Practical fast payback solutions to energy savings.

Reducing the fixed manufacturing cost is an area where most companies are looking to save money. The problem is to find areas where money can be saved with minimal capital spending. Many solutions require significant capital spending up front and a payback over a longer time. We have found that small changes and investments can impact the bottom line significantly.. In the following I will point out areas where small investments can produce fast payback both in energy saving and in some cases improved process control.

Combustion Blower.

Many direct and indirect fired furnaces and ovens have multiple burners that have a common combustion blower. The blower is sized for producing the required combustion airflow and pressure to overcome the piping restrictions and provide enough CFM at the individual burners to sustain the combustion at high fire. The maximum airflow is used at the start of the production. However at soak or stable output the requirements for combustion CFM drops significantly. With typical turndown of 20:1 for the burners the combustion air blower will be dead heading at low fire and soak. By installing a pressure transducer on the combustion air pipe and letting it transmit directly to a VFD (Variable Frequency Drive) installed in the control cabinet, it is possible to control the combustion air pressure in the optimum range for the burners. When the burners go to high fire the VFD speeds up the blower and when they are at low fire it slows the combustion blower down. A 50% energy savings has been documented on motor AMP's. In addition the burner control becomes more linear since the combustion air is supplied at constant pressure at the control valves during all firing ranges. Added benefits are noise reduction and wear reduction on the blower due to the lower speed during most of the process.

Routine maintenance like cleaning of the combustion blower wheels can also increase efficiency significantly. Many blowers do not have easy access to the wheels for inspection and cleaning. Adding an inspection port to the blower housing can help in the cleaning and inspection task. Another area of periodic maintenance is the inside of the combustion air piping. Dust and dirt accumulates on ridges and transitions in the system. We have found that control valves can be completely filled with dirt after just a few years of operation. See figure #1 This prevents good control. The combustion air piping should be designed/modified to allow easy inspections and cleaning of these components.

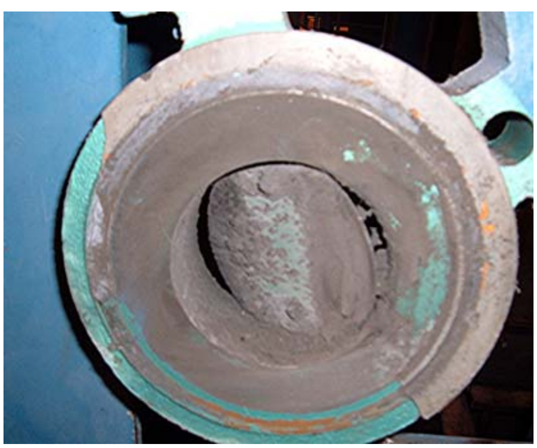

Figure #1
The picture shows an air control valve removed for inspection with a large buildup of dirt.

Indirect fired burners.
The proper adjustment of the burners is critical to the efficiency of the system. A small layer of soot in the tube can reduce the heat transfer by up to 20%. Good preventive maintenance practices like monthly/quarterly O_2 checks plus yearly inspections of the burners are excellent ways of ensuring good process economics. It shall be noted that new proportionators and in some cases new burners will add to the energy savings. We have found that more linear and lower excess O_2 levels are possible. Old systems are typically fired with 3% excess O_2 at high fire and 13-16% at low fire. With new proportionators and in some cases new burners on the same system we have been able to obtain good combustion with 2-3% O_2 at high fire and 6-8% at low fire without soot in the exhaust. Improved linearity of the combustion translates to significant savings since any excess air wastes fuel.

The use of recuperation on the exhaust leg can recover 15-20% of the exhaust energy and re-introduce it into the burner. Please note that maintenance of these devices is an additional cost.

Oven and furnace exhaust.
Direct fired equipment with exhaust blowers has many good opportunities for energy savings. A typical system will have motorized or fixed dampers in the exhaust system with a fixed speed exhauster. When the system goes to high fire the furnace/oven box pressure goes positive and when the system is in soak at a lower firing rate it might be only slightly positive or even negative. To compensate for the negative pressure, many times manual dampers are used to allow fresh air to enter the heater box. The fresh air introduces a heat load to the system which is compensated by the burner output. The solution used to remedy this is to install a pressure transducer on the furnace/oven box and connect it directly to the exhaust blower(s) VFD(s). The pressure should be programmed to be about +0.05-0.1" WC to ensure good uniformity at the door seals and other openings. The exhaust blower will now speed up when the burner(s) goes to high fire and slows down when operating at reduced firing rates. The fresh air intake can be reduced or eliminated and energy saving is immediate. (Please note that minimum airflow is required if products with solvent are processed per NFPA 86). It is recommended to install shaft sensors on the exhausters as part of the combustion safety equipment. Airflow switches will likely not work on the low fan speeds during soak. More than 50% in power reduction to the fan motor is common plus savings in energy to heat the excess air influx.

Rebuilds and upgrades.
The decision to rebuild or upgrade an existing furnace/oven depends on many factors, for example, the cost of replacing the equipment with new or new product mixes for the plant. I will review two examples where existing machines were modified with excellent results both in product capability and energy savings. We have found that most insulated boxes are in good shape. The controls and the heating equipment pose the biggest challenges for the plants. The following are examples of rebuilds of existing equipment

Example #1.
Bogh Industries LLC together with American Controls and Engineering completed a total heater and controls rebuild of a large cure oven. The project was initiated when it was discovered that the existing heat exchangers had reached the end of their duty cycle due

to heat damage and numerous repairs over the years. Airflow measurements had also shown that up to 30% of the fans capacities were lost by the restriction in these heat exchangers.

The heat exchanger is shown in the picture to the left.(Figure #2) The airflow came from the bottom through the top. The very tight spacing of the tubes is a big restriction in the re-circulation fans ability to circulate the air

Figure #2.

Fresh air and exhaust was used for low temperature operation due to the low turndown capability of the four existing burners. Significant energy losses were obvious.

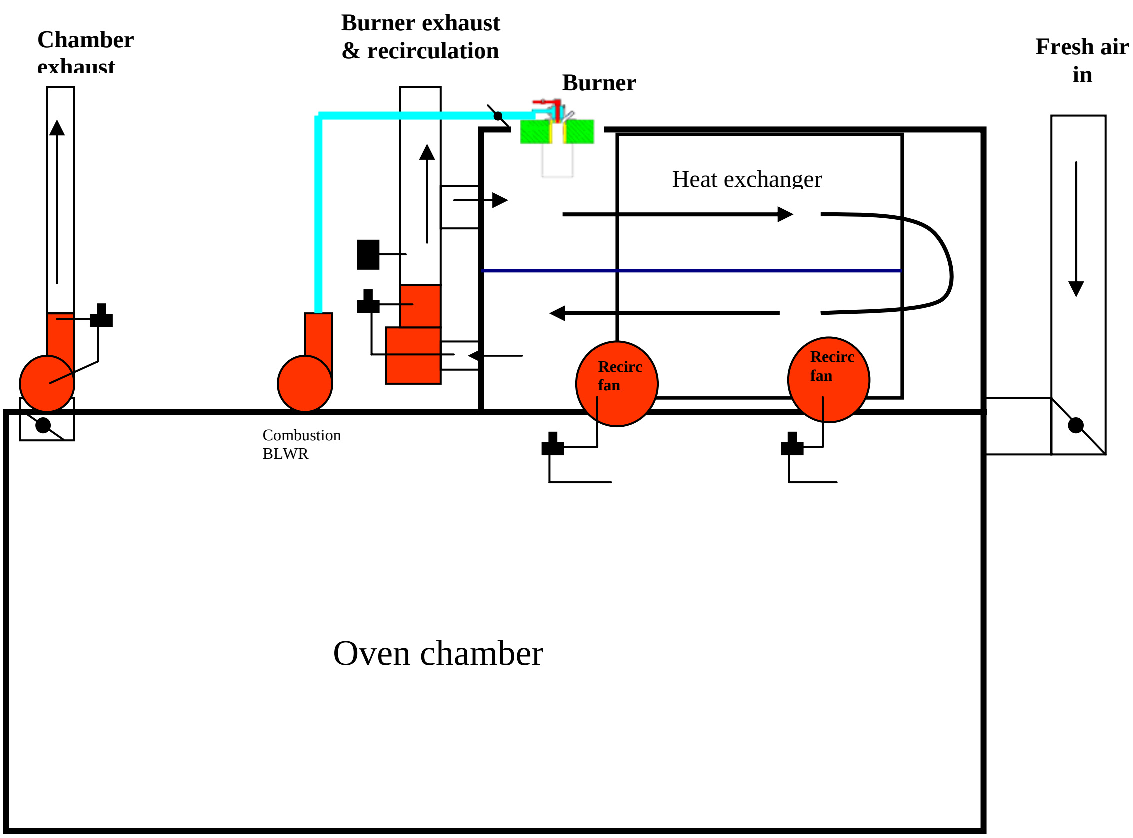

Figure #3. The figure shows the configuration of the oven in a schematic format.

Equipment specifications:
Oven chamber size: 40'Long x 20' Wide x 12' High
Two heat zones with 10 Mill BTU heat input each.
Heaters: Four Maxon Kinnemax burners firing at up to 5 Mill BTU each.
Certified temperature range 150F-350F +/- 10F

Modifications:
The modifications consist of both burner and control modifications.

1. The heat exchangers were replaced with eight (8) new 10" diameter "W" burner tubes attached to two easily removed burner plugs in the event of future repairs.
2. Eight (8) 10" Eclipse Tuboflame burners rated at 2.5 Mill BTU each replaces the four (4) 5 Mill BTU Kinedizer burners.
3. Pilot gas train eliminated with the direct ignition burners.
4. New high resolution control motors control each burner for precise heat input.
5. The two (2) 50 HP combustion re-circulation fans were eliminated from the design.
6. All fresh air for temperature control at low operating temperatures is eliminated due to better turn down with the eight burners compared to four burners. Burners are turned off when not needed adding additional turndown.
7. Combustion air is controlled with blowers that have VFD's and run at a set pressure. This cuts the energy usage by 50%.

Results:
The airflow increased with an average of 200FPM measured at the outlets of the supply duct. This resulted in better uniformity in the work zone. The maximum certified temperature was raised from 350 to 450F.

Energy saving:
Eliminating two (2) 50 HP combustion recirculation fans, two (2) 15HP exhaust fans (now only used for cool down) and cutting 50% usage from the combustion blowers saves 155HP worth of electricity from every hour of usage on the oven. Estimated **$1,400.00** per year saving.

Eliminating the use of fresh air for low temperature operation is estimated to save **$51,000-$54,000** per year in natural gas cost. In addition the improved heat transfer has shown that the oven has more heat available than needed for the process.

Labor saving:
The updated and simpler maintenance friendly gas train (Pilots are eliminated) and components are saving the customer significant maintenance and down time.

Capital saving:
The cost of the repairs and modification was less than 15-20% compared to replacement of the equipment. In addition the down time was only five weeks compared to the

estimated down time of six months with the installation of new equipment. The oven has extended it usefulness another 20-25 years.

Figure #4. This picture shows the two burner plugs getting the last welding performed during fabrication.

Example #2.
Resurrecting a storage space to an oven. The oven was built in 1991 and has a work chamber that is 40' long x 20' wide x 12'high. It is used for cure and aging cycles and the temperature range is 125F-500F.

The oven had been out of production for several years due to equipment problems. It was being used for storage of large fixtures in the plant. New production demands made it feasible to put it back into production

Bogh Industries was asked to evaluate the oven and complete the required upgrades to bring the machine up to code and into production.

	Before	**After**
1.	The gas train was not built per NFPA 86 and burner problems were evident per the old trouble log.	New main gas train with safety check capability installed.
2.	Minimum two of the twelve tube fired burners were always on during operation.	All burners can now be off at low temperature operation during soak. This eliminates heat load and shifts heating to the fan friction.
3.	O_2 levels were hard to control and burner shutoff valves did not have required proof of closure switches.	Twelve (12) new shutoff valves and proportionators installed and adjusted with very good results

	Before	After
4.	During low temperature operation the oven would creep and cooling coils were installed to cool the fresh air used for keeping the temperature in the oven down. Self draining cooling coils are also installed in the return ducts of the oven itself to control low temperature operation. Water leaks have flooded the oven in the past and oven panels were damaged by corrosion.	Cooling water requirements completely eliminated. The piping was drained and will be removed. Corrosion damage to the oven walls was repaired.
5.	Fresh air inlet blower 20HP and exhaust blower 30HP are running continuously while oven is operating. Fresh air and exhaust controlled by modulating dampers.	These fans are now only used during controlled cool down and the dampers are closed.
6.	Recirculation fans (2) 250HP running at max speed during all operation. VFD's used for soft start. The fans are generating about 1 Mill BTU per hour.	The PLC is now controlling the speed of the fans through the two VFD's at low temperature operation. The reduced airflow has not affected the ovens uniformity at 125F. The fans are running at 40% output at this temperature.
7.	Combustion blowers 20HP running at full speed at all burner inputs.	No change. VFD's on the motors and a pressure control setting can save about 40-50% energy on each of the two motors.

Below are the calculations for the savings by eliminating the blowers described above from the heating cycle.

Electric motor calculations					
Operation hours	12				
Eliminated fans	HP	KW	KW per day	Operating days	KW per year
Exhaust	30	22.5	2880	300	864,000.00
Fresh air	20	15			
Recirculation HP reduction (Low temp operation)	250	187.5			
Electric cost/KW	$0.06		**Electric saving per year**	**$53,568.00**	

Please note that significant additional savings are accomplished by eliminating burner demand during low cure temperatures (Up to 150F). This results in no gas and cooling tower usage for the system at these temperatures.

The PLC program and hardware were upgraded to accept the additional inputs and the operator interface upgraded to a new touch screen HMI. American Controls and Engineering Company were responsible for this part of the project.

This oven was scheduled for replacement and the capital cost is estimated at $1.5 Mill for a new installation. The upgrade was completed at a fraction of time and cost.

New equipment.

The decision to get new equipment should incorporate the latest energy saving techniques as described above. The equipment must also be built to complete the process most efficiently. Using existing equipment might not be the best option for the overall process. Recently we built a new oven using the techniques described above. This oven cut the customers heat up time from 18-22 hours to 6.5 hours on 300,000 lbs of steel dies. This rate eliminated three (3) older existing furnaces used for the task in the plant.

The oven is a 46' long x 13'-7" high x 19' wide gantry oven for heating up to 300,000 Lbs of steel dies per load. The oven was installed and commissioned in five weeks. The oven utilizes furnace construction with two heating zones and reversing airflow.

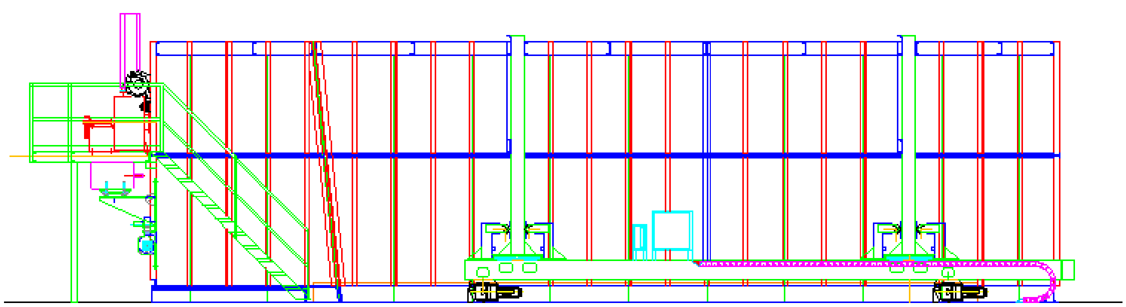

Figure #5. The figure shows the oven in the closed position.

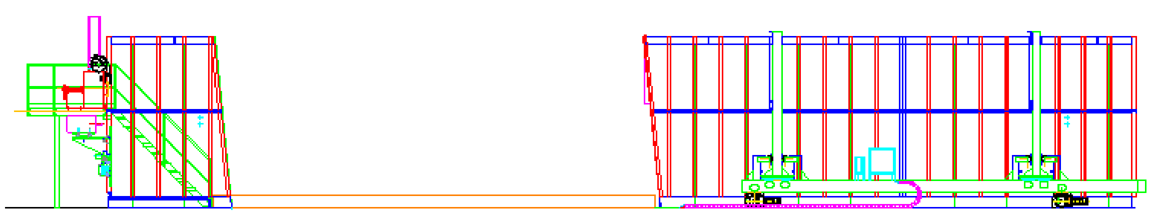

Figure #6. The figure shows the oven open position.

The oven has reversing airflow to ensure even and faster heat up of the heavy load. Heat up data shows parts coming up to temperature in approximately 30% of the time it took in the old equipment. Energy consumption is reduced by using burners designed for air heat applications and VFD controlled exhaust blower.

Figure #7. The picture shows the oven during final installation.

This design eliminated the need for a moving load car. The oven is very suitable for situations where large loads need to be heat treated. Loading the parts on the insulated pad by crane or fork lift makes the operations simple.

Bogh Industries LLC was established in 2002 and is working in the heat treat industry as a consulting and equipment supplier company. The main focus is rebuilds and upgrades of existing ovens and furnaces. Our close connection to experts throughout the industry gives us a large foundation for making our solutions work. By working closely with American Controls and Engineering Service on the control strategy we can provide complete integrated systems into the plant.

For more information on this article and equipment capabilities contact Bogh Industries directly by phone 253-732-8476 or through our web site www.boghindustries.com. In addition you can contact American Controls & Engineering Service through their web site www.theacesinc.com or by phone 316-776-7500.