



Comparative Technology White Paper

Comparative Technology Analysis of Energy Converting Technologies to that of the Fulcrum Thermal-static internal Pyrophenic system (TiPs)

This brief overview will focus on 4 existing technologies that convert everything from Municipal Solid Waste (MSW) to Coal and Bio-Mass into useful Combustible Gas and valuable Fuel Oils that have been around for decades. In the case of “Gasification” it has been around since the early 1800’s. The benefits and competitive advantage that the TiPs process has that none of the others has achieved in decades:

Microwaves

Let’s start with the latest innovation that has been up scaled for commercial use, Microwaves. There are roughly four commercial size facilities worldwide that are utilizing their own “proprietary” microwave technology. Most are focusing on recycling of tires. All claim to recover 40 to 50% “diesel” type oil, the same ratios of solids in the form of Carbon Black. All have stated the need for sulfur scrubbing due to gasifying the 2% of sulfur that most tires consist of. Further they introduce steam as a carrier as well and the need for supportive process to carry out various stages of “drying the solids” and separating metals. They also achieve “zero emissions” and 100% recycling.

There are long range practicality issues that remain today with microwave technology as the volume of tires processed at the largest facility is only reaching 5000 per day. The capital equipment costs (as stated on their web sites) are approximately 30 million dollars with a 12 month construction window. The information available on energy efficiencies is scarce. One can assume via available data that the BTU equivalent of electrical power for the high wattages required for Microwaves and the requirements of 60 ton boilers severely reduce the long term financial viability of Microwave technology.

The decades old formula for energy conversion technology viability is quite simple, BTU Input required to produce versus BTU output value in the product. If that ratio is not at least 3:1 in your favor, then the technology should not be considered. The second factor is the market value of the product produced. Unfortunately, in most cases, microwave technologies are marginally profitable at best.

Pyrolysis

Pyrolysis is a thermo-chemical decomposition of organic material at elevated temperatures in the absence of oxygen. Pyrolysis typically occurs under pressure and at operating temperatures above 430 °C. Most industrial applications of pyrolysis occur at temperatures in excess of 600 °C.

Pyrolysis is a form of thermolysis used for organic materials as one of the existing processes involved in charring. Pyrolysis of wood, which starts at 200–300 °C, can naturally occur when vegetation comes into contact with fire. In general, pyrolysis of organic substances will produce a gas, a liquid and leaves a solid residue behind usually richer in carbon content.

Extreme pyrolysis, which leaves mostly pure carbon as the residue, is called carbonization. This process is used heavily in the chemical industry to:

- produce charcoal, activated carbon, methanol and other chemicals from wood
- convert ethylene dichloride into vinyl chloride to make PVC
- produce coke from coal
- convert biomass into syngas
- turn waste into safely disposable substances
- transform medium-weight hydrocarbons from oil into lighter ones like gasoline

Specialized forms of pyrolysis are called various names, such as dry distillation, destructive distillation or cracking.

The sustainability of pyrolysis over the years has been largely due to the diversity in which it can be applied. Unfortunately, basic forms of pyrolysis can be a prime contributor to greenhouse emissions due to the large energy requirement needed to sustain a reaction. The energy used to sustain water at the temperatures required in pyrolysis is more than 7 times the amount required to bring water to its boiling point.

New pyrolysis techniques, such as “Plasma Pyrolysis” and “Pyrolysis Under Vacuum” are attempting to improve BTU out to BTU in economics. However, numerous technological hurdles remain to effectively scale these new techniques receiving scientific accolades. They remain decades from becoming economically viable.

Gasification

Gasification is a process that converts carbonaceous materials such as coal, petroleum, biofuel or biomass into carbon monoxide and hydrogen by reacting raw material at high temperatures within a controlled amount of oxygen. The resulting gas mixture is called synthesis gas or “Syngas” and is itself a fuel.

Gasification can be used to extract energy from many different types of organic materials. The advantage of gasification, when compared to pyrolysis, is that the syngas is more efficient than direct combustion of the original carbon source because it can be burned at higher temperatures. Syngas can be used directly in internal combustion engines, used to produce methanol and hydrogen or converted via the Fischer-Tropsch process into a synthetic fuel. Gasification can also utilize materials that are not otherwise useful fuels such as biomass or organic waste. The high-temperature combustion refines out corrosive ash elements like chloride and potassium and allows clean gas production from problematic fuels.

Currently, gasification of fossil fuels is widely used at industrial scales to generate electricity. Almost any type of organic material can be used as raw material for gasification. The technology relies on chemical process relationships that are created at elevated temperatures greater than 700°C. Advanced processes, like “Plasma Gasification” require operating temperatures in excess of 10,000°C. Four types of gasification processes are currently available for commercial use: counter-current fixed bed, co-current fixed bed, fluidized bed, and entrained flow.

A *counter-current fixed bed (up draft) gasifier* consists of a fixed bed of carbonaceous fuel (e.g. coal or biomass) through which the gasification agent (steam, oxygen and/or air) flows in counter-current configuration. The ash is either removed dry or as a slag. The slagging gasifiers have a lower ratio of steam to carbon, achieving temperatures higher than the ash fusion temperature. The nature of the gasifier means that the fuel must have high mechanical strength and must ideally be non-caking so that it will form a permeable bed, although recent developments have reduced these restrictions to some extent. The throughput for this type of gasifier is relatively low. Thermal efficiency is high as the gas exit temperatures are relatively low. However, tar and methane production is significant at typical operation temperatures, so product gas must be extensively cleaned before use. The tar can be recycled to the reactor.

A *co-current fixed bed (down draft) gasifier* is similar to the counter-current type but the gasification agent gas flows in co-current configuration with the fuel (downwards, hence the name "down draft gasifier"). Heat needs to be added to the upper part of the bed either by combusting small amounts of the fuel or from external heat sources. The produced gas leaves the gasifier at a high temperature and most of this heat is often transferred to the gasification agent added in the top of the bed, resulting in energy efficiency on level with the counter-current type. Since all tars must pass through a hot bed of char in this configuration, tar levels are much lower than the counter-current type.

In a *fluidized bed reactor*, the fuel is fluidized in oxygen and steam or air. The ash is removed dry or as heavy agglomerate that de-fluidize. The temperatures are relatively low in dry ash gasifiers so the fuel must be highly reactive; low-grade coals are particularly suitable. The agglomerating gasifiers have slightly higher temperatures, and are suitable for higher rank coals. Fuel throughput is higher than for the fixed bed but not as high as for the entrained flow gasifier. The conversion efficiency can be rather low due to elutriation of carbonaceous material. Recycle or subsequent combustion of solids can be used to increase conversion. Fluidized bed gasifiers are most useful for fuels that form highly corrosive ash that would damage the walls of slagging gasifiers. Biomass fuels generally contain high levels of corrosive ash.

In an *entrained flow gasifier*, a dry pulverized solid, an atomized liquid fuel or a fuel slurry is gasified with oxygen (or much less frequently used: air) in co-current flow. The gasification reactions take place in a dense cloud of very fine particles. Most coals are suitable for this type of gasifier because of the high operating temperatures and because the coal particles are well separated from one another. The high temperatures and pressures also mean that a higher throughput can be achieved. However thermal efficiency is somewhat lower as the gas must be cooled before it can be cleaned. The high temperatures prevent tar and methane in the product gas but the oxygen requirement is higher than other types of gasifiers. All entrained flow gasifiers remove the major part of the ash as a slag as the operating temperature is well above the ash fusion temperature. A smaller fraction of the ash is produced either as a very fine dry fly ash or as black colored fly ash slurry.

Some fuels, in particular certain types of biomasses, can form slag that is corrosive for ceramic inner walls that serve to protect the gasifier outer wall. Some entrained bed type of gasifiers do not possess a ceramic inner wall but have an inner water or steam-cooled wall covered with partially solidified slag. These types of gasifiers do not suffer from corrosive slags. Some fuels have ashes with very high ash fusion temperatures. In this case mostly limestone is mixed

with the fuel prior to gasification. The addition of limestone will usually suffice to lower fusion temperatures. Fuel particle must be much smaller than other types of gasifiers. This means the fuel must be pulverized, which requires more energy than for the other types of gasifiers. By far the highest energy consumption related to entrained bed gasification is not the milling of the fuel but the production of oxygen used for the gasification.

Numerous mass balance assumptions have been published by universities and research institutes in attempt to educate the public and political influences on the realities of gasification. Reducing landfill needs in a rapidly growing society while reducing emissions is a daunting task with current technologies. Regardless of the final fuel form, gasification itself and subsequent processing neither directly emit nor trap greenhouse gasses such as carbon dioxide. Power consumption in the gasification and syngas conversion processes may be significant though, and indirectly cause CO₂ emissions. In slagging and plasma gasification, the electricity consumption may even exceed any power production from the syngas. Combustion of syngas or derived fuels emits exactly the same amount of carbon dioxide as would have been emitted from direct combustion of the initial fuel. Biomass gasification and combustion could play a significant role in a renewable energy economy because biomass production removes the same amount of CO₂ from the atmosphere as is emitted from gasification and combustion. While other biofuel technologies such as biogas and biodiesel are carbon neutral, gasification in principle may run on a wider variety of input materials and can be used to produce a wider variety of output fuels.

One of the more successful Gasification Companies has been Dakota Energy. For 25 years they have been gasifying coal for syngas production and electrical production. They also have been the largest benefactors of government subsidies. Chevron started a coal gasification process in Texas in the 80's. After spending 75 million dollars over the course of 5 years they determined that the BTU out vs. BTU in ratio was not economically viable.

One has to ask, just like the failure of the ethanol program, without government grants and funding, are any of these technologies economically viable to stand on their own two feet and thus far history has proven they are not.

Fischer-Tropsch

The Fischer–Tropsch process (or Fischer–Tropsch Synthesis) is a set of chemical reactions catalytically and thermally induced that convert a mixture of carbon monoxide and hydrogen into liquid hydrocarbons. The process, a key component of gas to liquids technology, produces a petroleum substitute typically from coal, natural gas, oil sands or biomass for use as synthetic lubrication oil and as synthetic fuel. The F-T process has received intermittent attention as a viable source of low-sulphur diesel fuel. The chemical reaction requires metallic catalysts such as cobalt, iron, ruthenium and nickel.

Generally, the Fischer–Tropsch process operates in the temperature range between 150 -300 °C. Higher temperatures will promote faster reactions and higher conversion rates but will tend to favor methane production. As a result, the temperature is usually maintained at the low to middle part of the range. Increasing the pressure leads to higher conversion rates and favours formation of long-chained alkanes, both of which are desirable. Typical operating pressures range from one to several tens of atmospheres. Higher pressures would be favourable but the benefits do not justify the additional costs of high-pressure equipment.

A variety of synthesis gas compositions can be created. For cobalt-based catalysts, the optimal H₂: CO ratio is around 1.8-2.1. Iron-based catalysts promote a water-gas-shift reaction and can tolerate significantly lower ratios. This reactivity can be important for synthesis gas derived from coal or biomass which tends to have relatively low H₂: CO ratios. Cobalt-based catalysts are highly active. Iron may be more suitable for low-hydrogen-content synthesis gases such as those derived from coal due to its promotion of the water-gas-shift reaction. In addition to requiring an active metal, the catalyst typically contains a number of promoters such as potassium and/or copper. Group 1 Alkali metals, including potassium, is a poison for cobalt catalysts but is a promoter for iron catalysts. Catalysts are supported on high-surface-area binders/supports such as silica, alumina, or zeolites. Cobalt catalysts are more active for Fischer-Tropsch synthesis when the feedstock is natural gas. Natural gas has a high hydrogen to carbon ratio, so the water-gas-shift is not needed for cobalt catalysts. Iron catalysts are preferred for lower quality feedstock such as coal or biomass.

Unlike the other metals used for the F-T process (Co, Ni, Ru remain in the metallic state during synthesis) iron catalysts tend to form a number of phases including various oxides and carbides during the reaction. Control of these phase transformations can be important in maintaining catalytic activity and preventing breakdown of the catalyst particles. Fischer-Tropsch catalysts are sensitive to poisoning by sulphur-containing compounds. The sensitivity of the catalyst to sulphur is greater for cobalt-based catalysts than for their iron counterparts. Promoters also have an important influence on activity. Alkali metal oxides and copper are common promoters, but the formulation depends on the primary metal, iron vs. cobalt. Alkali oxides on cobalt catalysts generally cause activity to drop severely even with very low alkali loadings. C₅+ and CO₂ selectivity increase while methane and C₂-C₄ selectivity decrease. In addition, the olefin to paraffin ratio increases.

Although F-T operates at lower temperatures than other technologies mentioned, it has numerous economic cost factors associated with the introduction of catalysts. These costs, with extreme pressures and materials of construction required to combat the corrosive nature of the F-T process put questions on the Fischer-Tropsch process as to its long term viability.

TiPs Technology - Introduction to Thermal-static internal Pyrophinic system (TiPs)

Although new to the industry in terms of commercial viability, the process has been refined over 4 decades. Mr. Carl M. Wilwerding, the inventor, was a process chemist and catalyst developer who created and developed small scale versions of what we see today.

Hydrocarbon based feedstock enters a thermal static environment within a series of screw actuated enclosed tubes. It is then indirectly heated and processed under vacuum. The multi chambered heated enclosure provides a stoichiometric turbulent atmosphere in fluid communication within the auger tubes. The Auger tubes are electrically charged via DC Magneto while a natural insulating barrier between the screw and inner auger tube wall is formed. All components are manufactured with multi-content hardened steel components that have catalytic type properties. Superheated steam at up to 400°C but only 20PSI is injected into the tubes at multiple locations. The slight vacuum provides a velocity for the extracted hydrocarbons to move in the opposite direction of the feedstock that enhances the gas water

phase exchange. The electrically charged, steam saturated hydrocarbons exit the auger tubes and are instantly condensed in a series of condensing towers. TiPs can extract the entire hydrocarbon spectrum found entrained in all hydrocarbon-based feedstock with zero environmental impact.

Description

TiPs can solve multiple issues involving extraction and reclamation of hydrocarbons from waste and primary feed sources like tires, plastics, municipal waste, used oils, drilling muds, coal, oil sand, shale rock, biomass, PCB's and sewage. As referenced in the title, *Thermal- Static* refers to the use of thermal dynamic principles that utilize steam as a carrier for "steam stripping" of hydrocarbons. "Static" refers to the static electric atmosphere created via the DC Magneto and the rotational friction of the carbon atom against a revolving screw and the revolving reactor. No other technology takes advantage of electrolysis principles in motion. Pyrophinic refers to the relationships of the unique oils that are created due to the very reactive nature of the hydrocarbons carrying an electrolysis type charge while being thermally separated and instantly quenched or cooled while in this highly agitated state. The net result is a Methodology of combining the laws of *Thermal Dynamics, Electrolysis, Catalytic Principles of Refining,* and constant *Mechanical Motion* of feedstock while it controls the *Temperatures Gradient* throughout the process zones, while under constant vacuum. With the use of computer aided controlled process the TiPs technology produces highly aromatic refined oil, completely dried solids, void of any hydrocarbons or volatiles, and a process gas with BTU values of over 1500 per Cu/FT. This is accomplished with no environmentally harmful emission and energy efficiencies of 30:1 or greater, depending on the BTU value of feedstock, and no wastewater.

"The TiPs BTU out / BTU in economics is like no other technology."

The invention utilizes multiple unique mechanical control apparatuses that work in unison with thermal dynamic control systems which in turn communicates information to the hydrocarbon condensing phase that traverses to the produced gas phase all controlled by mechanical means via vacuum programming protocols unique to the extremely low thresholds of vacuum required, between .05-15 inches of water column, to control the reactions.

The invention comprises of indirect heating via multi chambered thermal core. Feedstock travels within the thermal-static vacuumed atmosphere separated from the heat source via conveyor tubes. The conveyor tubes transport feedstock via auger type actuation through multiple distinct temperature zones. The temperature zones are maintained via metered amounts of superheated steam and a proportional amount of external temperature zones that are located externally off the thermal static vacuumed atmosphere but within the multi chambered thermal core. Each auger conveyor within the thermal core is equipped with a custom built Electrostatic DC Magneto that allows the invention to pulse a controlled static charge within the vacuumed chamber. While the Electrostatic DC Magneto sends a controlled charge throughout the vacuum chamber, superheated steam is injected at various locations throughout the vacuumed atmosphere. This action is dependent on thermal coupler sensors feedback located throughout the invention; steam is introduced to this statically charged atmosphere as required to both quench exothermic reactions and enhance endothermic reactions. The steam thresholds range from 125C° to 350C° and at pressures ranging from 2 PSI to 25 PSI. The

precise metered amount of steam injected to the thermal static charged atmosphere is in the presents of free radical hydrocarbons under vacuumed atmosphere is truly unique.

The hydrocarbons while in the thermal statically charged state are directionally controlled via vacuum into the phase 1 condensing unit. The vapor states are at various temperatures ranges and are instantly quenched in a 35C^o-65C^o liquid. Phase II condensing occurs in a liquid chiller and on to Phases III and IV. The condensed hydrocarbons that comprise of a highly aromatic fuel type oil, free flow into an oil water separator and the resulting oil transports via pumps to bulk storage.

The 100% non-hydrocarbon, completely dry solids, exit the revolving core reactor through one of the four custom designed Vacuum retention materials transfer actuators at various temperatures. The solids flow through a water-chilled auger that further augments steam production. The solids are ready for remediation.

The invention will produce a process gas as well. The ratios of which are dependent on feedstock type. Due to the unique design of the multi chambered thermal core the process gas can be used directly or co-blended with the natural gas heating source.

The up-scale prototypes revealed the following attributes:

- An operable machine design through innovative engineering techniques
- A true "GREEN" technology operated in compliance with prevailing safety and environmental policy and regulations
- A Recycling Process that can produce multiple products with established marketplaces
- The potential for a sound intellectual property position
- Multiple clearly defined consumers that can utilize the product the tire solvent
- The opportunity to improve the economic attractiveness through development of markets for the produced carbon black and produced gas that are by-products.
- The ability to advance the TiPs process into numerous other waste streams or other carbon-based feedstock, such as tar-sands, coal, shale rock and bio-mass
- Attractive economics based on the sales of THE SOLVENT in oil-field service applications

* All samples were extracted via certified third parties. All lab reports and detailed oil analysis available upon request.

* References used for this comparative analysis:

- US Department of Agriculture, US Department of Energy
- The Netherlands Research Institute
- Wikipedia

Competitive Background Summary

Tires Recycling and Decomposition

Historically the bulk of used tires have been disposed of in tire dumps – some legal, some not. In the USA and worldwide there is a huge and growing stockpile of these tires. For example a recent U.S. E.P.A. report estimates there were some ten billion tires stockpiled in the U.S alone – representing a fraction of the worldwide total of 20 billion. Each year, in North America, 330 million passenger tires are added to the waste piles.

Disposal and Recycling

Apart from being eyesores, tire dumps have become environmental tragedies when they combust into difficult to extinguish fires and release a noxious mix of gases into the environment.

Tires are composed of a combination of refined natural rubbers, chemical binders and carbon black. They also contain sulfur, zinc, nylons and steel (between 8 and 15%). Tires represent a valuable source of raw materials although only small portion of used tires are shredded and recycled – generally with government subsidy – into low value products such as playground mats, as filler for asphalt in road construction ingredient and as base for landfills. Tire shred has also been used as fuel source (e.g. cement kilns) although most jurisdictions have passed laws banning ‘Tire Derived Fuels’ (TDR). These laws only add to the available used tire stockpile.

Decomposition Through ‘Traditional’ Pyrolysis

Since the late 1980’s various attempts have been made to decompose and recycle tires into valuable component products through micro wave heating, or more commonly pyrolysis – which is the chemical decomposition of an organic material at elevated temperatures in the absence of oxygen. The process is used heavily in the chemical industry, for example, to produce charcoal, activated methanol and other chemicals from wood. To its advantage, pyrolysis is a well understood and therefore useful process.

A main limitation of the pyrolysis technology is the enormous energy required to sustain a pyrolysis reaction (7 times the energy required to bring water to the boiling point). This energy inefficiency makes pyrolysis an expensive and a significant source of greenhouse gases

Traditional pyrolysis and TiPs produce an oil from tires along with a carbon product. However, in the case of pyrolysis, the oil produced is a low value ‘bunker fuel’ and the carbon produced is a sludge that requires further processing in order to be made into a saleable product. Utilizing our TIPS process creates a high value solvent oil with wide applications as an oilfield solvent (see above) and a high quality ‘carbon black’ in a single operational step. By comparison TiPs process requires minimal outside fuel source at start up only as the plant generates its own fuel source from process gas thus producing minimal greenhouse gases.

Coal Refining

Lignite coal is a readily available and abundant fuel source. In Canada, 13% of electrical power is produced from coal fired plants – but these plants also represent the single

largest contributor to greenhouse gas emissions.

The 'flashing off' of valuable hydrocarbons causes this high ratio of greenhouse gas as coal is burned. Coal to oil schemes has long existed as a potential alternative to harnessing the BTU value of coal. For example, variations of Fischer–Tropsch technology (invented in Germany prior to WW II) have been developed but, given high energy use, have only proven effective in very high oil price environments plus the environmental track record of these technologies have been poor.

TiPs has been extensively tested as a method for processing and refining coal. TiPs will capture the hydrocarbons normally lost in the burning process, converting 1 ton of coal into 1 barrel of highly aromatic oil (dependent on geography of coal source). During processing, moisture is removed, thereby increasing the BTU value of the "Clean Coal" dry solids. Gases released during coal processing is minimal.

"Imagine buying a ton of coal for \$50, processing it and selling the Bunker Oil, (see Southwest Research Report) for \$130.00 per barrel (16% of the ton) and selling the remainder of the now "Clean Coal", which has increased in BTU value up to a 20% higher value proposition than the original ton purchased".

Oil Sands and Shale

The Bureau of Land Management predicts that there are an estimated 3 trillion barrels of oil in the shale rock in Colorado, Wyoming and Utah areas. Canadian Oil Sands reserves rival those of the Middle East.

Current methods of processing oil from oil sands and oil shale have several economic and environmental limitations. TiPs has been tested on oil sands, oil shale and waste asphaltenes. The technology has demonstrated an ability to remove up to 99.9% of the oil, converting it into a -36C° pour point oil that does not require further upgrading. TiPs has also been shown effective in processing and liquefying tailing pond asphaltenes.

- Primary oil sands tested produced oil with a pour point of -36C° and yielded 12% oil by weight volume of input sand
- Testing on oil sands tailing pond asphaltenes showed complete liquefaction of the asphaltenes into sellable oil
- TiPs recovered 99.9% of the oil from Shale Rock taken from the DOE's retort facility in Rifle Colorado

Shale Rock

Shale Rock was donated from the US Department of Energy's (DOE) retort facility in Rifle Colorado. 20,000 pounds of rock was processed and converted to 13 barrels of oil. This represents a 20% extraction ratio of what has been estimated as a 3 trillion barrel reserve at just 10% extraction ration with currently used technologies. Relationships have been established with the Colorado School of Mines, the US Bureau of Land Management and the DOE that can be strategic in entry to this untapped resource.

Alternate Feedstock

Observations documented by Herty Advanced Material Research Center included pine and hickory chips which yielded 10% to 15% oils and carbon based solids with high BTU values. An early prototype of the technology, processed auto fluff, a by- product of automobile recycling: observed and reported by the US EPA in 1988. Medical Waste was processed for US Technologies in 1999. These feedstock's, predominately plastic, produced higher ratios of process gases and oils comparable to a #3 diesel fuel. Soil remediation with entrained toxic constituents have also been reduced to little or zero residuals

Corn

Corn was processed for Texas A& M University to establish a comparative with current ethanol and bio-diesel processes. The results of processing 2500 lbs. showed a 15% extraction of oil and 75% recovery of solids completely in the form of a carbon black that matches the type used for the carbon filter industry.

Greenhouse Gases, Carbon Credits and Greenhouses

The significant and comparative reduction of greenhouse gas emissions by TiPs processing will qualify Fulcrum for carbon credits that could add 15% to revenues depending on the feedstock.