COMBUSTION EFFICIENCY

THE EFFECT OF COMBUSTION ON THE EFFICIENCY OF THE HEATING APPLIANCE

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INTRODUCTION

The Combustion Efficiency is affected by the manner in which the combustion occurs.

That is, the

- ✓ Air : Fuel Ratio
- ✓ degree of atomising (liquid fuels)
- ✓ fuel-air mixing
- ✓ flame temperature
- ✓ flame shape
- ✓ fuel residence time in the combustion zone

As well as the amount of heat lost out of the system.

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AIR:FUEL RATIO

- ✓ The theoretical air:fuel ratio for complete combustion is known as the "STOICHIOMETRIC" ratio.
- ✓ In practice this ratio does not achieve complete combustion as the degree of mixing is never sufficient to allow every oxygen molecule to come into contact with a fuel molecule.
- ✓ Thus a certain amount of excess oxygen (air) is required to achieve full combustion.
- ✓ The range of **excess oxygen** required to achieve complete combustion in practical applications is between 1% and 5% depending on the combustion appliance.
- ✓ This implies that an **excess air** requirement of 5% - 25% is necessary, as there is only ~21% oxygen in air.

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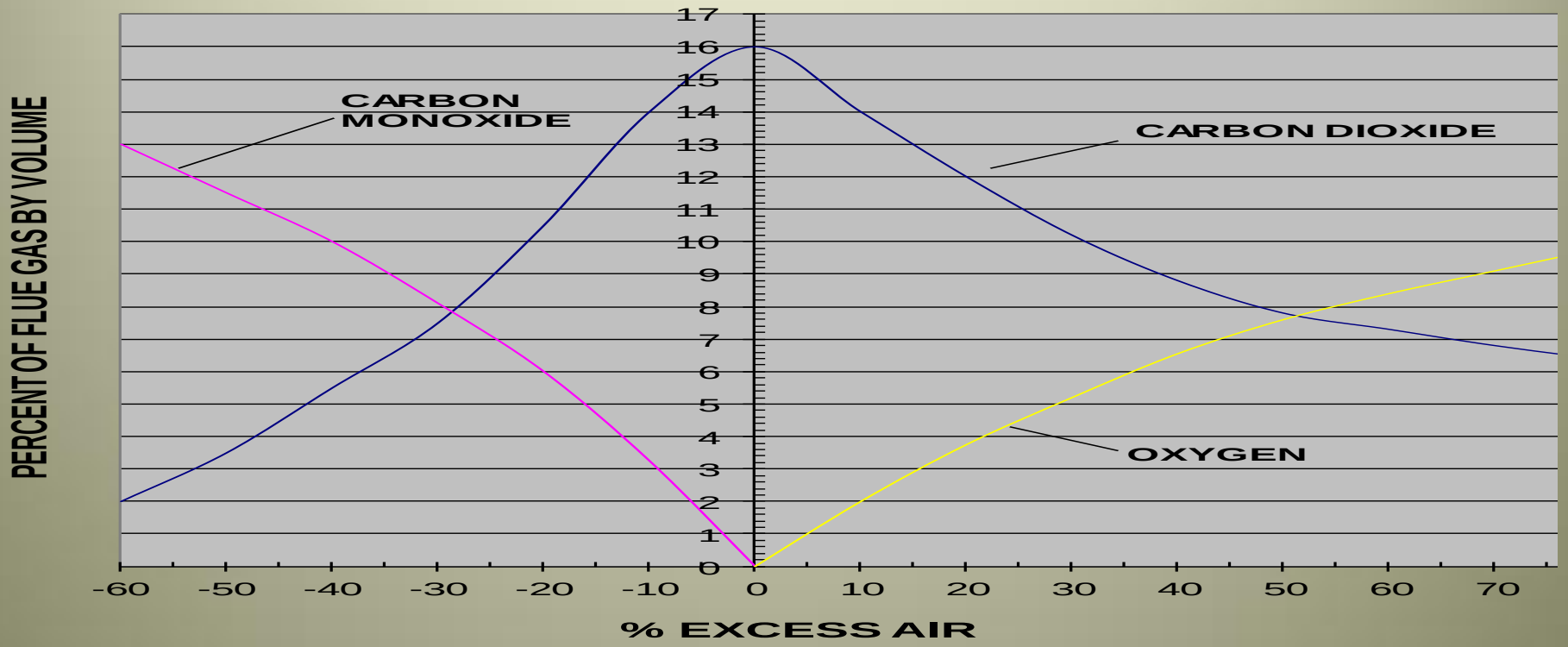
AIR:FUEL RATIO

FLUE GAS ANALYSIS



- ✓ An amount of excess air is necessary for complete combustion.
- ✓ Too much excess air is undesirable as it reduces efficiency by absorbing and carrying away heat.
- ✓ Typically the energy loss due to excess air is in the order of 1,2% for every 10% of excess air by volume.

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ATOMISING

- ✓ Applies to liquid fuels only.
- ✓ Is required to generate an even spray of droplets sufficiently small to allow good mixing with the oxygen to achieve complete combustion (usually <50 microns in diameter).
- ✓ Atomisation is dependent on fuel pressure and viscosity, atomising air or steam pressure, nozzle and burner design.
- ✓ The viscosity can be regulated by controlling the fuel oil temperature.

Primary causes of poor atomisation are:

- Worn nozzles
- Insufficient fuel-oil pressure
- Excessive fuel-oil viscosity
- Insufficient atomising air or steam pressure
- Incorrect nozzle size – excessive turndown
- Poor nozzle design
- Excessive fuel viscosity (>20 cSt)

FUEL:AIR MIXING

- ✓ The effectiveness of the burner in achieving adequate mixing of the fuel and air is crucial to efficient combustion.
- ✓ The burner must provide a stable spray of atomised fuel particles expanding into the combustion air in a manner that will sustain good combustion.
- ✓ The quarl helps sustain the shape of the flame necessary for good combustion.

Causes of poor mixing:

- Imbalanced air:fuel pressures
- Incorrectly set up burners
- Worn burner parts
- Misaligned burners
- Damaged or badly made burner tile (quarl)
- Dirty or blocked swirl plates

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FLAME CHARACTERISTICS

- ✓ Heavy fuel oils require more time than light oils and gas to achieve full combustion (respectively 0,1s – 0,01s – 0,001s). Thus the length of the combustion zone is important.
- ✓ Flame shapes are important as short flames may not provide sufficient residence time for full combustion and “woolly” flames allow un-burnt fuel mixture to escape from the side of the flame.

HEAT LOSSES

Useful energy (heat) is lost in the following manner:

- ✓ Poor combustion (0% - 20%)
- ✓ Insufficient radiance (5% - 15%)
- ✓ Lost out of appliance from poor insulation (2,5% - 15%)
- ✓ Up the stack (2% - 10%)
- ✓ Heating up excess air (0,5% - 3%)

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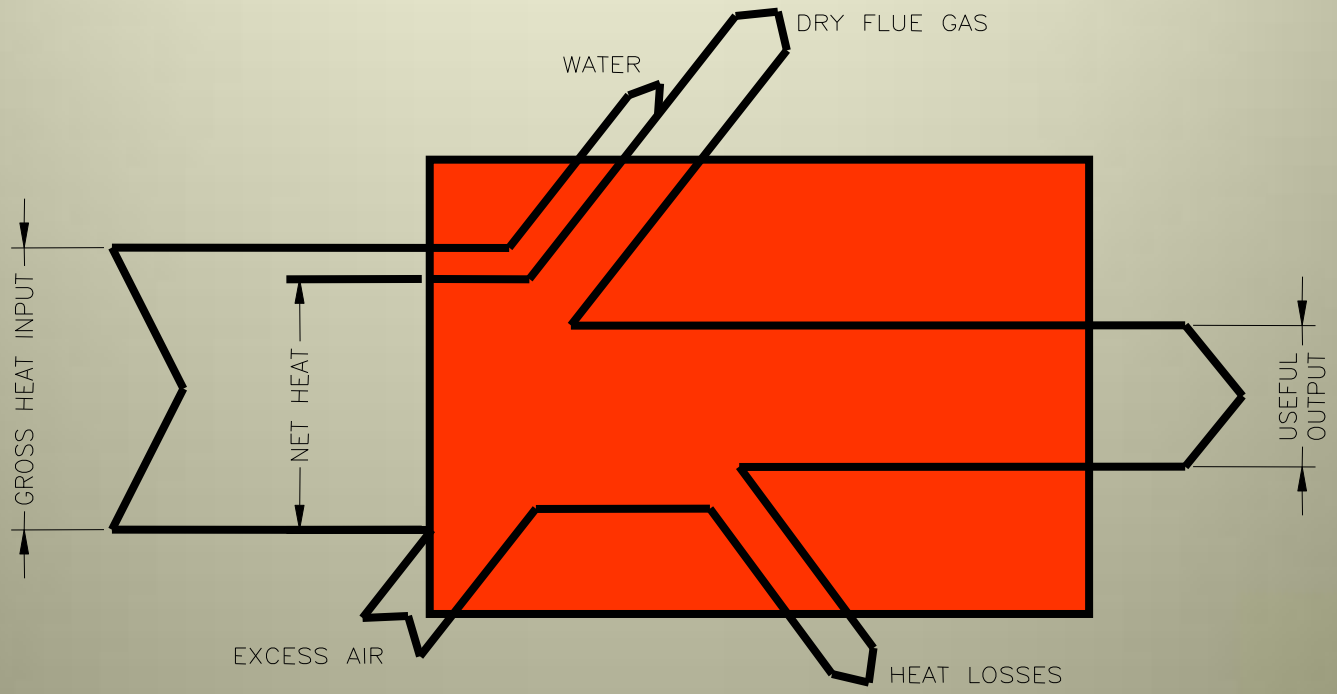
SANKEY DIAGRAM



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STACK LOSSES

- ✓ The heat load in the combustion gases is a loss of useful energy.
- ✓ Therefore the stack temperature should be kept as low as possible.
- ✓ The volume of gas should be minimised (excess air).
- ✓ Stack temperature in a boiler application goes up when the heat transfer surfaces become dirty.

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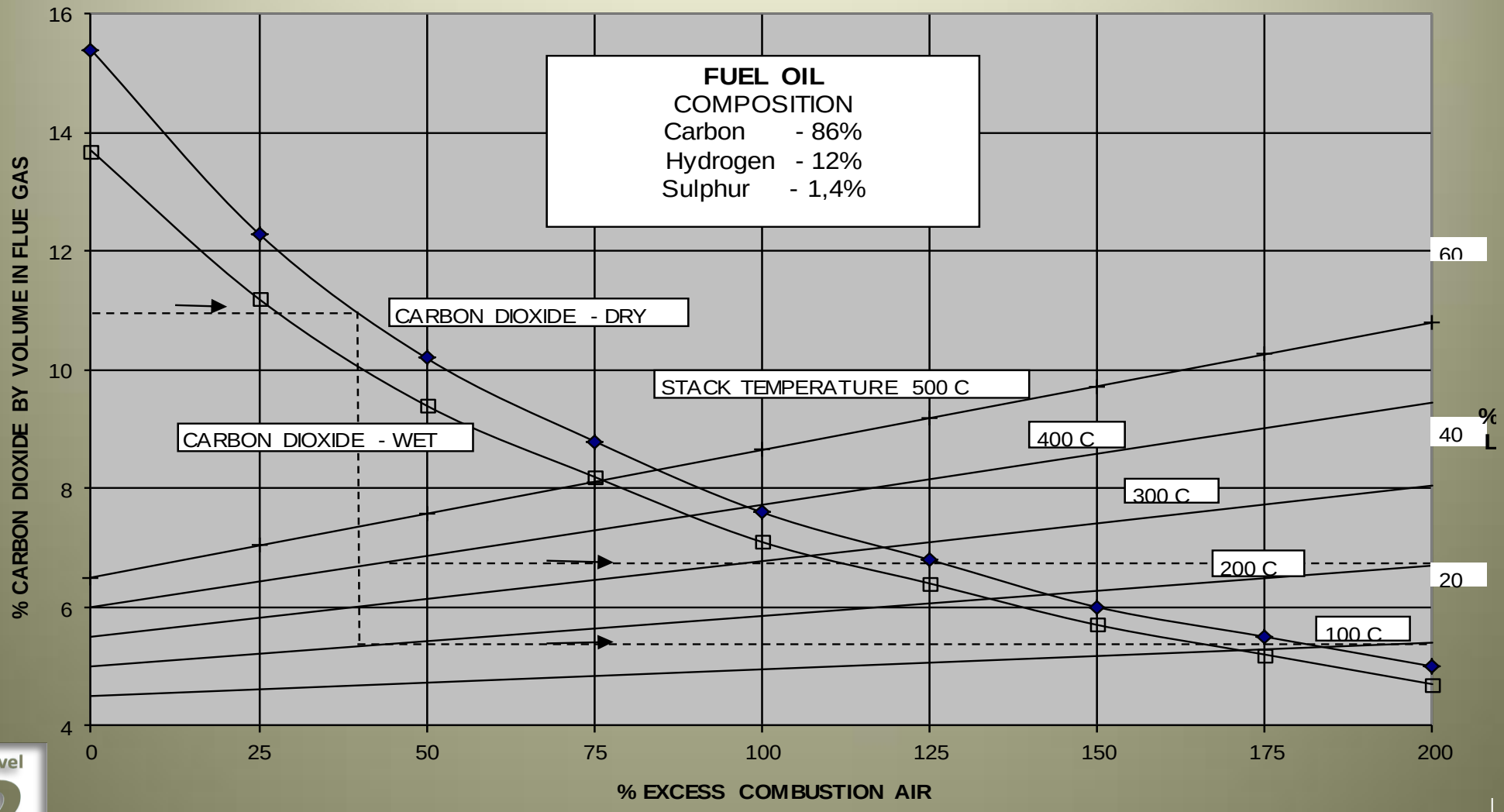
STACK LOSSES



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MEASUREMENT

- ✓ It is **virtually impossible** to set a burner's air:fuel ratio by eye to ensure complete combustion (minimum CO) and minimum excess air.
- ✓ The only reliable way is to measure the Oxygen (O_2) and Carbon Monoxide (CO< 10 ppm) content in the stack.
- ✓ The burner should be set for minimum O_2 in the stack gas without producing more than 10ppm of CO over a range of turn-down.

CONTROLS

- ✓ The only effective way is to install combustion analysers and control the fuel:air mixture automatically.
- ✓ There is a range of such instruments and systems on the market.

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CONCLUSION

Good combustion requires constant attention to detail, keeping all parts in good working order.

Significant savings can be made by controlling and measuring the combustion process.

THE END

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