LOW RANK COAL/LIGNITE UPGRADING TECHNOLOGIES

Although high rank thermal coal prices have significantly decreased during 2012–2013, there is still interest in low rank coal for securing long-term fuel cost reductions, utilising indigenous fuel to save foreign exchange and high rank coal conservation.

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There is a large amount of low rank coal in Australasia, South Asia and South East Asia, fuel that can be upgraded to increase its contained energy, increase its market value and make it a transportable and an exportable fuel. The low rank coals are often characterised by:

- High moisture content (sometimes > 50%)
- Moderate to high ash (although some are low ash, <10%)
- Low to moderate Specific Energy (12–25 MJ/kg, typically ~15 MJ/kg)
- In many cases a very low Ash Fusion Temperature (high Na/K content, high Base/Acid Ratios)
- A high propensity for spontaneous combustion
- Liable to degrade to excessive fines during transport and handling.

During the period of high thermal coal prices, 2009–2012, many coal users looked to replacing higher rank thermal coal with lower rank sub-bituminous coal and/or lignite as a fuel cost reduction measure. In replacing high rank coal with low rank coal, challenges rising from the above low rank coal characteristics need to be addressed. This has caused an increase in interest in processing low rank coal to specifications similar to higher rank coals.

PROCESSES AND TECHNOLOGIES

Some well-known processes/technologies (specifically traditional briquetting technologies) were reviewed for new applications and locations (including Pakistan) by major coal technology companies, while other groups went on to developing 'new' technologies. A selection of process developers is presented in Table 2.

The newly developed low rank coal processing technologies generally fall into two types, these being coal destruction through the application of heat, with the production of coal-gas, coal-oil (liquid distillation products) and coal char – Pyrolysis, Type A processes, Figure 1, and agglomeration processes that take raw coal and agglomerate it either with or without washing and produce a dewatered coal product – Agglomeration, Type B processes, Figures 2 and 3.

INNOVATION FOR PYROLYSIS

Type A processes includes pre-pyrolysis processing, the pyrolysis system, process efficiency and closing the energy balance between power/steam demand and coal-gas utilisation, and utilising the water contained in the fuel moisture content in the most efficient way. Regarding by-products, excess coal-gas could have some value in cement manufacture, brick manufacture and other industrial heat applications. However, the value of coal-gas with a Specific Energy (SE) of ¬say 16 MJ/m^3 will be low and for use in gas turbine based power generation will require considerable and expensive gas cleaning.

Challenges for Type A processes are that the produced char and coal-oil (pyrolysis oil) may not have an adequate market value for closing the process cost-to-income gap, the cost of preparing the feed for gasification and the coal-char product could be high, especially if briquetting is required, and the process water clean-up may be very expensive and produce hard to process residuals. On the positive side, coal char is normally chemically un-reactive and should not be prone to spontaneous combustion.

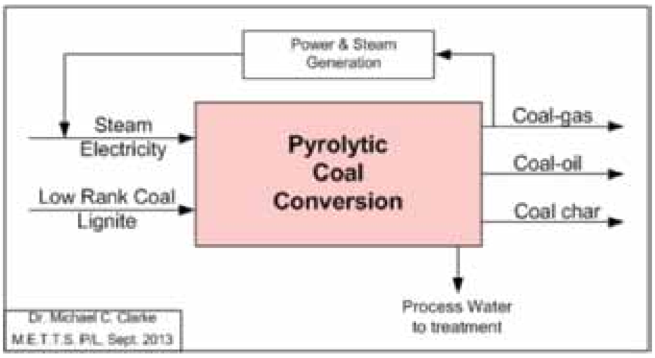

Figure 1 Pyrolytic coal conversion, inputs and outputs
Note that feed preparation, product cleaning, refining and/or agglomeration and water treatment processes are not shown in the schematic.

AGGLOMERATION PROCESSES

Including briquetting and pelletisation – that take raw coal and agglomerate it either with or without washing, will produce a dewatered coal product without seriously affecting the coal constituents. In some instances sodium and potassium and chlorine may be reduced, thus reducing challenges from low ash fusion temperatures and corrosion respectively.

INNOVATION FOR AGGLOMERATION

Type B processes include pre-agglomeration processing, the briquetting/pelletisation system (binders or no binders), ensuring process thermal efficiency (and closing the energy loop) and utilising the water liberated in the agglomeration process. It can be noted here that agglomeration-processed water will be less contaminated than pyrolysis-produced water.

Agglomeration should significantly increase the SE of the fuel through moisture reduction and reduce the chemical reactivity of coal (especially lignite), thus reducing the propensity for spontaneous combustion. It should also reduce the percentage of fines created at all transport legs and nodes, and reduce the corrosion potential on infrastructure. Agglomeration should therefore assist coal logistics (coal flow) from mine, to stockpile, and thence to combustion.

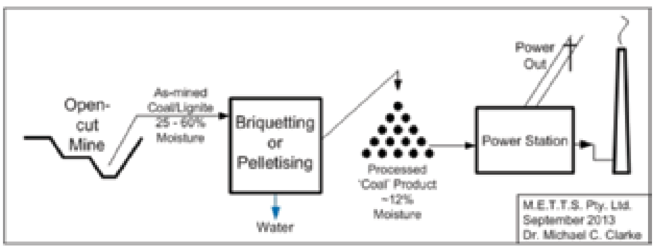

Figure 2 *Mine to power station briquetting/pelletising schematic*

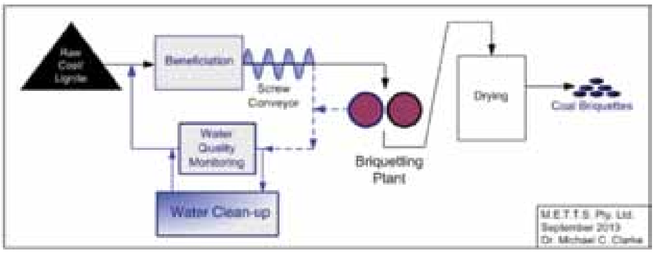

Figure 3 *A generalised coal/lignite briquetting process schematic*

UTILISING UPGRADED COAL (LIGNITE)

Lignite and lower rank sub-bituminous coal can be a blending fuel with higher rank coals; however significant increases in spontaneous combustion propensity and moisture content, together with decreases in SEs to where combustion conditions are significantly changed are not welcome. The ability of the agglomeration process (with moisture reduction) to make the processed coal/lignite 'more friendly' to the combustors is important and is what will govern the take-up of agglomeration technologies in many instances.

Where the major product is coal-char, the ability of the char to successfully combust and leave a low carbon-in-ash is very important. If the char has a medium to high mineral matter content that can occlude the combustion of fuel particles, fluidised bed combustion (FBC) with its strong particle abrasion function would be the best way of using coal-char and coal-char/coal blends.

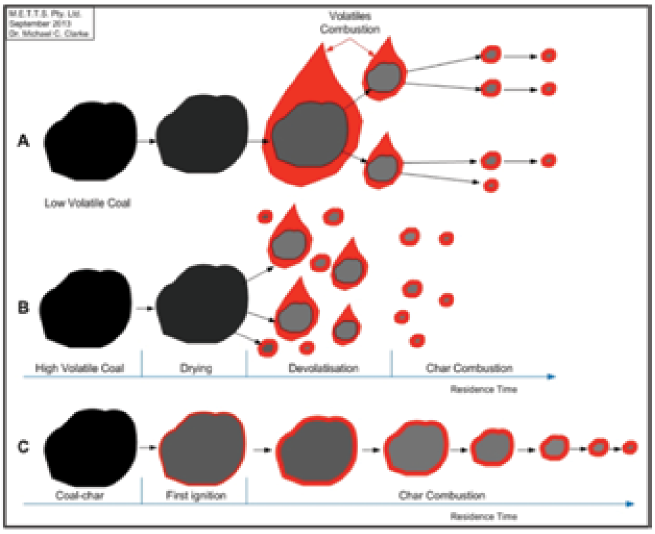

Figure 4 *Coal versus char combustion characteristics*

Coals and lignites, such as those found in the Collie Measures of Western Australia, have a strong propensity for spontaneous combustion (spon com), making them essentially a domestic fuel. There have been moves to make them 'exportable' by reducing their spon com potential. Briquetting or pelletising the Collie coals would be one way of increasing their potential for export. Likewise many Asian low rank coals and lignites could also be made export quality. In some cases, the exportability of the Asian fuels would be greatly enhanced by moisture reduction as well as increases in chemical and physical stability.

Lower rank coals and lignites also have a general tendency to have low ash fusion temperatures, high sodium and/or potassium content and high base/acid ratios, making them liable to combustor slagging and/or fouling in high temperature pulverised fuel combustors. Again the use of FBC technology, either circulating (CFBC) for units > 50 MWe or bubbling (BFBC) for < 50 MWe, with their relatively low operating temperatures, say 850–950°C, would be the technology genre of choice. Note: The units could be sub-critical FBC or the newer super-critical FBC variant.

UNDERSTANDING THE OPPORTUNITY, NEED AND LIMITS

In some instances low rank coal and lignite upgrading has the potential to realise the value of a stranded resource. The governing factor will be the total relative cost of upgraded fuel versus the cost of available higher rank coal. The removal of process risk is a major task of miners and traders who wish to sell upgraded fuel to existing power generators. For new power projects, having upgraded fuel as the reference or design fuel is another task. Here the project owners, the EPC contractors (including the actual combustor designers/fabricators) and the groups in the fuel logistics train must all be satisfied with the proposed fuel. For those involved in fuel logistics, the safety of transporting and storing the upgraded fuel will be critical and will determine if the fuel gains acceptance.

MARKET ACCEPTANCE FACTORS FOR UPGRADED COAL/LIGNITE	BUYER REQUIREMENTS
Energy content	VERY IMPORTANT: Similar to existing fuel or suitable as a reference/design fuel
Chemical stability – as spontaneous combustion potential	IMPORTANT: Spon com is a risk to miners, processors and users
Physical stability – as excessive fines production potential	MODERATELY IMPORTANT: Excessive fines can stop power plants, hold up coal flow and cause corrosion to infrastructure
Security of supply and stability of price	VERY IMPORTANT: This may be a positive marketing tool
Suitability for blending	IMPORTANT: Compatibility with other fuels in the blend is important
Perceptions of the fuel	IMPORTANT: Winning support from power station operators and owners will be required for acceptance
Relative cost of the fuel	CRUCIAL: Unless the fuel has an advantageous price, why should power station executives consider it?

Table 1: *Gaining acceptance and establishing markets for upgraded low rank coal/lignite*

The formula that the cost of mining, plus cost of upgrading (inclusive of environmental, process licensing and handling costs), plus having the product(s) marketed at a discount to other fuel (i.e. higher rank coal) resources to overcome buyer resistance to new products, must be understood and have a positive result. Upgraded fuel marketing must follow the laws of economics, of supply, demand and cost, being in agreement for success!

THE UPGRADING PROCESSES AND THEIR PURVEYORS

Examples of low rank coal and lignite upgrading technologies are shown in Table 2 (see over).

IDENTIFYING A COAL/LIGNITE DEPOSIT WITH POTENTIAL

Some of the companies listed above have operating upgrading plants or major pilot plants for testing bulk samples of prospective low rank coals/lignites that may be suitable for upgrading. They also have a set of parameters for running initial estimates of the suitability of a fuel for upgrading. It is important to gain an initial opinion of a specific coal/lignite's suitability for upgrading, but if that result is positive, then the minimum of a pilot scale test on a representative and fresh (mined coal does age) sample(s) should be undertaken.

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LOW RANK COAL/LIGNITE UPGRADING TECHNOLOGIES

Process name	Process type*	Purveyor	Country of origin	Target input raw fuel	Status
Coal Plus	A	Jatenergy Ltd (Australia)	China	Lignite and (some) sub-bituminous	Operating plants
CTC Pristine-M	A	Clean Coal Technology Inc	USA	Low rank coal (including lignite)	Pilot plant being built
Continuous Hydrothermal De-watering (CHTD)	B	Exergen Pty Ltd	Australia	Lignite and (some) sub-bituminous	Pilot plant
Binderless Briquetting	B	White Energy Ltd	Australia	Sub-bituminous, some lignite	Operational plant
Coldry	B	Environmentally Clean Technologies Ltd (ECT)	Australia	Lignite and (some) sub-bituminous	Pilot plant
ZEMAG	B & A	ZEMAG Clean Energy Technology GmbH	Germany & China	Lignite, brown coal	Operational plants

Table 2 *Examples of low rank coal and lignite upgrading technologies*

** A = Pyrolysis/coal destruction; B = Agglomeration, briquetting or pelletisation*
(This list is not meant to be exhaustive but is a snapshot of what is available.)

Companies that design and make combustors should also be asked for their plant fuel parameters. By matching combustor parameters with actual fuel specifications, process risk from using upgraded fuels can be greatly diminished, if not eliminated.

CONCLUSION

Low rank coal and lignite upgrading is technically possible for many fuels and the upgrading can increase the value of a lignite or coal and provide monetisation pathways. The nature of the upgraded fuel must be well understood in terms of its suitability for specific coal-to-electricity conversion technologies. If the total fuel costs are favourable, and the fuel is compatible with the conversion technology and logistics, then a successful power project should be very possible.

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