Reducing Gas Usage in a Galvanizing Plant.

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Introduction:

With the ever upward spiral of the price of natural gas we look at methods of reducing gas usage in the galvanizing plant. This paper will aim to answer the question that galvanizers most frequently ask when facing a high gas bill and offer answers that may require a change in operating practice only or require capital investments.

It will be necessary to assume to a kettle size and plant operation to demonstrate the potential savings and for this purpose we will use a plant with the following equipment dimensions and specification.

Kettle:

Length:	45'-0"
Width:	6'-6"
Depth:	9'-9"
Throughput Maximum:	21,000 lbs/hr.
Furnace Type:	4 Burner pulse fired high velocity 'turbo' system
Fume Extraction:	Enclosure
Process Tanks:	2 x Degrease @ 160°F
	5 x Acid @ Ambient temperature
	1 x Preflux @ 160°F
Working:	2000 Hour/year
Standby:	700 Hours/year
Standby Unused:	6060 Hours/year
Zinc Usage:	6%
Steel Temperature Before Galvanizing:	50°F
Gas Cost:	$1.50 / therm (U.S.)

We have used a pulse fired high velocity 'Turbo' furnace in this case because data is readily available.

The questions we propose to answer are:
1. What is efficiency?
2. How can I save money with my galvanizing furnace?
3. How can I save money in the pre-treatment area?
4. Can I use waste heat from the furnace?

What is Efficiency?

Thermal efficiency for a furnace can simply be put as a percentage of the gross Therms input that is realized as Therms used in the furnace. This can be expressed as:

$$\frac{\text{Therms used}}{\text{Therms Input}} \times 100\% = \text{Thermal Efficiency}$$

The efficiency of a furnace is calculated from the free oxygen present in the exhaust gas stream from the furnace and the temperature of that gas stream immediately upon exiting the furnace. (see graph 1). Low exhaust gas temperature alone is not enough because this can be achieved simply by increasing the air to the burners.

With zero percent free oxygen (no excess air) and an exhaust temperature of 840°F (the zinc temperature) the theoretical maximum efficiency is 73%. This is not achievable because in practice a little excess air is desirable (10% to 15%) to prevent production of CO, and the exhaust temperature has to be above the zinc temperature to obtain heat transfer through the kettle wall into the zinc bath. All modern nozzle-mix burners (such as the high velocity burner using an air blower) mix the gas and air almost perfectly and combust the gas perfectly. This means the correct gas and air ratios are maintained and we can ignore the actual combusting of the gas as a factor influencing efficiency. However, this is not the case with the older or self-aspirating type burners.
The unobtainable theoretical maximum of 73% efficiency is shown in figure 1. For the example furnace, at maximum output, the thermal efficiency is 65.7% meaning 34.3% of the gross heat input is lost to the flue figure 1. It can be seen with this example that the practical efficiency is only 7.3% below the unobtainable theoretical maximum. We can see that the gross input, at 21,000 lbs per hour throughput is 60 Therms/hr costing US $90 per hour (at $1.50/Therm) but $30.87 worth of energy is lost with the exhaust gases.

The efficiency of the furnace can be improved by reducing the heat transfer rate through the kettle wall, or simply put, increase the size of the kettle for a given throughput which would have an added advantage of increasing kettle life. The 'Turbo' function introduced by Westech achieves the same result by only using the maximum heat input available when absolutely necessary resulting in increased kettle life and a significant reduction in gas usage.

How can I save money with my Galvanizing Furnace?

The galvanizing furnace is commonly the largest single user of natural gas in the galvanizing plant. You will see from Figure 2 that at full production rate of 21,000 lbs/hr 36.6% of the gross heat input goes to the steel being galvanized, 26.8% is lost from the surface only, 2.2% is lost through the furnace insulation, and 34.3% is lost as exhaust gases of which 9.9% heat of vaporization of water.

When the furnace is on standby i.e. not in production, as seen in figure 3, the surface losses account for 59.2% of the gross heat input, 5.2% is lost through the furnace insulation. This assumes the furnace is fitted with a fume enclosure and the extraction rate at standby hours is half that of production hours and the zinc surface has an ash layer. During production practically nothing can be done to significantly reduce heat loss from the surface other than partly cover the surface when not utilizing the full length of the kettle but this may have a detrimental effect on kettle wear. Covering the kettle during unproductive or non working hours such as between shifts and weekends can give dramatic savings. For the furnace in question the surface losses can be reduced by over 80% making an hourly gross saving of US $6.00 per hour. This may not appear to be a large sum of money but when multiplied by 6060 hours the kettle is unused and can be covered the savings in US $36,360 per year for a small capital investment normally with a payback period of under 3 months.

To gain the advantage of fitted covers requires a reduction of heat input from the burners to 6.6% of maximum and is expressed as a 15:1 turn down. If the burners are not capable of this turndown then either burners must be switched off, or the zinc temperature will rise out of control, or the temperature will rise out if control until the burners are turned off by the furnace overtemperature safety system.

Switching burners off is an option but not desirable because cold air is still blown into the burners switched off, cooling the circulating gas stream. Although the air can be prevented from being delivered to burners switched off it would require either manual or electrical powered isolating valves and additional airflow control making improved turn down the preferred option.

The furnace insulation is also an area where energy and money can be saved. The furnace discussed only loses 2% of its gross input on high fire through the furnace walls, corresponding to external surface temperature of less than 35°F above ambient temperatures. Many furnaces still in use today have much higher wall temperatures and subsequently can be almost impossible to touch or even work near. Unfortunately improving the insulation on an old furnace is not simple and can be relatively expensive and therefore is rarely justifiable. However the type of insulation used should be considered seriously when choosing or building a new furnace.

How can I save Energy in the Pre-Treatment area?

In the example given the degrease tanks would each use 6.31 Therms per hour at full production and the preflux tank would use 7.43 Therms per hour as shown on figures 4 and 5.

Although the operating temperature of the tanks is the same the steel temperature entering the pre flux is higher and only half the production goes through each degrease tank. Assuming the tanks are heated using water instead of steam we can take the boiler thermal efficiency as 80%.

As can be seen most of the heat in all conditions is lost to the surface, this is especially notable during standby, see figures 6 & 7. Surface losses increase considerably with bath temperature and the temperature should be no higher than required for process chemistry. If we consider the flux tank and its temperature is reduced from 160°F to 150°F the saving would be 1.06 Therms per hour and reducing to 140°F would save a further .84 Therms per hour. If the pre-flux tank temperature was reduced from 160°F to 150°F and not covered over the year it would save US $13,929.

The tank surface losses are a combination of several losses i.e. radiant, convection, evaporation and make up water losses. If the flux in the above example is covered during non-work hours e.g. by a simple membrane or steel plate the losses can be reduced by over 50% resulting in annual saving of US $19,914 when operating at 160°F. If all heated tanks were covered the annual saving would be at least US $60,000. Covering the tanks when not in use has the added advantage of reducing the amount of corrosive fume escaping in to the plant and attacking the building structure.

Can I use Waste Heat from the Furnace?

Heat from the furnace exhaust gases can be used for:

- Heating hot water or steam condenstate to indirectly heat pre-treatment tanks
- Directly heat pre-treatment tanks through the tank walls.
- Directly or indirectly for drying or pre-heating.
- Pre-heating combustion air for the galvanizing furnace burners.

As can be seen in figure 8, using our furnace model, 16.3% of the gross heat input or 48% of the waste heat can be 'safely' recovered and used. In practice it is advisable not to recover too much heat and lower the temperature of the exhaust gas below the dew point because this would produce a mildly acidic condensate, possibly blocking or corroding the heat exchanger.

In our furnace example this would mean 9.78 Therms of heat energy can be recovered and re-used. Because this energy would normally be produced in a boiler we can say that by virtue of the 80% boiler efficiency we achieve in an actual saving of 12.22 Therms per hour during full production. Figure 9 shows the heat available for recovery at varying throughput of our typical furnace. If the annual throughput for the year were 20,000,000 lbs (average throughput of 10,000 lbs per hour), then the heat available for recovery would be the equivalent to 92,532 Therms generated by a boiler at $1.50/Therm, the annual saving would be US $138,798.

Using the exhaust gases to heat hot water and then pumping this water through heat exchanger coils in the pre-treatment tanks is the most commonly used method of using waste heat. The exhaust gases are drawn off the main flue or chimney and passed through a gas to water heat exchanger. The hot water is then circulated by a pump to heating coils mounted in the pre-treatment tanks. Heat recovery is normally used to supplement heat provided from a boiler but is very rarely adequate to heat the pre-treatment tanks, especially during non-working hours, if the kettle is covered, and waste heat is not available in a sufficient quantity.

Heating pre-treatment tanks by ducting the hot gases is possible but not common. Because of the corrosive nature of most of the liquids being heated the inside surface of the tank should be at the very least coated with corrosive preventing material making heat transfer through the tank a problem. Galvanizing kettles have been used as flux tanks and the hot gases passed around the kettle but long insulated ducts and accurate maintenance of the pH of the flux has made this method unpopular.

The hot gases can be used directly for drying or pre heating but care should be taken because the high gas temperature on high fire rates can cause the flux on the work to oxidize above 250°F. Also when the furnace is on low fire or standby the exhaust gas volume is reduced significantly and the gases can be cooled dramatically causing condensation to form on the cooler work. It is advisable to use the exhaust gases indirectly by heating fresh air introduced to the drier preventing overheating of the pre-flux and hot gases condensing on the work.

Finally the exhaust gases can be used to preheat combustion air for the burners. Galvanizing is a relatively low temperature process and consequently the exhaust gas temperature is too low to make pre-heating of combustion air viable because the cost of the preheat system is high. Gas-air ratio control is complicated because the air flow should be metered before heating but with multiple burners this is not practical making electronic control necessary. The burners currently available such as recuperative and regenerative burners do not lend themselves to galvanizing because of capacity, mounting arrangement and sensitivity.

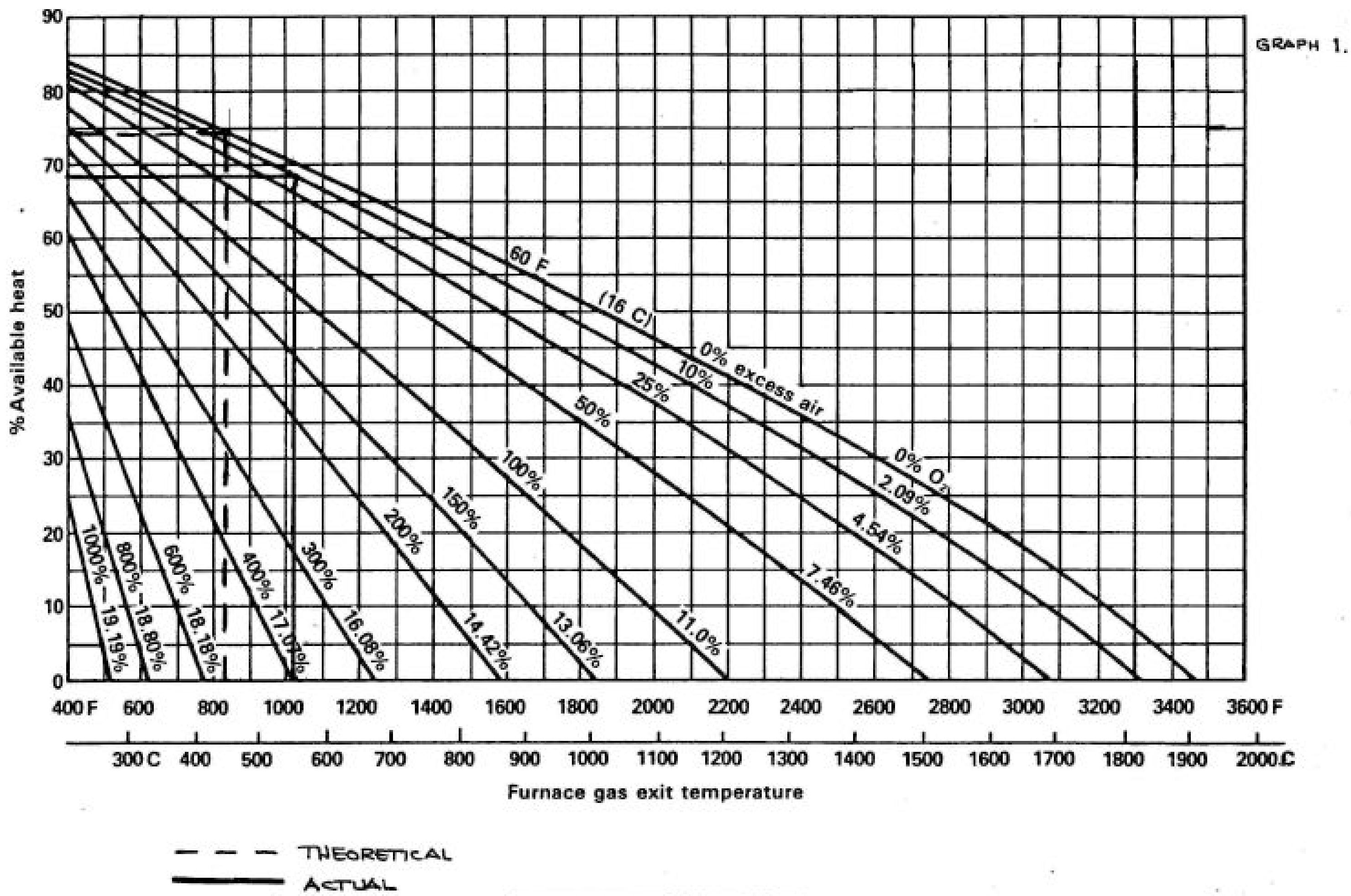
The fuel savings from using pre-heated air are significant at approximately 10% but the high cost of the system added to the higher maintenance cost makes this the least practical method of utilizing waste heat.

Summary

We can summarize by suggesting a few useful tips.

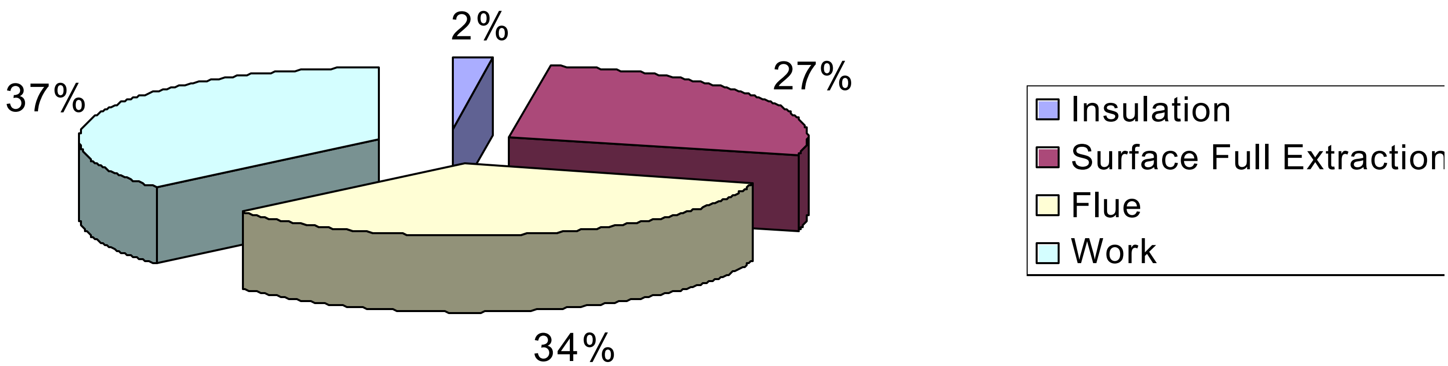
- Have your furnace checked regularly to obtain best possible combustion.
- Cover your kettle when not used.
- Make sure your burners will turn down low enough to prevent temperature overshoot when the kettle is covered.
- Reduce fume extraction flow rate between dips (this will also reduce electrical power consumed).
- Recover the waste heat if financially viable.
- Have an energy survey carried out by a heating engineer.
- Cover your pre-treatment tanks when not used.
- Reduce the temperature of your pre-treatment tanks if possible.

The potential savings are enormous and require very little investment in most cases. In the competitive environment we all are living in you can increase your profit or maintain your profits as gas prices rise without increasing your turnover. **It's money for the taking**.

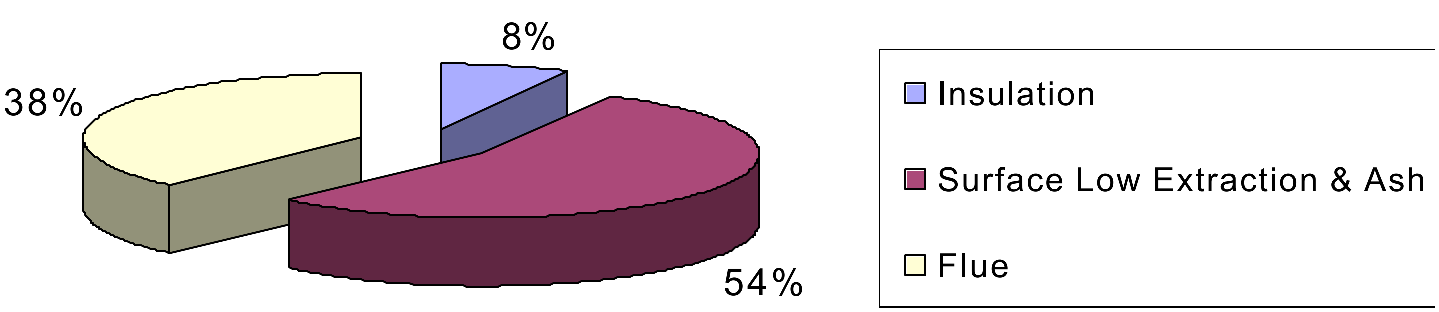

GRAPH 1.
% Available heat
90
80
70
60
50
40
30
20
10
0
60 F
(16 C)
0% excess air
10%
25%
50%
100%
150%
200%
300%
400%
600%
800%
1000%
0% O2
2.09%
4.54%
7.46%
11.0%
13.06%
14.42%
16.08%
17.07%
18.18%
18.80%
19.19%
400 F
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600 F
300 C
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000 C
Furnace gas exit temperature
THEORETICAL
ACTUAL

Galvanizing Furnace Heat Balance

Production - Fig.2

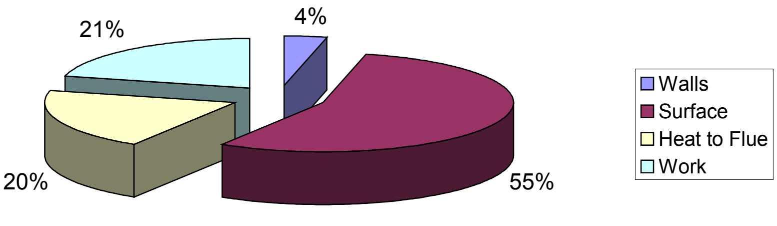


Standby (Uncovered) - Fig.3

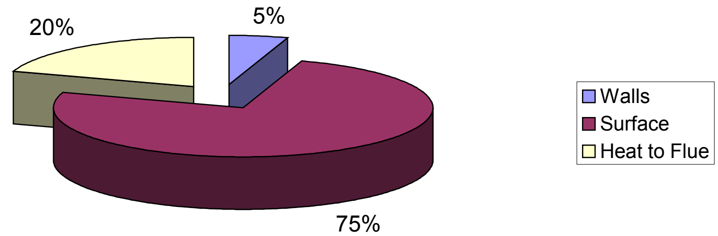


Pre-Treatment Tanks Heat Balance

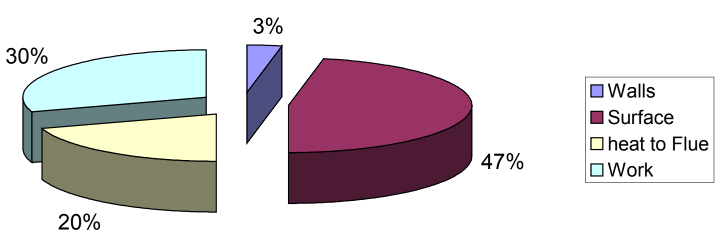
Degrease Tank - Production - fig.4



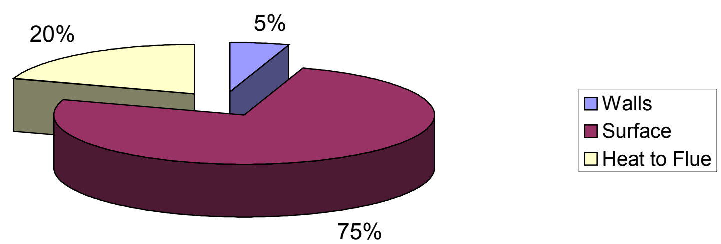
Degrease Tank - Standby - fig.6



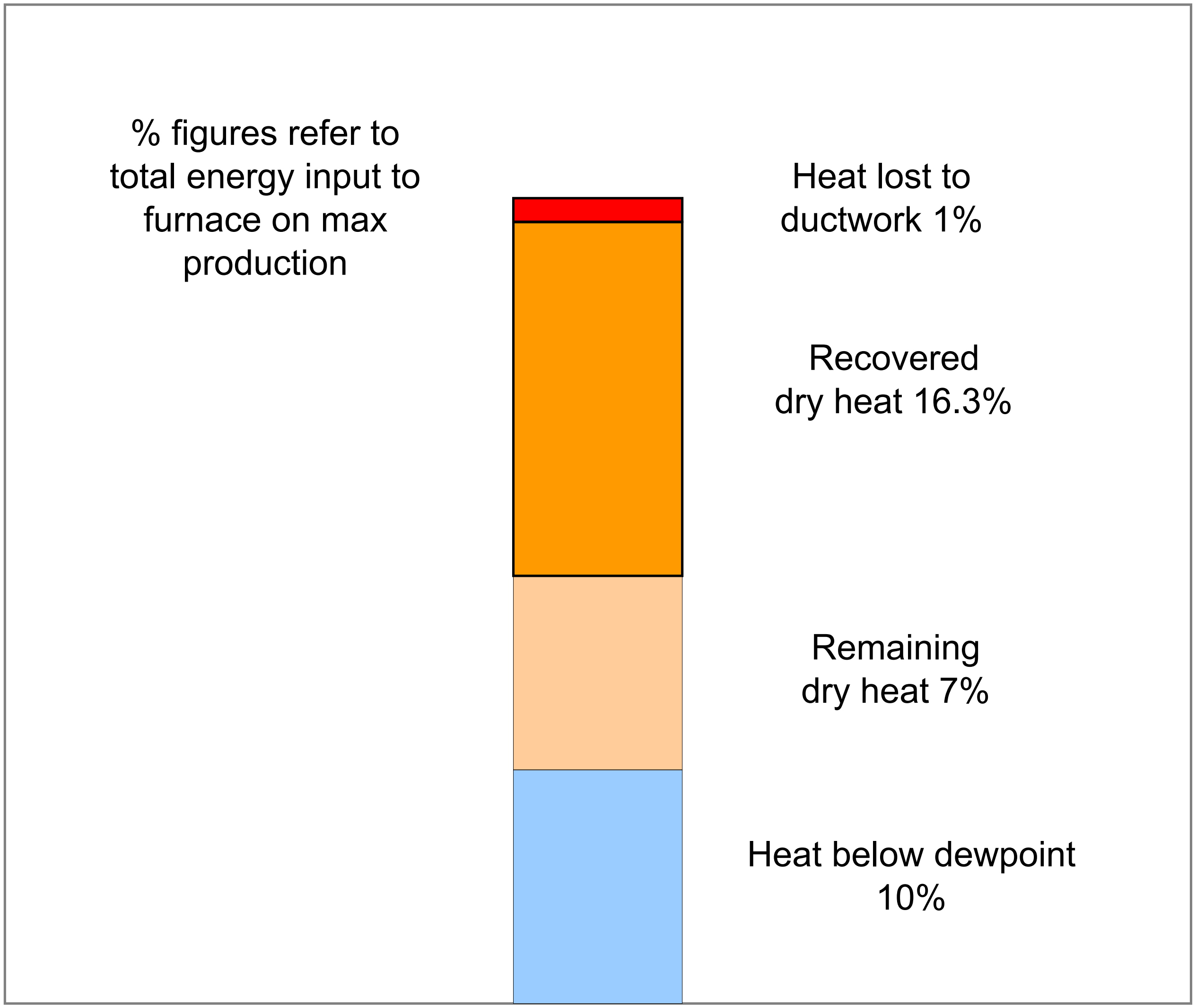
Pre-Flux tank - Production - fig.5



Pre-Flux Tank - Standby - fig.7



Available Heat in Furnace Flue Gas Fig.8



Available Heat for Recovery for Galvanizing Furnace - fig.9