# Transportable fast pyrolysis process for distributed conversion of waste biomass to bio-oil

**Paul Yelvington of Mainstream Engineering Corporation, USA, takes us through progress in their pyrolysis reactor development**

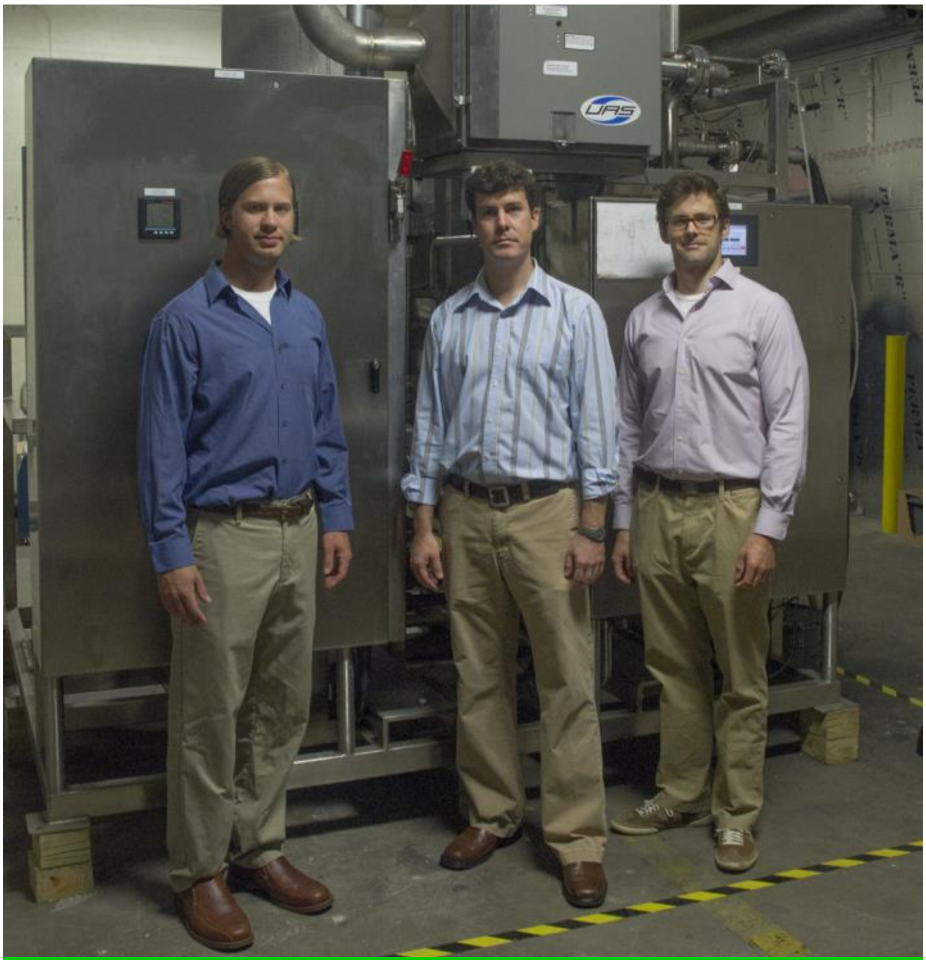

Figure 1: Mainstream Engineering Corporation's pyrolysis project team (left to right: Nich Schwartz, Paul Yelvington, and Ted Amundsen) pictured with the 1 tonne/day pilot reactor at the company's Rockledge, Florida facility.

Mainstream Engineering Corporation (MEC) is developing a transportable, small-scale pyrolysis reactor for the conversion of lignocellulosic waste biomass and mixed waste to pyrolysis bio-oil. The company operates a 1 tonne/ day (tpd) pilot reactor at its Rockledge, Florida facility. Funding for the work has come primarily from the US Air Force with additional funds provided internally and from the US Office of the Secretary of Defence. The Air Force's interest arose from a desire to extend the lives of landfills at Air Force installations by diverting some of the incoming organic waste material.[1] In addition, expanded on-site generation of renewable energy was seen as a way to improve energy security and help mitigate the risk of power outages, supporting the Air Force's goal of producing 25% of on-base power from renewable sources by 2025.[1] MEC is also targeting commercial applications—as MEC is a Florida company, initial waste biomass feedstocks of interest include logging residues, yard waste, storm debris, and sugarcane bagasse.

While MEC's implementation of fast pyrolysis includes new features geared to address several key roadblocks, the underlying fast pyrolysis technology benefits from at least 25 years of development and refinement by the global scientific and engineering community. The focus has been on circumventing technical and cost barriers that have prevented small-scale pyrolysis from taking hold commercially, namely keeping unit production costs low while avoiding shrinking process capacity (i.e., overcoming the "six-tenths" rule), as well as finding a viable near-term offtake route for raw or mildy upgraded bio-oil. The current pilot process uses a bubbling fluidised bed reactor (41cm ID) with a patent -pending quench stage designed to minimise secondary cracking reactions.

The company's biomass programme began in 2008 and has progressed from analytical pyrolysis kinetics measurements to bench-scale testing (1kg/hr), and now to pilot-scale testing (45kg/hr). The 100-person firm specialises in providing solutions to energy

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# Transportable fast pyrolysis ...continued

conversion and thermal control problems, so thermochemical biomass conversion was a natural extension of previous work at the company. Pyrolysis kinetic data along with yield data (bench scale) and product quality data (bench-scale and pilot-scale) were reported in 2013.[2] The bench-scale reactor has been run with pine sawdust and the pilot reactor has been run with pine sawdust as well as a mixed-waste surrogate feedstock. The mixed-waste feedstock contained granulated paper, corrugated cardboard, and several plastics (polystyrene, PET, and HDPE).

The pine bio-oil from the bench-scale reactor was fully characterised and found to meet all ASTM D7544 requirements with the exception of ash content, which was slightly higher than the acceptable value. The high ash content may have been due to entrainment of solid ash/char particles in the bio-oil. The pine bio-oil collected from the pilot-scale reactor was slightly higher in moisture content and lower in heating value compared to the bench-scale reactor. These differences in product quality are believed to be due to differences in bio-oil collection efficiency between the pilot and bench reactors.

The water content was lower for the mixed-waste bio-oil compared to the pine bio-oil and the heating value was considerably higher. The oxygen content of the bio-oil produced from mixed waste was also considerably lower than the pine bio-oil. The lower oxygen content of the oil derived from mixed waste is due to lower oxygen content in the feedstock which included some oxygen-free plastics. The lower oxygen content lends itself to better bio-oil stability (less ageing) and improved upgrading potential (lower hydrogen requirement for deoxygenation). Although not measured, the mixed-waste bio-oil was observed to have a considerably higher viscosity than the pine bio-oil.

Figure 2: Pilot-scale fast pyrolysis process during laboratory testing (bubbling fluidised bed reactor shown in inset).

Recently, the team's efforts have focused on making improvements to the solids conveyance and product separation portions of the process. Under a recently announced grant from the US Department of Energy set to begin this month, a new feedstock preprocessing and conveyance unit will also be developed with the aim to reduce capital and operating costs. This technology is particularly well-suited to small-scale operations where operator costs have a huge impact on the bottom line.

The long-term vision of the company is to commercialise small-scale pyrolysis reactors at the 1tpd scale for military applications and the 10tpd scale for commercial applications. It is envisioned that the 1tpd unit would be packaged in a standard Tricon shipping container, and the 10tpd unit in a standard semi-trailer. MEC is also interested in partnering with other researchers to evaluate innovative fast pyrolysis techniques in our well equipped pilot facility.

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2. Yelvington, P.E., N.R. Schwartz, D.J. Zastrow and T.J. Amundsen, "Transportable Fast-Pyrolysis Process for Distributed Conversion of Waste Biomass to Renewable Liquid Fuels," paper presented at the 2013 AIChE Annual Meeting, San Francisco, CA, Paper No. 324743.