Installing a Wood Gasifier to Generate Producer Gas

Background

- Canterbury Clay Bricks
- Darfield, Canterbury
- Single Tunnel Kiln

- Preferentially fired with used oil (75%) and diesel
- Fuel costs substantial portion of operation
- Operates 24/7 for 350 days of the year

Project Aim

Investigate the feasibility and economics of installing a wood gasifier to generate producer gas for the current kiln and a proposed second kiln.

Study Approach

- Energy Audit to determine current and future loads
- Develop an RFI for Gasifier manufacturers
- Assess gasifiers based on supplied information
- Assess local fuel supply
- Determine economic feasibility

Current Operation

- Clay and feed materials supplied from local area
- One day shift to prepare bricks
- Kiln operates 24/7, automatically fed by mechanical systems
- Kiln fired by used oil and diesel, dependent on brick type
- Waste heat used in drier

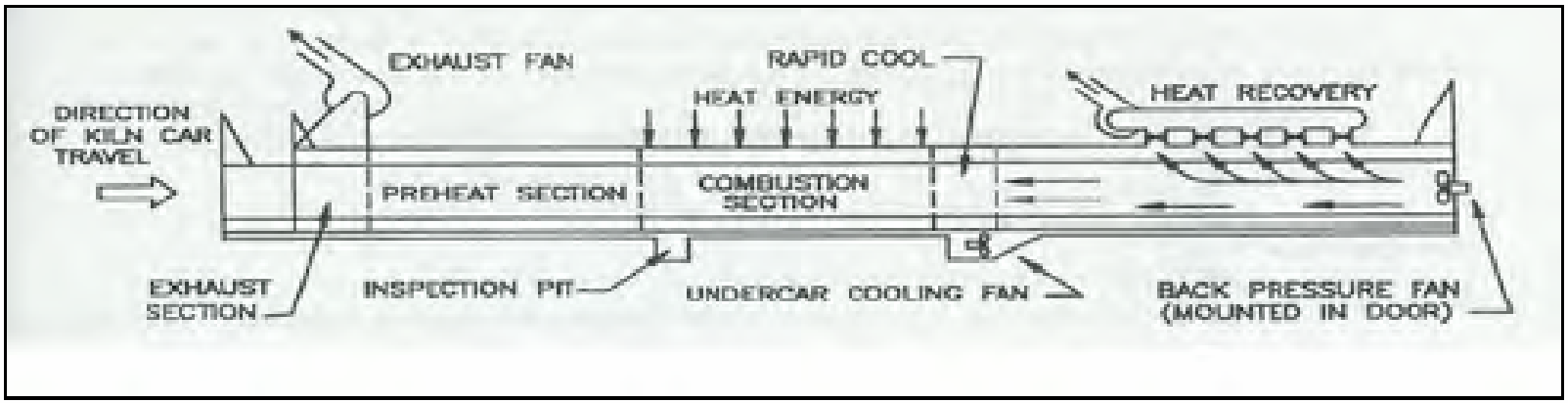
Materials Processing

NEW ZEALAND CENTRE FOR ADVANCED ENGINEERING

Dryer

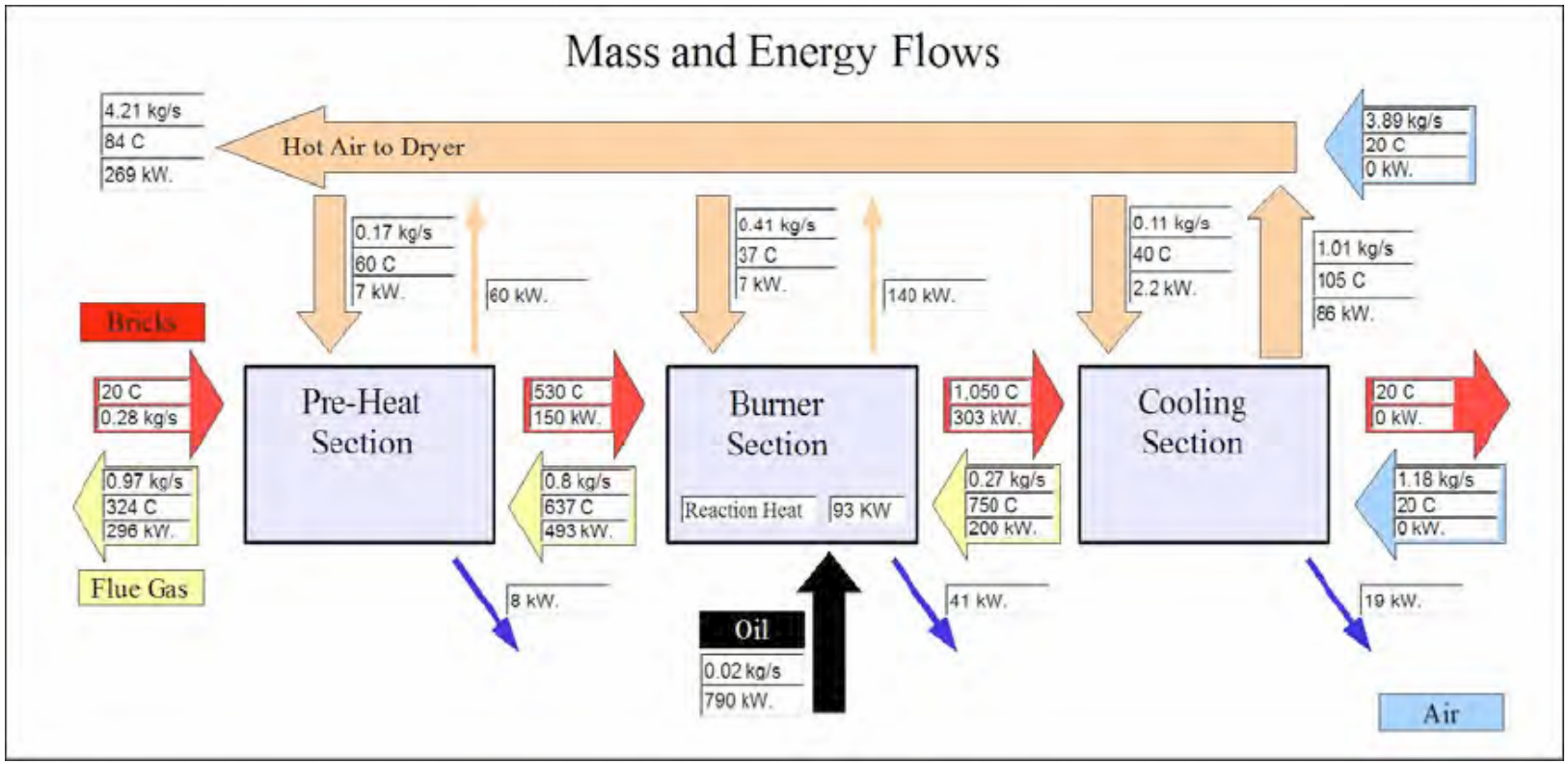
Burners

Process


EXHAUST FAN
RAPID COOL
HEAT ENERGY
HEAT RECOVERY
DIRECTION OF KILN CAR TRAVEL
PREHEAT SECTION
COMBUSTION SECTION
EXHAUST SECTION
INSPECTION PIT
UNDERCAR COOLING FAN
BACK PRESSURE FAN (MOUNTED IN DOOR)

Kiln Exit

Mass & Energy Flow



Audit Results

	Heat In kW	Heat Out kW	Difference kW
Preheat	500	513	-13
Burner	1146	1069	77
Cooling	305	305	0
Overall	790	726	64

		Standard	*Darfield*	*Increase*
Heat for reaction	[kJ/Kg/brick]	335	335	Assumed
Loss in Flue	[kJ/Kg/brick]	375	1065	284%
Loss through walls	[kJ/Kg/brick]	174	243	139%
Heat to Dryer	[kJ/Kg/brick]	456	970	213%
Heat Supplied	[kJ/Kg/brick]	1340	2842	212%

Energy Requirements

- Fuel/energy consumption rates
  - Oil 2,000 L/day
  - Equivalent to 890 kW
  - Peak consumption 1,200 kW
- Gas quality issue with fluctuating output
  - Need to reduce differential between peak and average consumption figures
  - Modulating or staged control of burners vs current on/off control

Identify Suppliers

- 14 suppliers identified
- 7 proposals received
  - Ankur
  - Carbo
  - Keyuan
  - Netpro
  - Powerhearth
  - Puhdas
  - Radhe

RFI Specification

- Gas quality - suitable for 20 separate modulating burners on up to 100m small diameter pipe
- Gas heating value - 11000 degrees C
- Heat required - 2.4 MW
- Operator attendance, day time, 5.5 days/week
- Gas Temperature < 50 degrees C

Gasifier

- Gas cleaning
- Normal operating range
- Turn down ratio
- Gas properties
  - Tar loading
  - Dust loading
  - Temperature
  - Heating value
  - Typical analysis rate

Fuel

- Type - wood or coal
- Size range
- Ash content
- Moisture content
- Ash fusion temperature
- Sulphur content
- Swelling number
- Other limitations

Budget Cost

- Estimated Capital Cost
- Commissioning, training, installation
- Man hours
- Manning requirements
- Electrical usage
- Water usage
- Compressed air usage
- Delivery time
- Maintenance schedules

Environmental

- Solid wastes
- Liquid streams
- Area required for plant
- Height of plant
- Weights of major items
- Noise levels
- Emergency flare operation

Supporting Information

- Commercial experience with similar units
- Links with Australia or New Zealand
- Quality management system
- Warrantees
- Ongoing technical support
- Health & safety record

Technical Evaluation

Main Issues

- Gas quality
  - Contamination, Tar
  - Energy content, 5 MJ/Nm3 min. required
- Turndown ratio
  - Minimum flow rate of 790 kW

Technical Evaluation

- Site Issues
  - Variety in size
- Ease of operation
- Environmental
  - Char and ash (downdrafts) output
  - Preliminary dry cyclone, maybe phenolic compounds
  - Liquid scrubbing

Process Comparison

Country of Origin	USA /NZ	India	India	South Africa	Finland	India	China
Gasifier:							
Gasifier Type	Downdraft, linear hearth	Downdraft	Open top downdraft rebum	Downdraft	Downdraft	Up Draft, Pyrolitic	2 Stage Gasifier
Fuel	Wood	Wood	Wood	Wood	Wood	Wood or Coal	Coal
Gasifier Cleaning system	Fuel Rate at design Output		Cyclone, coolers and scrubbers	Cyclone, scrubber	Electrostatic	Wet scrubber	Cyclone and electrostatic
Overall Thermal Efficiency	>76%	>75%	0.75	0.8	0.81	0.75	
Operating Temperature	1200 -1300C	1050-1100 C		1400-1500 C			
Turn down ratio	>1:5	>1:3	P	1:6	1:4	1:3	
Maximum Output – kWth	2560	2550	2640	1659.722222	3000	2400	5058.083333
Minimum – kWth	512	850	880	276.6203704	750	800	1686.027778
Fuel Rate at design Output	900 kg/hr	700 kg/hr	2 * 425 kg/hr		3 * 240 kg/hr		800 kg/hr
Control system	Fully Automated	Fully Automated	Basic no start up/ shut down	Basic system only	Fully Automated		Automated
Gas properties:							
Tar loading	0	3mg/Nm3	50 ppm	0.012g/Nm3	<100 mg/Nm3	Low	
Dust Loading	0	6mg/Nm3	Combined above	0.2 g/Nm3	<10 mg/Nm3	<120 µg/m3	
Temperature	593 – 400 C		Ambient		50C	150-300°C	
Heating Value MJ/Nm3	5.410518609	>4.4 (5.4)	4.6	5.5	6	5.0232	6.0697
Typical Analysis							
CO	21.9	14	20±2%,	23	22±3%,	20±2%,	
CH4	1.75	3.4	2±1%	2	1-3%	03±1%	
H2	26.7	18.6	20±2%	22	20±3%	18±2%	
CO2		11	12±2%	10	8-10%	10±2%	
N2		50	Balance	Balance	46±2%	Balance	
Rate Nm3/hr at design	1596.889434	2000		1086	1440	1200	2000
Area Required for Gasifier	3m by 6m	20m by 30m	200 m2		21m by 7.3m	About 200 Sq.m	18m by 22m
Overall height of unit	3.3 m	9m	12m		5.3m	17m	10m
Weight of major items	1.32 tonne		30 tonne			10 tonne	
Manning Requirements	2-3 hours per day	3-4 hours/day	2 per shift	2 per shift	On Call – 1 hr day		3 per shift
Equipment Life (Aprox.)	Lifetime warranty			> 20 years		Aprox. 15 years	

Comparisons

- Environmental

Solid Waste	Clean Ash	Ash with char	Wet sludge	Dry solids	Char	Wet Ash, Ash Clinkers,	Dry Ash clinker, ESP discharge
- Rate	119 kg/DAY	900 kg/DAY	800 kg/day	540 kg/DAY	580 kg/day	800kg/day	Not given
- Moisture	Dry				Dry		
- Carbon	0.1	0.8	0.9	0.7	0.8	0.85	
Liquid Streams (If applicable)	None	See below	Phenolic water Discharge	See Below	None	See Below	Phenolic water discharge
- Rate			Not given				Not given
- BOD			112g/hr				
- Suspended solids							
Compounds classified as Hazardous in any way	None	Recirculated Phenolic Water, evaporated to biological solid	Phenolic water Discharge	Recirculated Phenolic Water, evaporated and recycled	Dry ash from ESP recirculated in with Fuel	Recirculated Phenolic Water, evaporated and recycled	Liquid tar, recycled or burnt, plus phenolic water

- Fuel

Drier Included	Yes	No	No	No	Yes	No	No
Types of fuel (eg coal, wood)	Wood waste General Biomass	Wood waste can be configured for wide range.	Woody biomass	Woody biomass	Wood Chip. Bark <20%, Fines (max D <30mm)<5%	Charcoal, Steam Coal, Biomass Briquettes, Wood	Coal
Size range – maximum, minimum	Ideal size 20 to 50 cc but adaptable	10mm – 100mm	25 – 40mm	11cm * 40 cm Cross section	l=30-100mm w= 20-70mm Thick=3-20mm	>10 & <50mm	20-40mm or 25-50mm or 30-60mm
Maximum Ash Content			<5%	<3%		Up to 25%	<12%
Maximum moisture content	<50%	0.2	<15%	<20%	<50%	<15%	<20%
Minimum Ash Fusion temperature						1400°C	<1250
Maximum sulphur content						<0.3%	<1%
Swelling number						< 1.00	<1.0
Other limitations on specific fuels			Bulk density >250kg/m3	Clean		FC. 35-40% by weight	

Comparisons

- Experience

Commercial experience with similar units	1 commercial in NZ others under manufacture	Extensive 700+	>60,000 hours operation of units >100Kwe	>5 with generators only	5 Finland 1 USA	Supplied 200+ plants	Several plants in China
Existing links with NZ or Australian Companies	Yes, NZ and Australian fabrication	AES NZ agent	Nil	Nil	Investigating Australian agents	Negotiating with an Australian Company for the designs of small capacity Gasifiers	Nil
Quality Management system		ISO 9000				Nil	
Applicable warranties (Performance, plant availability and material)	One year performance guarantee		One year from date of commissioning		One year	One year warranty on performance and equipment	

- Cost estimates ranged widely
  - $377,500 to $3,528,030

Fuel Supply

- 4,700 T/annum, 15% MC
- 8,300 T/annum, 50% MC

- Investigated several local options
  - Preference clean dry wood ready to use
  - Sawmills want single customer (CHH)
  - Fresh logs $40/T, 0.1 - 0.7 m diameter
  - Wood merchant $120/T delivered

Economic Assessment

Item Details	Comment
Fuel storage bunker	Tilt slap, with life floor. Sufficient to store dry fuel for just over two days. Trucks assumed to unload directly into bunker.
Dry, chipped fuel delivered to site	Supplied by wood fuel merchant
Average firing rate	It was assumed that the gasifier has an average firing rate of 1.78MW(th) for 350 days of the year (remaining 15 days allow for annual plant shut-down)
Gasifier supplied by Ankur	The analysis was based on Ankur because it was the lowest price option for a supplier with a reasonable track record.
No extra labour required for plant operation, incl. fuel handling	For the purposes of this study, it was assumed that the gasifier itself requires minimal supervision only (fully automated operation) and that the fuel is delivered in to a life floor bin. Where the fuel delivered exceeds the capacity of this bin, it is assumed that it is unloaded onto an adjacent concrete pad, from which the existing front end loader transfers it into the life floor bin when space permits. To avoid fuel contamination, an allowance has been made for the cost of a separate bucket for the front end loader, which would be used for fuel handling. Loader tyre wash down may still be required but no allowances have been made for this in the economic assessment.

Key Assumptions

Item Details	Cost
Capital cost (fuel handling & storage, gasifier, gas piping & burners, instrument & electrical, civil & structural, indirect costs and contingency)	~$1.3 million
Wood fuel (~4,700t/a, delivered)	$120.-/t
Diesel (~380,000L/a, refer to other commercial assumptions below)	$0.9/L
Used oil (~1,140,000L/a, refer to other commercial assumptions below)	$0.4/L
Annual maintenance costs	~$24,000.-/a
Ash disposal costs/revenue (refer to other commercial assumptions below)	$0.-/t
Labour (plant assumed to be automated, thus assumed minimal extra labour required, refer above)	$0.-/a
Economic life of plant	15 years
WACC (no assumptions have been made as to how the investment is financed). Note: this interest rate for the base case was chosen before the latest rise of the OCR. Please refer to the sensitivity analysis for an analysis as to how higher interest rates impact on the annual savings. Also, inflation was not considered.	7.5%
Carbon credit (~4,100t CO_2t/a, no allowance for broker and certification fees)	$0.-/t
Annual brick production	10.5 million

Results

Annual cost savings	~$75,000
IRR	negative
NPV (WACC = 7.5%)	negative
Simple payback	~17.3 years

Fuel cost, based on firing with producer gas made from gasifying wood	5.36 Cents/brick
Fuel cost, based on firing with 100% diesel	13.08 Cents/brick
Fuel cost based on firing with 100% used oil	5.81 Cents/brick
Fuel cost based on firing with mix of used oil (75%) and diesel (25%)	7.63 Cents/brick

Watch Conditions

- Increase in value of Carbon Credits
- Availability of cheaper biofuels
- Subsidies for electricity produced from renewable resources
- Decrease in availability of waste oil
- Local user of low grade heat from electricity production

Recommendations

- Appears to be no major technical barriers
- Current fuel cost structure mean insufficient energy cost savings
- Two recommended suppliers
- Further energy efficiency measures for existing kiln