AN ARTICLE ON FUEL – COURTESY IFRF HANDBOOK

By K.K.PARTHIBAN, Boiler Consultant
Venus Energy Audit System
Email ID:parthi2006@gmail.com / venus.energy@gmail.com

WHAT IS A FUEL?

For the purposes of industrial Combustion, a Fuel is defined as a substance containing carbon and hydrogen, which may combine within the industrial combustion process, with the oxygen contained in atmospheric air.

This rapid combination releases heat at relatively high temperature, which may then be used for industrial process heating, including the generation of steam and high-pressure hot water.
The combustion chemistry is very simplistically represented as:

$2C + O_2 \rightarrow 2CO + Heat$
$2CO + O_2 \rightarrow 2CO_2 + Heat$
$H_2 + O_2 \rightarrow H_2O + Heat$

Industrial fuels can contain other fuel elements, the most important of which is sulphur, which when oxidized, can contribute significantly to the overall heat release in combustion. However the use of high sulphur containing fuels is strongly restricted at the time of writing, due to heavy limitations in the emission of sulphur dioxide.

HOW DID INDUSTRIAL FUELS DEVELOP?
WOOD

Naturally the development of industrial fuels was dependent on the demands of developing industrial processes. Almost certainly the earliest industrial fuel was Wood, or derived from wood - Charcoal, fired in various open fires, ovens and kilns.

The development of metallurgical industries required charcoal, which also supplied the carbon for ore reduction. Thus charcoal burning itself became an industry, eventually consuming large tracts of forest. Later, raw wood became almost displaced as a fuel for large-scale industry, but it is again becoming important as a component of Biomass fuel or BioFuel.

COAL AND COAL-DERIVED FUELS

Wood was eventually replaced by Coal, both in terms of an industrial fuel and as the source of a reducing agent in metallurgical processes by the coal based product - Coke.

Coal is a solid fossil fuel in the form of dark, compact, stratified rock-like mass of decayed plant debris interspersed with smaller amounts of inorganic matter and covered with sedimentary rock, typically brown or black in color.

Coal is a Fossil fuel of widely varying quality, existing in below surface “seams” of varying thickness, depth and extent. Initially, surface seam “ends” were “outcropped”, progressing to deep mines with drift and/or vertical shafts, leading eventually to the modern techniques of opencast mining. These days a large proportion of coal is traded globally; the remainder is utilized close to the mine.

In modern times coal is used mainly for:

- Power generation and cement manufacturing, fired typically as a pulverized fuel, and steam or hot water raising, fired as a pulverized fuel or as a crushed fuel in fixed or fluidized beds.

- As a raw material for the manufacture of metallurgical coke, a process giving a by-product– Coke Oven Gas – a rich fuel gas that may be regarded as a secondary fuel, and which is fired typically in integrated iron and steelworks. Metallurgical coke is in turn used to fuel iron manufacturing in blast furnaces which gives rise to a further by-product gas, a low grade secondary fuel known as Blast Furnace Gas.

Coal can also be gasified, traditionally to Producer Gas and Water Gas, by passing steam and/or air through hot coke beds. These processes either individually, or in combination, give a relatively low calorific value fuel gas. At various times and locations, in the second half of the 20th century, there has been considerable RD&D to develop commercially successful coal gasification processes. But the advent of plentiful supplies of relatively cheap natural gas - see below – has tended to prevent widespread application, and to displace Town Gas as the coal derived gaseous fuel distributed in urban areas for over a century.

PETROLEUM FUELS – LIQUID FUELS

The next set of fuels to become important in industry was essentially a variety of "liquid fuels". Liquid fuels are mainly oils, tars and pitches and are derived primarily from Crude Petroleum, but also from Oil Shale by distillation and from coal by carbonization and Hydrogenation.

Crude petroleum (also known as crude oil or simply "crude") is a liquid, light brown to black in color and varying considerably in viscosity depending upon origin. It occurs in sedimentary rock strata and is a fossil fuel, derived over millions of years from the decomposition of marine organisms, ocean bed plant life and land based organisms carried into lakes and to the sea bottom. All industrial fuels derived from crude petroleum are classed as fossil fuels. Crude petroleum is found regularly with Natural Gas - see below – and also gives rise to a commercial gaseous fuel – LPG, also described in the following section.

Crude Oil was initially recovered seepage from near surface wells. As demand for petroleum products increased towards the end of the 19th century, deeper and deeper wells were identified and exploited through advancing exploration and drilling techniques. In recent decades, land based production has been substantially augmented by the development and exploitation of under-sea based oil fields.

Crude oil is processed to produce a whole range of domestic, automotive and industrial fuels. The last group contains, Petroleum Distillate Fuels light fuels, and a range of Petroleum Residual Fuels broadly described as light, medium and heavy oils. These fuels were relatively cheap and easier to transport and handle and fire than coal. Eventually at the end of the 1940s petroleum residual fuels commenced to take over from coal-derived fuels for the firing of industrial heating processes.

In 1974, the so-called "oil crisis" gave rise to a temporary loss of crude petroleum supplies and also to a considerable rise in oil prices. This commenced the search for "alternative fuels", alternative supplies of crude oil or indeed liquid fuels alternative to petroleum. In the 1980s research was carried out into the firing of very heavy residuals, the production of coal-water slurries, the development of Bio-oils and so forth. The application of these alternative fuels was however curtailed by the eventual reduction in crude oil prices. Nevertheless it is strongly believed that the use of liquid, petroleum based industrial fuels will remain important in the early decades of the present century although their market share may decrease.

NATURAL GAS-GASEOUS FUELS

The final range of fuels of industrial importance is "gaseous fuels" which are generally the easiest fuels to handle and fire. At the time of writing, Natural Gas, a high calorific value, gaseous fossil fuel composed mainly of methane – CH_4, often found in association with crude petroleum deposits, is the most abundantly distributed and fired. This gas is also transported in bulk, in liquefied form – LNG. A further industrial fuel derived from natural gas or from petroleum refining is LPG, a very high calorific gaseous fuel composed primarily of propane and/or butane, distributed as a liquid prior to firing in the gaseous state.

In the iron and steel manufacturing industry, Coke Oven Gas (COG), Blast Furnace Gas (BFG) and Basic oxygen steel making gas (BOS gas) are regularly used for associated process heating – e.g. for the firing of reheating furnaces, Cowper stoves etc., and for power generation. Similarly in the petro-chemical industries a variety of gaseous by-product streams are used for the firing of associated processes.

Town Gas, usually derived from coal, is a medium calorific value gas formerly used extensively for residential applications in the urban areas of mature economies, but now largely superseded by Natural Gas.

RENEWABLE FUELS
BACKGROUND

The combustion of fossil fuels effectively releases carbon, stemming originally from decomposed plant and animal organisms, stored for millions of years as hydrocarbon molecules in coal, petroleum or natural gas. This carbon is released as Carbon Dioxide – CO2. It is presently believed that the massive increase in the combustion of fossil fuels commencing at the start of the industrial revolution has significantly increased the concentration of carbon dioxide in the atmosphere.

Carbon dioxide is a so-called greenhouse gas which is said to contribute to the phenomenon of "global warming", exhibited as climate change. The Kyoto protocol requires the curtailment of carbon dioxide emissions from fossil fuel combustion which can be achieved, among other ways, through:

- Increasing the overall thermal efficiency of the use of fossil fuels;
- Substituting fossil fuels by so-called renewable fuels in combustion processes;
- Providing process energy from sources not requiring the conversion of any form of fuel – e.g. electricity produced form nuclear power stations, Wind Energy, Solar Energy, etc.

FOSSIL SUBSTITUTE FUELS

This an important area of development, which considers the developing role of biomass.
Generally this set of fuels is based on plant forms, including:

- Plants from wood to straw, that can be grown and harvested as a fuel (so-called energy crops);
- Waste residues from plant processing – piths, bagasse etc.

In addition to biomass, a further developing area includes fuels derived from municipal (domestic, commercial and industrial) wastes – so-called Refuse Derived Fuels – RDF – and sewage sludges. With the increasing prohibition of landfill and river and sea dumping as a means of disposing of these wastes, recycling of waste products including the development of potential industrial fuels streams is a developing area, and one of interest to industry as a source of fossil replacement fuels.

There has been considerable research in the last decade into the firing of such fuels, either in the co-firing mode or in combustion equipment specifically designed for the firing of these fuels with built-in heat recovery.

Co-firing essentially means the mixing, for example of an RDF with a coal, in combustion equipment designed for coal preparation and firing. The heating process can be steam raising for power production of a cement kiln.

The essential point is that the amount of waste for disposal is reduced and that the calorific value of the RDF or other waste fuel streams is released in a controlled manner at a point where it can be easily utilized, reducing the need to fire a specific fossil fuel.

CONCLUSIONS

For the foreseeable future, fossil fuels will continue to provide the bulk of the industrial fuel supply. Gradually developing fossil substitute fuels, based on biomass and recycled wastes will contribute a relatively small but nevertheless significant portion of the industrial fuel supply.