**Assessment Recommendation**

**Eject Waste Heat of Injection Molding Machines**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Assessment Recommendation Summary | | | | | |
| ARC# | Annual Resource Savings | Total Annual Savings | Capital Cost | Other Cost | Simple Payback |
| 2.2437 | |  |  | | --- | --- | | Electric Usage: | 78,619.98 kWh | | $4,166.86 | $5,092.71 | $7,087.50 | 2.92 years |

**Current Practice**

Currently, waste heat from ~27 molding machines is being released into the plant floor of the clean rooms. The Arbourg and Sumitomo Injection Molding Machines are modeled as a 3ft x 3ft hot plate with a surface temperature of around 400-700 oF.[[1]](#footnote-1) The figure below shows a similar molding machine model, highlighting the hot plate in question.

A machine in a room

Description automatically generated

**Recommended Action**

It is recommended that ducts be installed above the hot plates to capture a portion of the waste heat generated from the molding machines. The hot air can be blown outside in the summer to reduce cooling load for the conditioned spaces. The system can be turned off during the winter months so that the waste heat can be utilized to reduce heating load.

**Anticipated Savings**

The heat transferred from one machine to the surrounding air by convection can be calculated using the following equation:

*Qa* = Heat transferred to surrounding air by one machine

= Free convection coefficient of heat transfer[[2]](#footnote-2) *5*

A = Surface area of the hot plate[[3]](#footnote-3) *0.84*

= Surface temperature of the hot plate[[4]](#footnote-4) 550 oF (*560.93* K)

= Temperature of the surrounding conditioned air[[5]](#footnote-5) 68 oF (*293.15* K)

= Conversion from W to kW *0.001*

Substituting,

In the summer months, the hot air should be exhausted out of the plant to reduce the cooling load. The energy savings associated with this action can be estimated by the following equation, calculating the annual energy savings (AES).

*Qa* = Heat transferred to surrounding air by one machine *1.13*

*PC* = Number of injection molding machines[[6]](#footnote-6) *27*

*PC* = Percentage of hot air captured by exhaust duct[[7]](#footnote-7) *75 %*

*PHM* = Percentage of the annual hours that the molding machines run[[8]](#footnote-8) *80 %*

*HRS* = Annual hours during which cooling is required[[9]](#footnote-9) *3,672* *hrs*

*η* = Efficiency of cooling system[[10]](#footnote-10) *0.85*

*P =* Power draw of the ventilation system[[11]](#footnote-11) *0.17 hp*

*=* Conversion from hp to kW *0.74*

Substituting,

Note that this value does not account for electricity required to provide the additional ventilation.

Given an average electricity cost of 0.053 $/kWh, the estimated total annual savings (*TAS*) is as follows.

**Implementation Costs**

Implementation costs are given in the table below. Quotes from the 2011 RS Means Mechanical Cost Data Handbook were used to make cost estimates. Note that the RS Means Line Number is included for easy reference. The following table describes an estimation of implementation costs assuming that plant maintenance staff will perform all necessary installation.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *Description* | *RS Means #* | | *Quantity* | *Unit Price* | *Total* |
| *Flexible Air Duct, Insulated, 1” thick, PE jacket, 12” diameter* | *233346.101910* | | *270[[12]](#footnote-12)* | *8.85 $/ft* | *$2,389.50* |
| *Axial Flow HVAC Fan, Direct drive, 12”, 1,060 CFM, 1/6 HP* | *233413.100510* | |  |  |  |
| *1* | *$715* | *$715.00* |
|  |  |  |
| *Metal Ducts, Round and Flat-Oval Spiral Ducts, Connector, 36” diameter, 1 foot length* | *233813.107830* | | *27[[13]](#footnote-13)* | *29 $/ea*  *RS Means Material Subtotal*  *Location Adjustment Factor*  *RS Means Total* | *$783*  *$3,955.5*  x*1.03*  *$4,074.17* |
| *Installation* | *N/A* | *162 hrs[[14]](#footnote-14)* | | *35 $/hr[[15]](#footnote-15)* | *$5,670* |
|  |  | |  | *RS Means Material + Installation Subtotal* | *$9,744.17* |
|  |  | |  | *Clean Room Consideration Factor[[16]](#footnote-16)* | x*1.25* |
|  |  | | Total | | $12,180.21 |

The simple payback period can be determined as follows.

1. Measurements taken on site by ITAC personnel. [↑](#footnote-ref-1)
2. Conservative estimate of free convection if air over a plate with 30oC temperature difference. [Convective Heat Transfer Coefficients Table Chart](https://www.engineersedge.com/heat_transfer/convective_heat_transfer_coefficients__13378.htm#google_vignette) [↑](#footnote-ref-2)
3. Measured by IAC personnel; 3 ft length square hot plate. [↑](#footnote-ref-3)
4. Measured by IAC personnel; Averaging temperature data. [↑](#footnote-ref-4)
5. Obtained from site staff. [↑](#footnote-ref-5)
6. Obtained from site staff. [↑](#footnote-ref-6)
7. An estimate of the efficiency of the air duct. [↑](#footnote-ref-7)
8. Accounting for machine down time. [↑](#footnote-ref-8)
9. Based on a cooling season from April to September (153 days), assuming cooling is required 24 hours a day. [↑](#footnote-ref-9)
10. Estimated by IAC personnel. [↑](#footnote-ref-10)
11. Power draw for a recommended single axial flow HVAC fan with 1,060 CFM capacity, utilized for the entire system, resulting in a ventilation rate of ~40 CFM per machine. [↑](#footnote-ref-11)
12. Estimating 10 feet of duct per machine. [↑](#footnote-ref-12)
13. Estimating cost for a tapered duct for each inlet to increase area of capture. [↑](#footnote-ref-13)
14. Estimating 6 hours of installation per machine. [↑](#footnote-ref-14)
15. Obtained from Pre-Assessment Survey [↑](#footnote-ref-15)
16. Considers additional material costs and labor costs for maintaining the clean room air sensitivity. [↑](#footnote-ref-16)