AUTO-FED RESEARCH BIOREACTORS

The objective of semi-continuous AD research is to evaluate the response of the whole system test conditions in a manner likely to reflect real life. The main controls of AD operation are: temperature, mixing, and feeding regime in the absence of oxygen. Ideally, lab reactors should use the same feedstock under similar feed regimes of full-scale plants. AD plants feed on hourly or two-hourly basis, and their performance and microbiology reflect that. While full-scale plants tend to operate at higher OLRs without failure (with rarer foaming occurrence), most lab reactors fed once a day limit their loading to <3kgVS/m3.d to avoid foaming or VFA increase. Feeding less regularly can contribute to instability (transient increase in CO_2 of biogas, VFA increase, pH drop). At full-scale, the feeds of one day takes several minutes to be pumped into a digester, a significant difference with most labs where one feed is delivered in a few seconds. The result is that full-scale plants are not shock-loaded by near-instant feeding and biogas production is more stable than when feed is manual.

Advances in analytical chemistry and microbiology have not been matched by improvements on research digester capability where feeding of real substrate is largely done manually, once a day. Future progress on AD research, such as performance optimisation, microbiology and metabolomics studies, or developments in bio-refining require enhanced capabilities that replicate better the conditions of full-scale operation and that allow more flexibility of research.

Anaero Technology semi-continuous digesters offer:

- **Automatic feeding of heterogeneous fluid substrates**. Thick slurries up to 24%DS can be pumped with high precision in as many feeding events per day as required.
- **Homogenisation of thinner feedstock** during feeding to avoid settling.
- **316 Stainless reactors** can be operated as hydrolysers, digesters, or pasteurisers.

Reactors per set	**2 to 12 depending on volume and model**
Reactor volume (l)	1 to 20 *can provide bespoke models
Reactor material	316 stainless steel
Automatic feeder modules	Individual feeder (*i*-models), or one beam can operate multiple feeders
Reactor Mixing	1 paddle mixer with programmable mixing motor per reactor, 24VDC
Feeder dispenser volume (l)	0.6 to 20 litres (1.8litre standard volume)
Feeder dispenser agitator	1 agitator per feed dispenser
Individual reactor heater	Electric jacket 110VAC, 150w
Feeding frequency	Up to 999 feeds per day
Gas flow meter	Acrylic and 316SS. Real-time monitoring
PLC control, monitoring	110VAC touchscreen PLC with software

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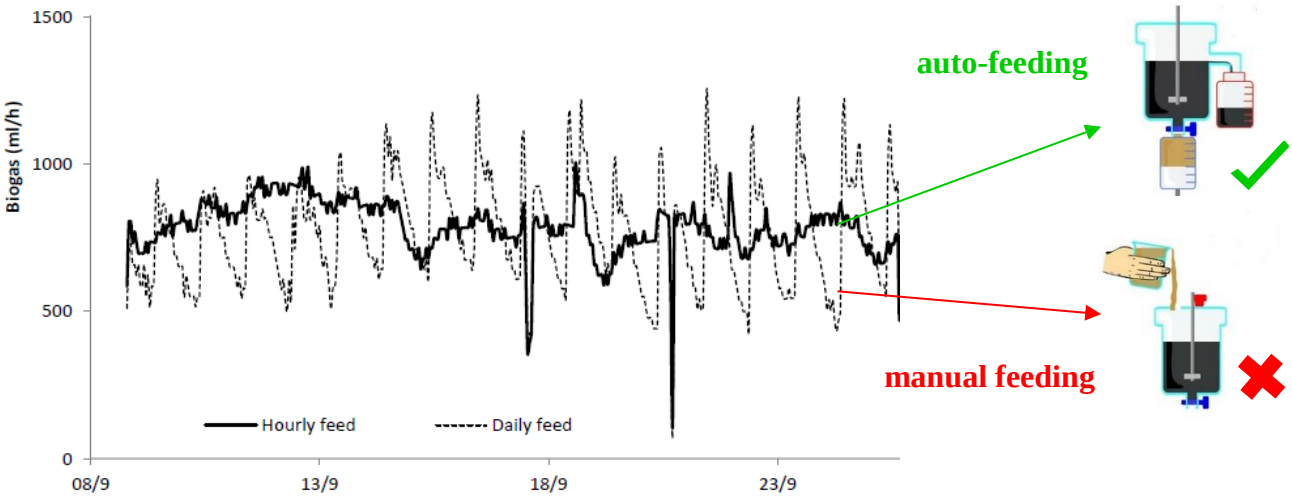

Figure 2. Gas flow (ml/h) for digesters fed manually once a day and hourly at the same organic loading rate (3.5kg VS/m 3 .d), feeding food waste at 17%VS.

- Feeders: Our automated feeding regimes allow the user to set the frequency and size of feeds throughout the day for advanced process control and significant time saving. Cooling coils for the feeder are low cost optional. Most fluid materials can be delivered with our feeder, but high fibre material, such as energy crops require pre-blending for fluidisation
- Mixing: Each digester has a paddle mixer run by individual motors (0 to 80 rpm, 24VDC, 14W). The mixing regime is controlled by the PLC, enabling variable or intermittent mixing to be set for each reactor.
- Heating: Electric heater/insulator jackets enable individual temperature control for all reactors in a set with operating range ambient to 95°C.
- Digesters: Paddle-mixed 316stainless steel digesters with fill and spill ports. Volume range 1 to 20 litres depending on the model. All models use sanitary fittings for ease of assembly and maintenance, such as for tests requiring regular autoclaving. Gas-tight access ports for dosing, monitoring or sampling, and contingency 1.5” port for initial seeding and optional feeding of solids.
- Monitoring. Touchscreen PLC controller with remote access allows the user to set all operational parameters and access monitoring data remotely or directly from the screen. Screen sizes from 5” to 15” depending on the model and number of reactors in the project.
- Multi-stage digestion operation is possible either using the two feeder models, or by connecting reactors in series (black swan models). Reactors of different sizes (1, 2, 5, 10, 20 litres) can be interconnected with heater jackets and agitators fitted to additional stages.

Although, it is evident that feeding regimes impact the performance and microbiology of AD processes, researchers to date have not paid this factor sufficient attention. Results from once a day feeding are extrapolated to represent the bacterial communities and performance of semi-continuously fed AD plants. In other cases work surveys operational sites where conditions cannot be easily changed for experimentation. Manual feeding is time consuming and introduces significant bias to experiments. The main reason for not feeding more regularly at lab-scale has been the lack of equipment capable of doing it. Commercially available pumps (peristaltic, roto, etc.) are not capable of accurately and consistently delivering heterogeneous mixtures at the low rates required by lab-scale reactors. The smaller peristaltic pumps are not accurate enough and block easily with the smallest of fragments. Even pre-screening feed (not done at full-scale) does not allow accurate pumped feeding at the low rates required for lab digesters. Some researchers resort to building “pilot-scale” digesters to feed more closely to real life. However, pilot-scale presents significant logistical challenges for sourcing, processing and storing of sufficient feedstock and, only a few digesters are used, often only one (no proper controls or over-extended research projects).

The automatically-fed digesters developed by Anaero Technology allow research with real feedstock that closely reflects the operational conditions of real AD plant, and enable alterations to reactors without the risks of doing it at full-scale, or the limitations of manual feeding for more advanced and representative research.