roof to the MUAs. Detailed MUA intake design and anchoring design for the steel ducts requires further details on rooftop structure and MUA unit configuration.

5 Conclusion

Installation of a transpired air collector on the southeast facing wall at the Linamar CAMTAC facility in Guelph, ON would improve the energy efficiency of the facility. Annual energy savings of approximately 240 MWh/yr could be achieved through the installation of 600 m\(^2\) of TAC to preheat ventilation air for two of the existing MUAs. These energy savings would come at an initial cost of approximately $84,000 CDN. Simple payback analysis shows that the project would break even after approximately 12 years, and $130,000 CDN could be saved over the 30 year project lifespan.

6 Acknowledgements

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References

1. Minogue, M. Personal Communication, Linamar, Guelph, ON (200).