

THE INSTITUTE OF METAL FINISHING

One day symposium on

“Energy efficiency in surface finishing and manufacturing”

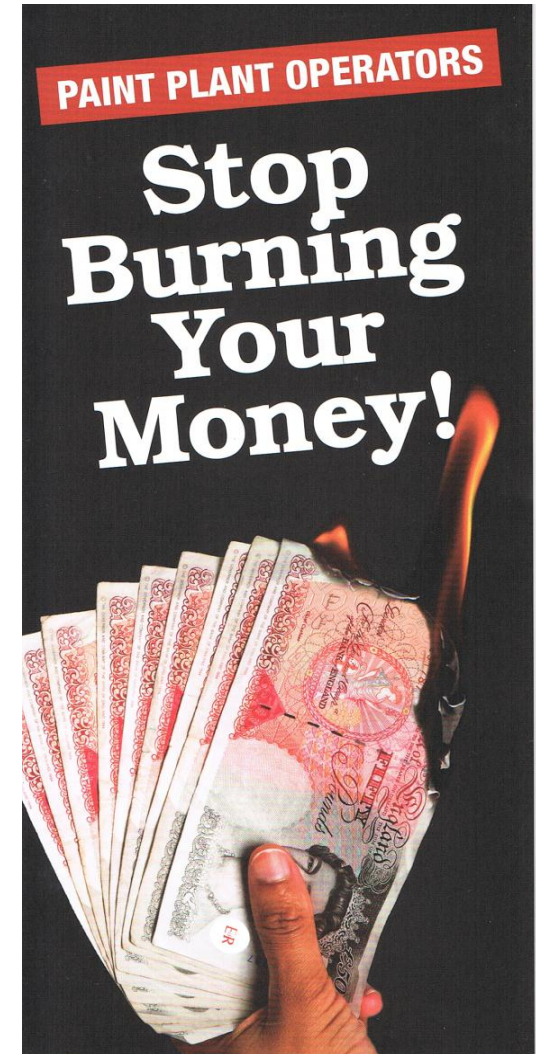
Wednesday 14th September 20011

At
FG Wilson
Dough Road
Monkstown
Co.Antrim

Controlling paint plant energy cost

By
Mike Milner

Redford Design Limited



INTRODUCTION

Mike Milner



Redford Design Ltd

Background

For the past 40 years I have designed, manufactured and installed a wide range of product finishing plant

During the last 10 years I have become more involved in advising clients on how to reduce energy costs in the majority of cases with funding from the Carbon Trust.

I have never achieved less than a **10%** reduction and in one instance managed **50%**.

This afternoon I would like to present examples of what we have achieved and hopefully look to help you to make savings in your own company.



These will be the topics which I would like (time permitting) to discuss

TOPICS

- Insulation
- Exhaust air rates
- Oven apertures, vestibules and air curtains
- Combustion and heat transfer efficiency
- Air and temperature distribution
- Powder booths and extraction systems
- Wet paint booths and air replacement systems
- Control systems
- Plant compatibility

ILLUSTRATION

Powder curing oven

Length

40Ft (13.5M)

Processing

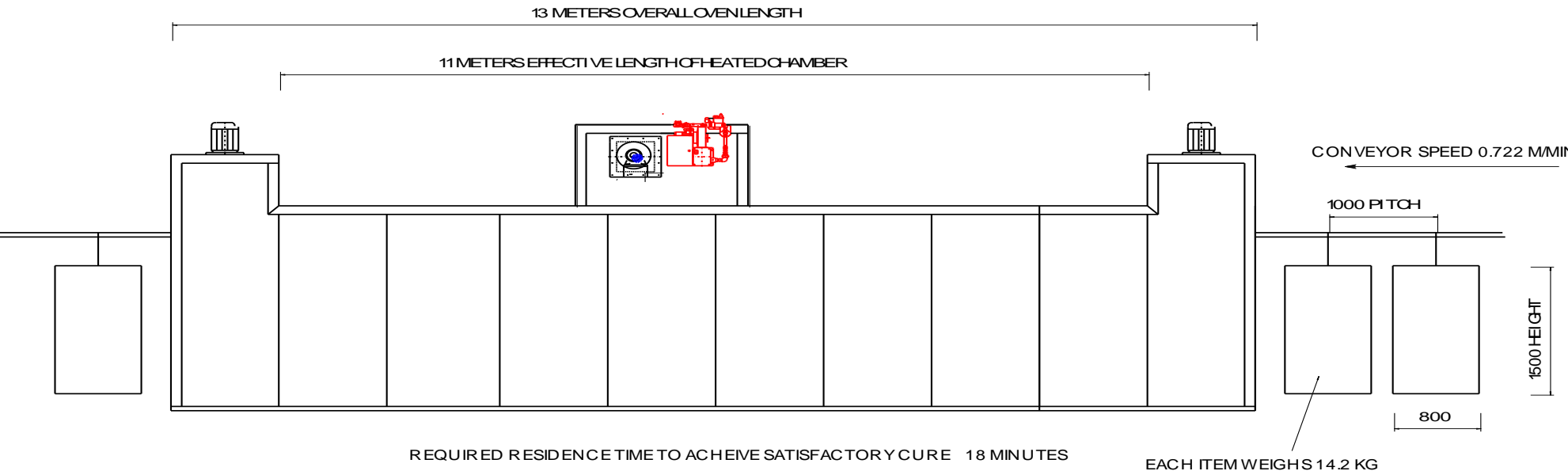
1.5mm steel trays 1500x 800 at 1000mm pitch on conveyor and weighing 14.2Kg

Required dwell

18 minutes at 210°C

Conveyor speed

0.733M/min



HEAT REQUIRED

Input values	
Oven Length	13 Metres
Oven Width	2 Metres
Oven Height	2.4 Metres
Height to bottom of aperture	0.5 Metres
Thickness of oven steel	0.0012 Metres
Density of oven steel	8003 kg/m ³
Specific heat capacity of stainless steel	0.510 kJ/kg.K
Insulation Thickness (walls)	150 mm
Insulation Thickness (floor)	50 mm
Insulated floor (1) or uninsulated floor (0)	1
Insulation Thickness (roof)	150 mm
No. of Air Changes	3
Max Temperature	215 deg C
Ambient Temperature	10 deg C
Weight of Conveyor	5 Kg/M
Specific Heat of Conveyor	0.469 Kj/Kg deg C
Weight of Product	14.2 Kg/M
Specific Heat of Product	0.469 Kj/Kg deg C
Conveyor Speed	0.722 M/Min
Width of Work Aperture	0.900 Metres
Height of Work Aperture	1.80 Metres
Assumed air curtain efficiency	25%
Burner rating	450 Kw

Heat loss (walls)	3.99	Kw
Heat loss (floor)	3.97	Kw
Heat loss (roof)	1.44	Kw
Heat loss to exhaust	48.90	Kw
Heat loss to conveyor	5.78	Kw
Heat loss to product	16.43	Kw
Heat loss from work apertures	174.13	Kw
Total Losses	254.64	Kw
Gas consumption (90% efficiency)	282.93	Kw



USEFUL ENERGY = that needed to raise product to curing temperature

Generally less than 10% of the total energy consumed

This does not take into account
Oven warm-up time,
Breaks in production
Colour changes

And assumes
Conveyor is always fully loaded
The oven is running efficiently

In reality this figure is between 1 and 5 %

SAVE COST

Any savings go straight to our bottom line profit

CONSERVE RESOURCES

Which will also serve to keep prices down

REDUCE POLLUTION OF OUR ATMOSPHERE

This can only be a benefit whatever our views on global warming

It has taken 2.8million years to accumulate the gas we have – we are predicted to use it in the next 200





MY GRANDCHILDREN

We owe it to them and their generation to act responsibly with their resources and their environment



INSULATION



Insulation thickness has a less of an effect heat loss than is generally appreciated
Spreadsheet shows 6M x 3M x3M box oven with alternatively 100mm and 150mm
insulation

	100mm	150mm
Heat Loss to walls	5.99 Kw	4.08 Kw
Heat Loss to Floor	2.82 Kw	2.82 Kw
Heat Loss to roof	1.50 Kw	1.02 Kw
Heat Loss to Exhaust	24.85 Kw	24.85 Kw
Heat Loss to Product	14.00 Kw	14.00 Kw
Heat lost to structure	16.21 Kw	16.21 Kw
Total Losses	65.36 Kw	62.98 Kw

CASE STUDY

A double ended box oven of these dimensions with rise and fall doors

Top door seals had worn leaving a 6mm gap

Heat loss through this gap - 17Kw/hour 34Kw for 10 hours/day 230 days/year at 3p/Kw
hour **£2,346**

Cost to fit new door seals - **£100**

Integrity of all oven enclosures should be checked regularly



EXHAUST SYSTEMS

The volume of exhaust = products of combustion + any solvents released

Too much exhaust = money is wasted

Too little = risk of explosion

Oven manufacturers usually design for 10% of air in circulation

Example quoted earlier = 11.5%.

Dry-off oven = 5%

Solvent curing = 25%

Calculate required rate and set correctly on commissioning and check regularly

CASE STUDY

Customer whose oven was taking progressively longer to achieve working temperature.

Inspection revealed exhaust damper had worked loose, and become fully open.

Burner on the oven was oversized and managed to maintain temperature

However a staggering 70% heat input to the oven was being discharged to atmosphere



OVEN APERTURES

Greatest % heat lost is through the oven apertures – generally around 50%

Keep aperture sizes to a minimum – don't process 5% efficiently and 95% inefficiently

Consider using a box oven for large items and also nuisance jobs

Comparison

Heat requirements for 40ft oven

Heat loss (walls)	3.99 Kw
Heat loss (floor)	3.97 Kw
Heat loss (roof)	1.44 Kw
Heat loss to exhaust	48.90 Kw
Heat loss to conveyor	5.78 Kw
Heat loss to product	16.43 Kw
Heat loss from work apertures	174.13 Kw
Total Losses	254.64 Kw
Gas consumption (90% efficiency)	282.93 Kw

Heat requirements for 60ft oven

Heat loss (walls)	5.71 Kw
Heat loss (floor)	5.96 Kw
Heat loss (roof)	2.17 Kw
Heat loss to exhaust	60.99 Kw
Heat loss to conveyor	8.81 Kw
Heat loss to product	25.03 Kw
Heat loss from work apertures	174.13 Kw
Total Losses	282.79 Kw
Gas consumption (90% efficiency)	314.2 Kw

50% increase in throughput for 11% increase in energy

13M = 85,000 units annually (230 days) = energy cost of £22,700
 19.5M = 85,000 units (153 days) = energy cost of £16,600



VESTIBULES AND AIR SEALS

“Total loss” air seal systems are designed capture air from within vestibule preventing it spilling into the workshop.

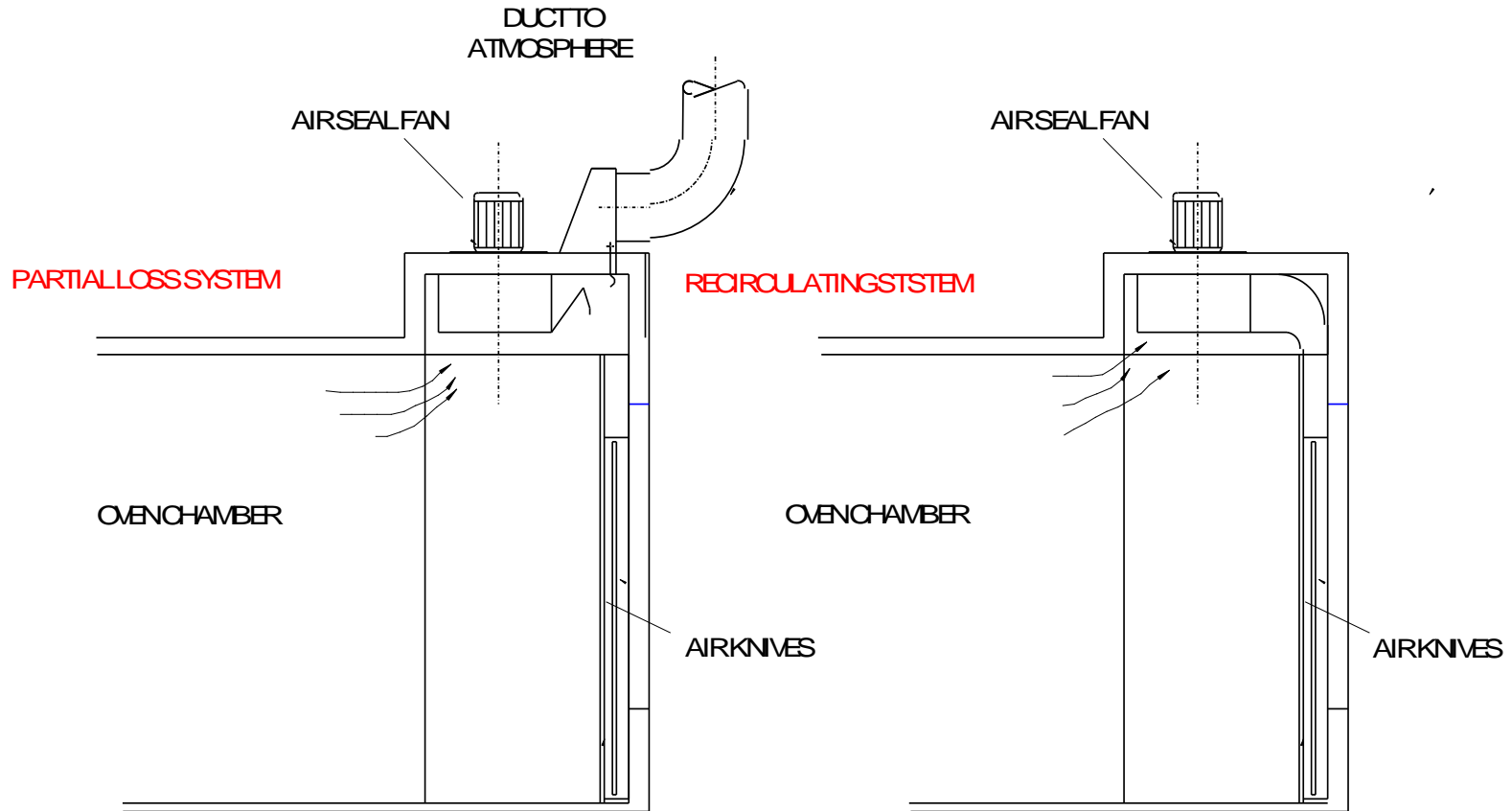
Extreme care must be made to ensure only that air which would normally escape is captured



TOTAL LOSS VESTIBULE EXTRACTION SYSTEM



OTHER VESTIBULE AND AIR CURTAIN ARRANGEMENTS



With total and partial loss system, ensure air volume is correctly controlled



COMBUSTION AND HEAT TRANSFER EFFICIENCY

PRE-TREATMENT SYSTEMS

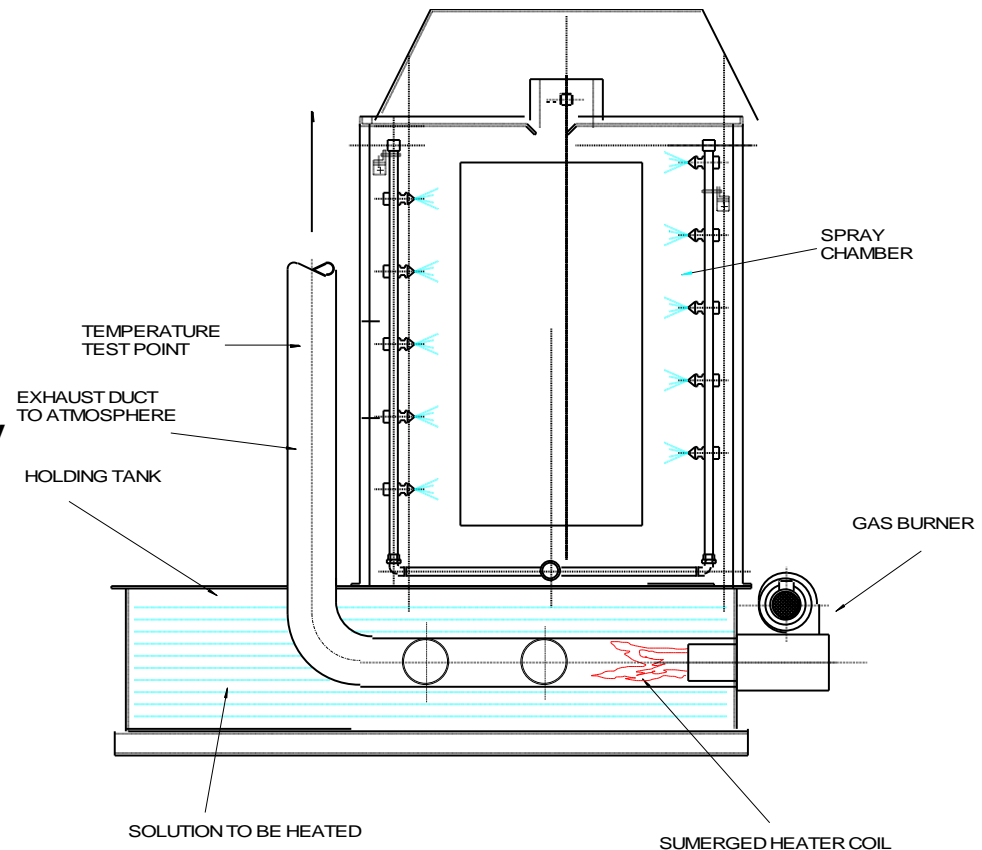
Gas burners are high energy users

Critical they operate efficiently

Set by regulating the air intake,
 Too little air = incomplete combustion
 Too much air = heat wasted

Analyse flue gas to check combustion efficiency

Check flue gas temperature to determine
 combined burner and coil efficiency
 Higher temperature may indicate coils have
 become coated
 Alternatively burner may be over-firing



CASE STUDY (700Kw Burner) Courtesy of Lanemark International

Flue temperature (°C)	183	204	229	260	298	344	408
Heat lost (kW)	0	9	20	34	50	71	101
Cost per annum (single shift)	0	£310	£690	£1,173	£1,725	£2,450	£3,588



COMBUSTION EFFICIENCY - OVENS

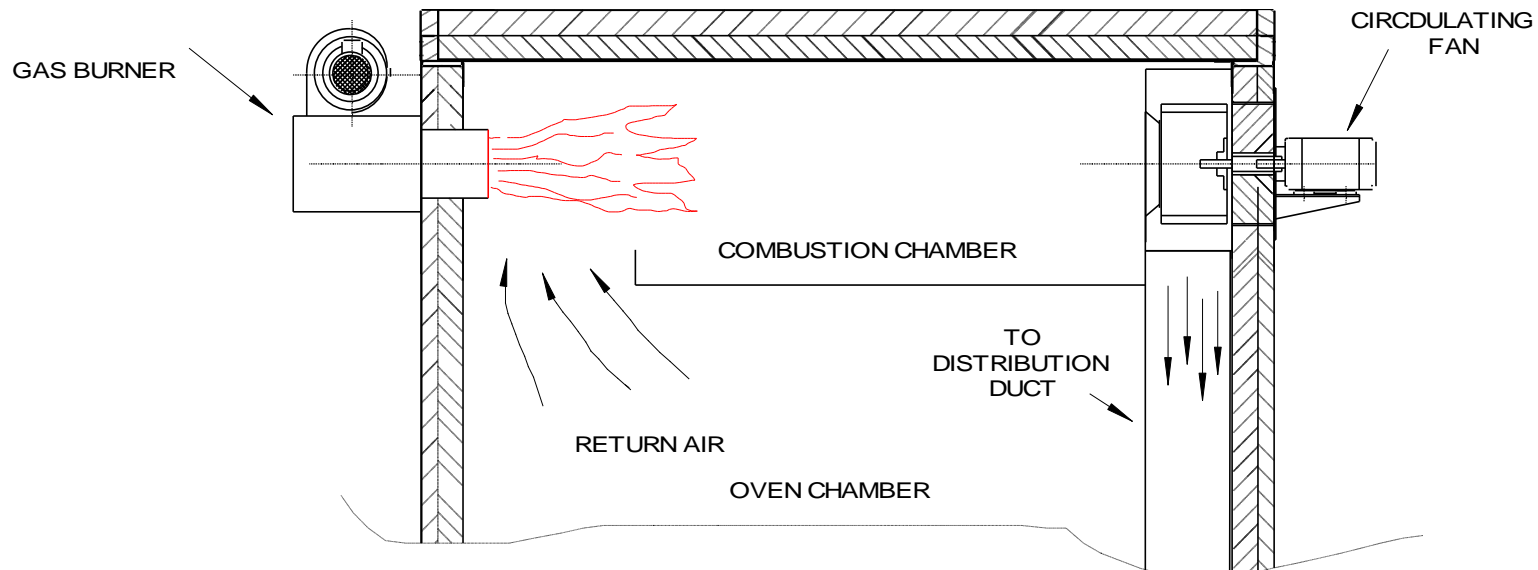
Efficiency of Direct fired burners cannot be determined due to products of combustion mixing with the air in circulation

Engineers generally set up the burner by judging the colour of the flame

The circulating fan can often induce more air than is required

Air entering the oven will almost double in volume in the combustion chamber.

To much excess air can lead to air spilling from the oven **wasting energy.**



INDUCED DRAUGHT BURNERS

The problem is particularly acute where induced draught burners are used.

These rely on combustion air to be drawn in by the circulating fan with little control over excess air



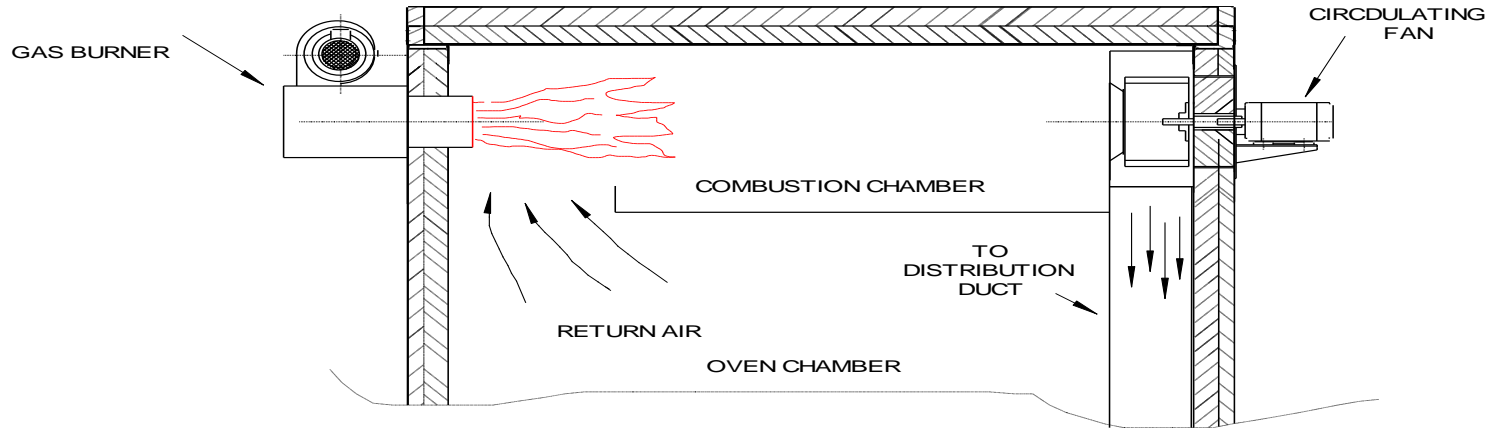
CASE STUDY

A burner of this type was replaced at one of our customers in Newcastle resulting in a reduction in gas consumption of 16%

CASE STUDY

Pre-heat oven which had four combustion chambers each with a 250kW Burner and a high volume circulating fan. Although burners were of the blown air type, the dampers were in a very poor state and a large volume of excess air was being induced. These were replaced on an Interest free loan from the Carbon Trust and the running load reduced from 675Kw to 589Kw giving a saving of just under **£10,000pa**

HEAT AND TEMPERATURE DISTRIBUTION



The key to any efficient oven is an adequate and even distribution of air

On curing ovens **3 air changes/minute** are recommended

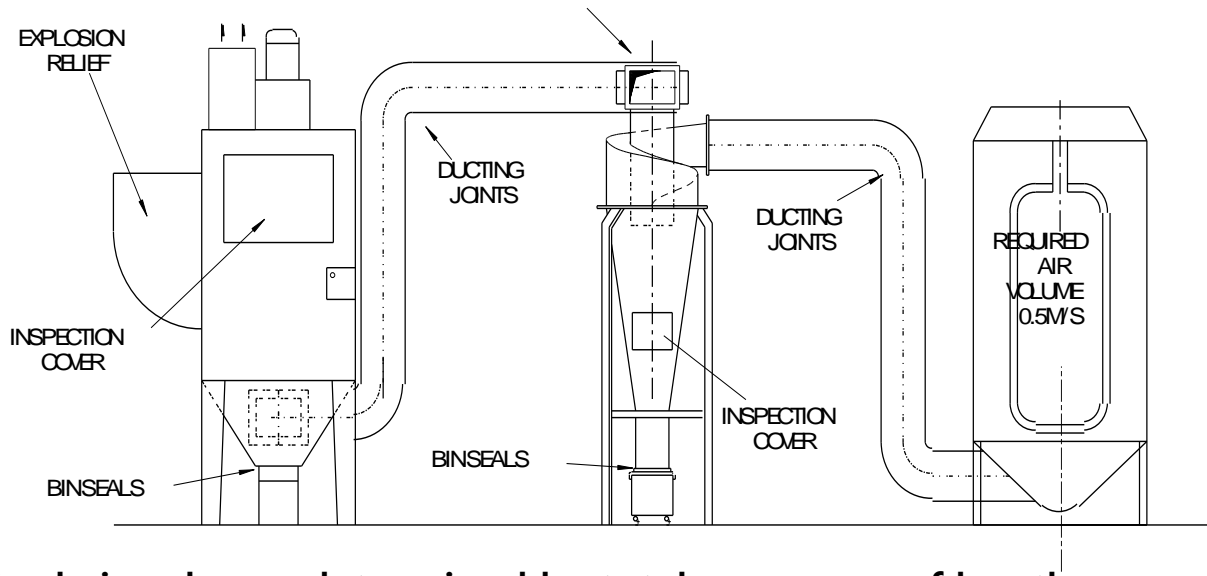
If this volume of air decreases, the temperature rise in the air leaving the combustion chamber will increase. As a consequence, the variation in temperature within the oven chamber will be greater.

The volume of air within the oven should be evenly distributed

Case study

We checked a clients oven and found that the volume of air was greatest on exit end , we adjusted this to bias the air toward the entry end . This resulted in the product heating faster which increased the cure index from 84 to 104

POWDER COATING BOOTHS AND EXTRACTION SYSTEMS



Required air volume determined by total open area of booth

Smaller openings = less air volume = less power required

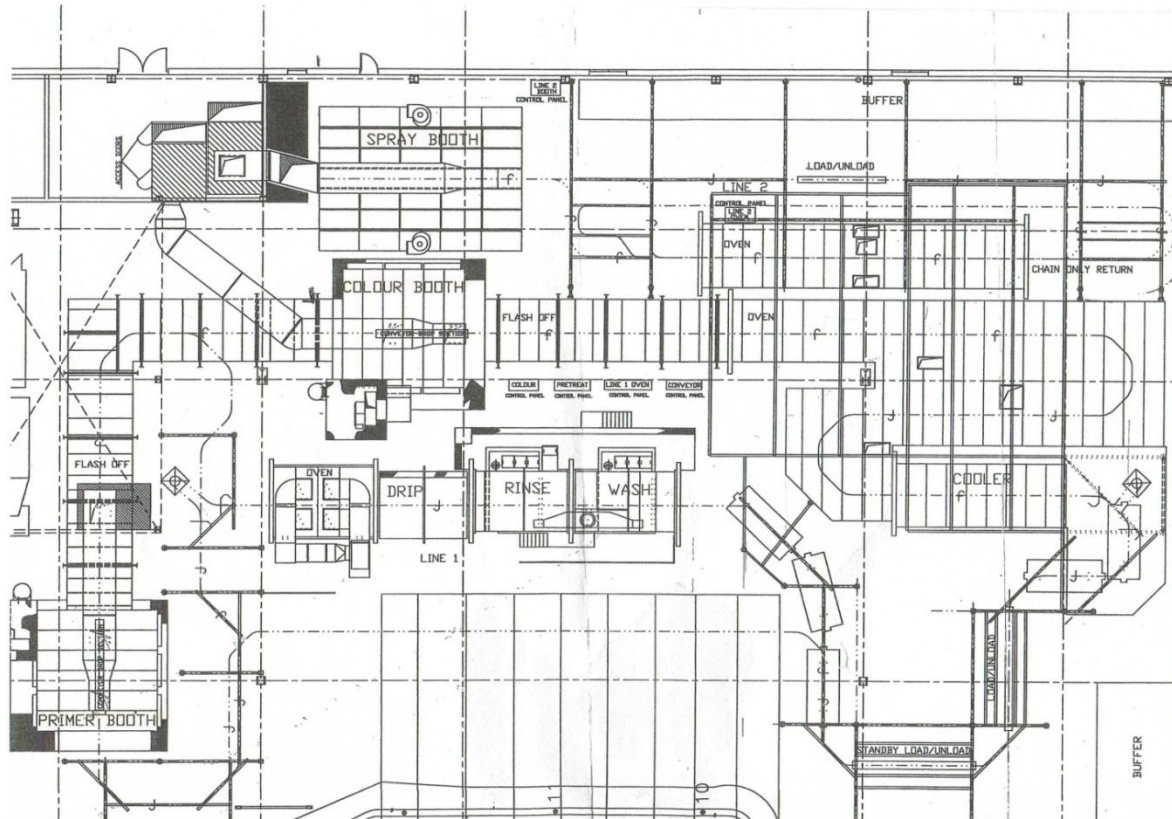
Any leaks reduce volume extracted from booth Dirty filter media reduces volume extracted from booth

Insufficient volume = powder escaping = contamination = **indirect cost**

Minimise leaks - Keep filter cartridges or filter bags clean – check pulsing and shaking mechanisms regularly



WET PAINT BOOTHS AND AIR MAKE_UP



Total power of extraction and air make-up fans = 197Kw

Total heat input at 10°C ambient 22°C booth = 280Kw

Reduce air volume by 20% reduces power consumption of fans by 50%

Reducing booth temperature by 5°C reduces heat input by 50%

For every non spraying hour per day the saving would be £2,450 per annum



CONTROL SYSTEMS - CASE STUDY

Client manufacturing Hydraulic and fuel tanks for earth moving vehicles

Processed in batches due to limited storage space

Much of the equipment left running, particularly on night shift

Introduced touch screen control system which detected product entering pre-treatment system .

Items of plant brought into operation only as and when required resulting in substantial energy savings

Other benefits

Eliminates push-buttons and indicator lights

Can store menus for various processes

Record production level

Record power consumption

Restrict control of plant to authorised users



PLANT COMPATIBILITY

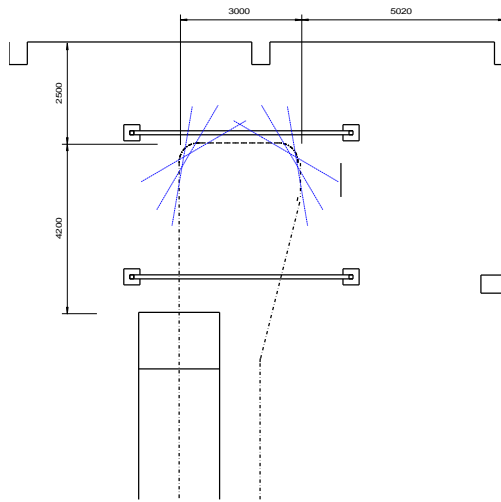
Check for “weak link” in the system

CASE STUDY 1

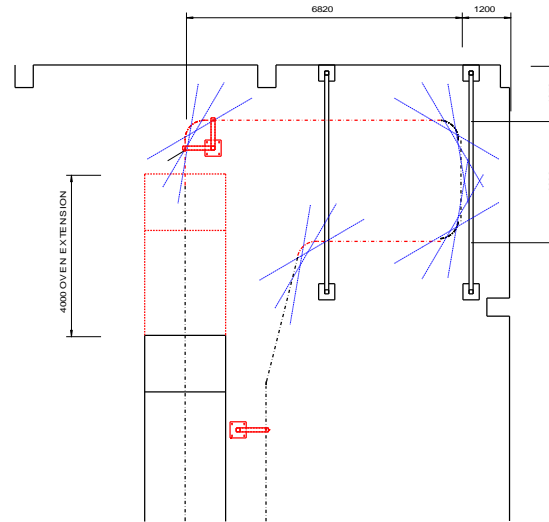
Length of the curing oven was not matched to the remainder of the plant.

Increasing the length of the oven from 12m to 15m gave a 25% increase in throughput for 6% increase in energy

Maintaining production levels would have saved £6,600 for the year. Customer increased production which resulted in a far greater economic benefit.

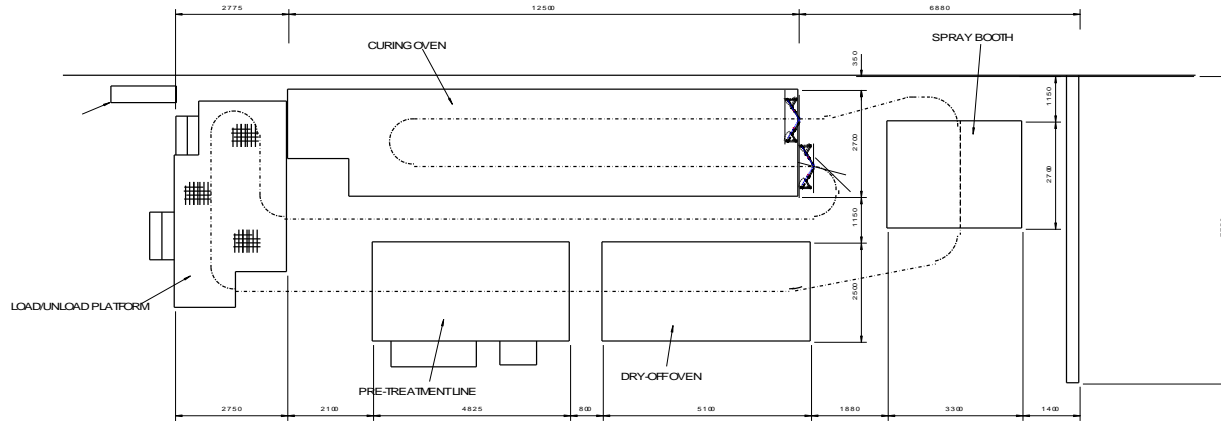


EXISTING LAYOUT



PROPOSED NEW LAYOUT





CASE STUDY

Company manufacturing industrial springs in Rochdale. Plant was operating at around half the design speed

Small springs could not be loaded quickly enough ,large springs where too hot to be removed from the conveyor.

Remove two spray rings from the phosphate cleaning system saving **32Kw**

Company operated a two-shift system saving of **£3,840**

Cost of modification **£45.48**

Heated dry-off oven with exhaust gasses from curing oven. Disabled pumps and some fans when conveyor stopped. Converted cure oven burner back to natural gas. Fitted automatic doors to oven apertures

Total savings £60,000 (50% of original spend) Reduction in carbon emissions of 292 tonnes p/a

Unfortunately, many users have insufficient experience to specify exactly what they require, and too few plant manufacturers take the trouble to provide adequate guidance.



On one survey I could not reconcile my readings for gas consumption with those on the main gas meter

After some time we found that a digital display on pressure correction meter was faulty

I obtained a rebate of over £40,000 for this client

I persuaded another client to convert from LPG to natural gas to save money, this cost him £18,000

After several months he expressed dissatisfaction at not seeing the cost savings he had expected

I investigated this and found that he was being invoiced in units of 100cu ft rather than CuM. He received a rebate of £26,000.

Amazingly, these client were situated within a mile of each other. Either this is a statistical miracle or there a significant number of other users with similar problems