# **AR ${AR}: Install Heat Exchanger to Recover Heat from Exhaust Gas**

**Recommended Action**

Recover exhaust heat from the thermal oxidizer and use this recovered heat to preheat the air for the drying ovens by applying a heat exchanger.

**Summary of Estimated Savings and Implementation Costs**

|  |  |
| --- | --- |
| Annual Cost Savings | ${ACS} |
| Implementation Cost | ${IC} |
| Payback Period | ${PB} |
| Annual Natural Gas Savings | ${NGS} MMBtu |
| Annual Electricity Savings | ${ES} kWh |
| Annual Demand Savings | ${DS} kW |
| ARC Number | 2.2442.2 |

**Current Practice and Observations**

The furnace is exhausting heat to the atmosphere at about ${TI}oF with a volume of ${CFM} CFM. This exhaust heat can be recovered for use in the plant.

**Anticipated Savings**

The potential natural gas savings, NGS, can be estimated as follows:

NGS = CFM × ρ × C1 × CP × (TI - TO) × η × OH / C2

where,

CFM = Total exhaust flow rate of furnaces; ${CFM} ft3/min

ρ = Density of exhaust gas (at ${TI}oF); ${RHO} lb/ft3

C1 = Conversion constant; 60 min/h

CP = Specific heat of exhaust gas[[1]](#footnote-1) (at ${TI}oF); ${CP} Btu/lb⋅°F

TI = Temperature of exhaust air at the entry of heat exchanger; ${TI}°F

TO = Temperature of exhaust air at the exit of heat exchanger; ${TO}°F

η = Efficiency of air-air heat exchanger; conservatively ${ETA}% (depends on design)[[2]](#footnote-2)

OH = Oxidizer operating hours; ${OH} hrs/yr (${HR} hours per day, ${DY} days per week, ${WK} weeks per year)

C2 = Conversion constant; 1,000,000 Btu/MMBtu

Using the parameters discussed above, the natural gas savings, NGS, can be calculated as follows:

NGS = ${CFM} ft3/min × ${RHO} lb/ft3 × 60 min/h × ${CP} Btu/lb⋅°F × (${TI} °F - ${TO} °F) × ${ETA} × ${OH} hrs/yr / 1,000,000 Btu/MMBtu

= ${NGS} MMBtu/yr.

There will be an increase in electrical energy as a fan will be required to move the hot air through the heat exchanger and into the oven inlets. The associated cost is as follows:

HP = Fan horsepower; ${HP} HP

C3 = Conversion constant; 0.746 kW/HP

CF = Coincidence factor; ${CF}% per month

C4 = Conversion constant; 12 mos/yr

The potential fan electricity usage, EU, can be calculated as follows:

EU = HP × C3 × OH

= ${HP} HP × 0.746 kW/HP × ${OH} hrs/yr

= ${EU} kWh/yr

The potential fan demand usage, DU, can be calculated as follows:

DU = HP × C3 × CF × C4

= ${HP} HP × 0.746 kW/HP × 12 mos/yr × ${CF}%/mo

= ${DU} kW/yr

The total annual cost savings; ACS, is equal to:

ACS = NGS × Natural Gas Cost - EU × Electricity Cost - DU × Demand Cost

= ${NGS} MMBtu/yr × ${NGC}/MMBtu - ${EU} kWh/yr × ${EC}/kWh - ${DU} kW/yr × ${DC}/kW

= ${NGCS}/yr - ${EUC}/yr - ${DUC}/yr

= ${ACS}/yr

**Implementation Cost**

The implementation cost is associated with installing the heat exchanger, fan, and ducting to the existing oven inlets. This is estimated at ${IC}.

**The annual natural gas savings for this AR will be ${NGS} MMBtu. The estimated annual cost savings is likely to be ${ACS} and, with ${IC} in implementation costs, the payback period will be ${PB}.**

**Implementation Cost References**

The below links are for implementation cost references. We do not endorse/recommend these brands or products. Furthermore, these products may or may not be suitable for the application. The client should contact a vendor(s) to conduct a detailed study of the process, in

order to determine the best product for the recommended application.[[3]](#endnote-1)[[4]](#endnote-2)[[5]](#endnote-3)

1. Density and specific heat of exhaust gas is approximated to the properties of air. [↑](#footnote-ref-1)
2. Sunden, B. "Heat exchangers and heat recovery processes in gas turbine systems." *Modern Gas Turbine Systems*. Woodhead Publishing, 2013. 229. Cited as 80-93% [↑](#footnote-ref-2)
3. A Guide to Heat Exchangers for Industrial Heat Recovery- New York State Energy Research and Development Authority cites the payback period for heat recovery - specifically, economizers and waste heat from boilers- between 2 and 3 years. [↑](#endnote-ref-1)
4. Boiler Economizer Systems - Presented by: Hayward Burton, H.V. Burton Co. cites the average payback period for economizers and other heat recovery as 3 years. [↑](#endnote-ref-2)
5. Willems, Daniel. “Advanced System Controls and Energy Savings for Industrial Boilers.” ASME 2006 Citrus Engineering Conference, 2006, <https://doi.org/10.1115/cec2006-5202>. Cites the payback period as 2 years for heat recovery projects. [↑](#endnote-ref-3)