Recommendation

Tune the natural-gas curing ovens annually and install a recirculation system into the stack. This will reduce associated energy consumption by 75.9%.

Annual Savings Summary

Source	*Quantity*	*Units*	*Cost Savings*
Natural Gas	795	MMBtu	$5,065

Implementation Cost Summary

Description	*Cost*	*Payback (yrs)*
Before Incentives	$5,807	1.1
After Incentives	-	-

Facility Background

The facility has three natural gas curing ovens with an estimated 3,120 annual operating hours each. The ovens cure composite products on 700 lb steel fixtures every hour. Oven 2 and Oven 3 have firing rates of 0.880 MMBtu per hour. The curing ovens operate at 100 °F for one hour, and then 265 °F for two to three hours. A fan at the burner is used to keep the temperature throughout the oven consistent. Exhaust is carried from the oven through a 12” duct to the roof exiting at seven miles per hour. Oven 5 operates similarly, but analysts were unable to obtain oven specifications.

Opportunity Background

Combustion occurs when fossil fuels, such as natural gas, coal or gasoline, react with oxygen in the air to produce heat. Oxygen in the air reacts with carbon and hydrogen in the fuel to form carbon dioxide and water, releasing energy. Ideally, an oven would use just enough air to burn all of the fuel, with no excess air. Excess air carries heat up the stack and reduces efficiency. In practice, a small amount of excess air is required for complete combustion [1]. Vendors indicate that excess airflow is a common industry practice which can be improved.

Two solutions to this high stack loss include recirculating a portion of stack flow back to the oven or adding a high-temperature fan blade in the oven. The following analysis recommends the installation of a recirculation system. Doing so will increase overall thermal efficiency and reduce natural-gas consumption. Additionally, by tuning the oven, excess air is minimized, increasing heating efficiency.

Proposal

Tune the natural gas curing ovens yearly to achieve 4.0% excess oxygen and install a recirculation system in the stack. Annual cost savings are estimated at $5,065 after an implementation cost of $5,807, resulting in a simple payback period of 1.1 years.

Implementation

Install ducting and a recirculation fan to recycle heated exhaust air from the stack into the oven. The fan will recover heat that would otherwise be lost into the atmosphere. The natural-gas burner will burn less often, consuming less natural gas, and saving energy. Facility may need to install an air filter in the ducting to prevent excess moisture in the oven. Annual tuning of the oven will maintain efficient operation.

Calculation Methodology

The Process Heating Assessment and Survey Tool (PHAST) is used to model the energy consumption of the oven in its current state and proposed state [2]. The proposed state takes into account a decreased in the excess air (EA) resulting in an increase in overall thermal efficiency. Analysts propose an excess oxygen level of 4% in the exhaust stream.

Next Steps

Tuning ovens is an iterative process. It is recommended that the ovens are tuned annually to ensure maximum efficiency and savings.

Notes

Combustion readings were obtained from Oven 5 as Oven 2 and Oven 3 were not operating. Nameplate information was gathered from Ovens 2 and 3, but Oven 5 was inaccessible. An assumption was made that Oven 5 operates similarly to Oven 2 and Oven 3.

PHAST is a free tool provided by the Department of Energy that helps industrial users survey process heating equipment that consumes fuel, steam, or electricity, and identifies the most energy-intensive equipment. The tool can be used to perform a heat balance that identifies major areas of energy use under various operating conditions and test "what-if" scenarios for various options to reduce energy use [1].

Exhaust air recirculation may affect productivity and curing process, due to the introduction of exhaust products. Analysts suggest facility personnel analyze the effects that this system may have.

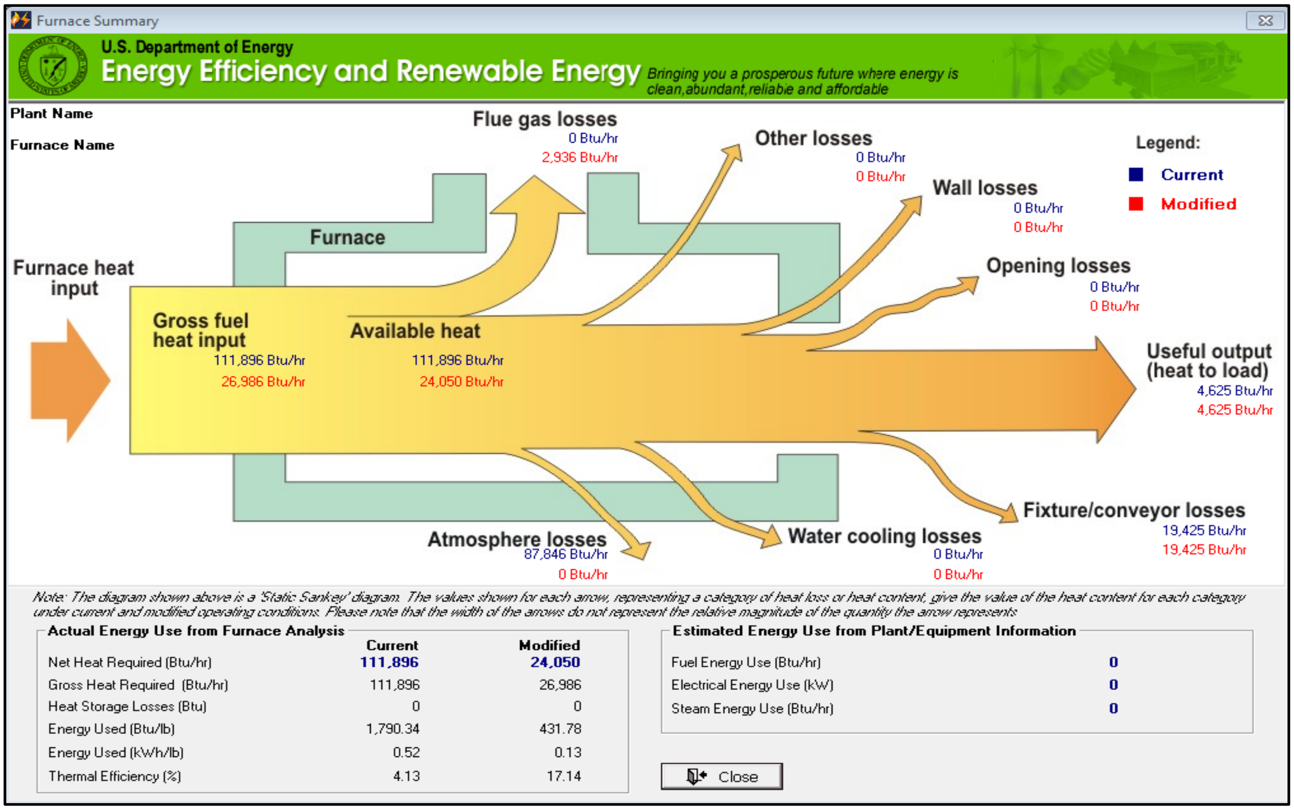
References

[1] Incorporated, Tsi. *Combustion Analysis Basics - An Overview of Measurements, Methods and Calculations Used in Combustion Analysis* (n.d.): n. pag. [Online]. Available: https://www.engineeringtoolbox.com/fuels-combustion-efficiency-d_167.html [Accessed: 10 Feb. 2017.].

[2] US Department of Energy, Energy Efficiency and Renewable Energy, Process Heating Assessment Tool, [Online]. Available: https://www.energy.gov/eere/amo/articles/process-heating-assessment-and-survey-tool [Accessed Mar 2017.]

[3] RS Means, *Mechanical Cost Data.* Rockland, MA: RS Means, 2016.

[4] The Engineering Toolbox "Optimal Combustion Process - Fuels and Excess Air." *The Engineering ToolBox*. [Online] Available: https://www.engineeringtoolbox.com/fuels-combustion-efficiency-d_167.html. [Accessed: 10 Mar. 2017]



PHAST Inputs

PHAST Inputs	Value	Source
O_2 in Exhaust Stream	20.7 %	Site Data
Stack Temperature	216 °F	Site Data
Combustion Air Temperature	65 °F	Site Data
Hours of Operation	3,120 hrs	Obtained from Facility Personnel
Steel Fixture Mass Flow Rate	700 lb/hr	Obtained from Facility Personnel
Steel Fixture Target Temperature	350 °F	Obtained from Facility Personnel
Proposed Oxygen Percent	4.0 %	Excess Oxygen Percentage Value for Natural Gas obtained from The Engineering Toolbox [4]

Notes

N. 1) Atmospheric losses were converted to flue gas loss as the air lost previously is now being reused for combustion.

3 - AR No. 4 - Analysis

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Oven Tuning/Recirculation, style 2018 v1.0

Data Collected

Oven #3 Operational Data

Curing Oven Operation Time	(t)	*3,120*	hrs/yr	**(N. 2)**

Utility Data

Incremental Natural Gas Cost	(IC_G)	*$8.26*	/MMBtu	**(N. 3)**

Energy Analysis

Current Conditions

Current Oxygen Percent	(O_C)	*20.7%*		**(N. 4)**
Gross Fuel Heat Input	(E_{GC})	*111,896*	Btu/hr	**(N. 5)**
Number of Ovens	(n)	*3*		**(N. 6, N. 7)**

Proposed Conditions

Proposed Oxygen Percent	(O_P)	*4.0%*		**(N. 8)**
Gross Fuel Heat Input	(E_{GP})	*26,986*	Btu/hr	**(N. 5)**
Number of Ovens	(n)	*3*		**(N. 6)**

Savings

Gross Fuel Energy Savings	(E_{GS})	*254,730*	Btu/hr	**(Eq. 1)**
Annual Fuel Energy Savings	(E_S)	*795*	MMBtu/yr	**(Eq. 2)**
Annual Cost Savings	(S)	*$6,565*	/year	**(Eq. 3)**

Equations

Eq. 1) Gross Fuel Energy Savings (E_{GS})

$$(E_{GC} - EG_P) \times n$$

Eq. 2) Energy Savings (E_S)

$$E_{GS} \times t \times \frac{1\ MMBTU}{1{,}000{,}000\ BTU}$$

Eq. 3) Annual Cost Savings (S)

$$E_S \times ICG$$

Notes

N. 2) Information provided by facility personnel

N. 3) Information sourced from the Utility Analysis located in the Site Data section of this report

N. 4) Current oxygen percent value obtained from combustion analyzer readings.

N. 5) Developed in the PHAST tool, located on the previous page.

N. 6) Information gathered on site by analysts.

N. 7) Analysts assume the operating conditions for all the ovens are the same.

N. 8) Oxygen percent value is based on previous recommendations and is considered a conservative value for typical combustion tuning.

3 - AR No. 4 - Implementation

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Implementation Cost Analysis

Material Costs

Exhaust Recirculation Fan	(C_F)	*$660*	/oven	**(N. 9)**
Exhaust Fan Damper	(C_D)	*$31*	/oven	**(N. 9)**
Metal Duct	(C_T)	*$3.72*	/ft	**(N. 9)**
Length of Duct	(D_L)	*12*	ft/oven	**(N. 10)**
Quantity	(n)	*3*	ovens	**(Rf. 2)**
Total Material Cost	(C_M)	***$2,207***		**(Eq. 4)**

Labor Costs

Fan Crew	(L_F)	*$79*	/hr	**(N. 9)**
Fan Hours	(H_F)	*6.67*	hrs	**(N. 9)**
Fan Installation	(I_F)	***$530***		**(Eq. 5)**
Damper Crew	(L_D)	*$88*	/hr	**(N. 9)**
Damper Hours	(H_D)	*0.5*	hrs	**(N. 9)**
Damper Installation	(I_D)	***$44***		**(Eq. 5)**
Metal Duct Crew	(L_T)	*$79*	/hr	**(N. 9)**
Metal Duct Hours	(H_T)	*0.133*	hrs	**(N. 9)**
Metal Duct Installation	(I_T)	***$126***		**(Eq. 5)**
Oven Tuning	(O_T)	*$500*	/yr	**(N. 12)**
Total Labor Cost	(C_L)	***$3,600***		**(Eq. 6)**

Economic Results

Annual Cost Savings	(S)	***$5,065***	/year	**(Eq. 4, N. 13)**
Implementation Cost	(C_I)	***$5,807***		**(Eq. 8)**
Simple Payback	(t_{PB})	***1.1***	years	**(Eq. 9)**

Equations

Eq. 4) Total Material Cost (C_M)

$$[CF + CD + (C_T \times DL)] \times n$$

Eq. 5) Installation Cost (I)

$$L_{F\ D\ T} \times HF_{\ D\ T}$$

Eq. 6) Total Labor Cost (C_L)

$$(IF + ID + IT + OT) \times n$$

Eq. 7) Annual Cost Savings (S)

$$(E_A \times ICG) - (OT \times n)$$

Eq. 8) Implementation Cost (C_I)

$$C_M + CL$$

Eq. 9) Simple Payback (t_{PB})

$$\frac{C_I}{S}$$

References

N. 9) Cost of materials and labor were sourced from RS Means [3].

N. 10) Analysts assume 12 feet of duct will be required to complete the exhaust recirculation system. Actual costs will vary depending on duct length.

N. 11) Information gathered on site.

N. 12) Oven tuning is based off of typical expenses of tuning a boiler.

N. 13) Annual Cost Savings is different than savings in Analysis due to the cost of annual oven tuning