Hydrodynamic Cavitation Technology

- Process Intensification
- Sustainable Chemistry
- Upscale Bioresources
- Circular Economies

Powered by Rotocav

biogas • bioresources • oils & fuels • food & drink • water treatment
Hydrodynamic Cavitation by CaviMax are the leading UK supplier and knowledge bank for Hydrodynamic Cavitation Process Intensification & world wide distributor and engineering systems integration for the patented E-Pic S.r.l. Rotocav cavitation reactor
The Biomass Disintegrator for biogas plants

Maximise your biogas plants potential
What is hydrodynamic cavitation?

Hydrodynamic cavitation for disintegration of high lignin feedstocks and recalcitrant substrates

CaviMax – The Biomass Disintegrator

Benefits of cavitation for anaerobic digestion and renewable gas sector
What is Hydrodynamic Cavitation? (HDC)

The short version....

The CaviMax reactor induces hydro (water) dynamic (changing) cavitation (bubble formation), the energy released by this natural phenomenon is the principal mechanism for biomass disintegration.
The long wordy version...

- The CaviMax cavitation reactor produces physical rotational forces that create hydrodynamic shockwaves in liquids, capable of breaking down bonds at a macro and molecular level and forcing together seemingly incompatible gas/liquid/solid mixtures into flowing substrates – homogenisation and particle size reduction.

- The microjet shockwaves are induced by a liquid moving from a high to low to high pressure environment, causing millions of microscopic bubbles to form and collapse. Each bubble collapse event creates tremendous localised pressures, which shear solid particles, break down cell walls and allow liquids to bind with solids. This in turn creates a substrate of increased surface area which is more readily available to be broken down by anaerobic digestion bacteria.

But what does this mean exactly, better explained in pictures...
Cavitation Explained

Vapour Pressure Curve - pressure determines the temperature that solids/liquids/gases change phase.
Cavitation Explained

Vapour Pressure curve - control the pressure to manipulate the boiling point of liquids – create the conditions for bubble formation and collapse, cold boiling
Hydrodynamic cavitation

Imploding bubbles create millions of cyclical high pressure microjets in the chamber

Asymmetric bubble collapse causes high pressure microjets in the liquid; these project their energy into the particles in the substrate, causing collateral damage to surrounding biomass / solids.
CaviMax – The Biomass Disintegrator

Inside the cavitation chamber – liquids pumped at speed through a spinning rotor-stator, forcing liquids through channels creates pressure differentials in the liquid.
cavitation induced biomass disintegration reduces viscosity of substrates

= less wear on pumps and mixers
What do the effects/results look like? Reduced particle sizes & viscosity

Sample from maize fed AD plant recirculating substrate line – fed back into the same digester

Before cavitation – see lots of fibres and solid material left in the hand after squeezing the water out of the sample

After cavitation – much less left in the hand after the ‘squeeze test’
What do the effects look like?

Cavitated sample on the right uncavitated on the left – see reduced viscosity, thinner, less particles, freer flowing.
cavitation induced biomass disintegration reduces particle sizes, this increases surface areas of feedstocks and bioavailability for anaerobic digestion = extra biogas
Effects of cavitation – reduction in particle sizes

Same dry matter content, however particle sizes are redistributed

- Untreated Substrate
- Cavitated Substrate
cavitation induced biomass disintegration is powerful enough to breakdown lignocellulose to access cellular juices for biogas production

= ability to use high lignin feedstocks recalcitrant materials as feedstocks
Results of cavitation of straw = viable biogas feedstock

Biochemical Methane Potential (BMP) Test - STRAW

<table>
<thead>
<tr>
<th>Batch test results - STRAW</th>
<th>Untreated</th>
<th>Treated with cavitator</th>
<th>% change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Matter (%)</td>
<td>36.31</td>
<td>36.31</td>
<td>0% change</td>
</tr>
<tr>
<td>CH4 in biogas (%)</td>
<td>47.8</td>
<td>47.8</td>
<td>0% change</td>
</tr>
<tr>
<td>Length of test (days)</td>
<td>26</td>
<td>26</td>
<td>0% change</td>
</tr>
<tr>
<td>Methane per tonne of dry matter (m3)</td>
<td>195.9</td>
<td>287.4</td>
<td>68% increase</td>
</tr>
<tr>
<td>Biogas per tonne of dry matter (m3)</td>
<td>409.8</td>
<td>601.2</td>
<td>68% increase</td>
</tr>
</tbody>
</table>

methane percentage increase in cavitated sample = 68%
Results of cavitation of straw = viable biogas feedstock

Biochemical Methane Potential (BMP) results of straw treated with hydrodynamic cavitation

- Biogas per tonne of dry matter (m3)
- Methane per tonne of dry matter (m3)
- Length of test (days)
- CH4 in biogas (%)
- Dry Matter (%)

Treated with cavitator vs. Untreated

methane percentage increase in cavitated sample = up 68%
### Grass - Batch Test Results

<table>
<thead>
<tr>
<th></th>
<th>Untreated</th>
<th>Treated with Cavitator</th>
<th>% change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of test (27 Days)</td>
<td>27</td>
<td>27</td>
<td>0% change</td>
</tr>
<tr>
<td>Dry Matter (38.75%)</td>
<td>38.75</td>
<td>38.75</td>
<td>0% change</td>
</tr>
<tr>
<td>Ch4 in Biogas %</td>
<td>54.2</td>
<td>56.7</td>
<td>5% increase</td>
</tr>
<tr>
<td>H2S content (PPM)</td>
<td>518</td>
<td>211</td>
<td>59% reduction</td>
</tr>
<tr>
<td>Methane per tonne of DM (m3)</td>
<td>269.6</td>
<td>368</td>
<td>36% increase</td>
</tr>
<tr>
<td>Biogas per tonne of DM (m3)</td>
<td>497</td>
<td>643</td>
<td>29% increase</td>
</tr>
<tr>
<td>Biogas per tonne of Fresh matter (m3)</td>
<td>194</td>
<td>253</td>
<td>30% increase</td>
</tr>
</tbody>
</table>

- Methane in cavitated sample = 36% increase
- Hydrogen sulphide (H2S) in cavitated sample = 59% decrease
Cavitation of grass = viable biogas feedstock

Biochemical Methane Potential (BMP) results of grass treated with hydrodynamic cavitation

- Untreated
- Treated with cavitator

0% change
0% change
5% increase
59% decrease
29% increase
36% increase
30% increase

Graph showing the biochemical methane potential results of grass treated with hydrodynamic cavitation compared to untreated grass.
What can the CaviMax Biomass Disintegrator treat in the biogas plant?

- High lignin feedstocks – agricultural residues
- Secondary sewage sludges
- Food and drink production waste
- Floating layers
- Part digested substrate

The greatest biogas % increase is achieved through treating the recalcitrant materials that are indigestible, unusable and the energy usually wasted.
Where does it fit in?

CaviMax positioned mid-process – treating the floating layer

Draw off floating layer from the top of the digester pass through CaviMax to homogenise the substrate

Return cavitated substrate back to the bottom of the digester for further digestion which increases flow and bioavailability of the substrate

Access the energy of undigested feedstocks, turn a problem into a bonus of 15% extra biogas
Where does it fit in? CaviMax positioned to pre-treat high lignin feedstocks

Traditional feedstocks

High lignin feedstocks

Feed in system

CaviMax

Recirculate digestate to hydrate feedstock to create pumpable substrate

To secondary digester / end store

Unlock the potential of straw, grass, biosolids & secondary sludges
Where does it fit?
CaviMax positioned mid-process between digesters

The CaviMax in this position will reduce particle sizes of the substrate, providing increased plant efficiencies and biogas yield.

Ideal position to treat recalcitrant materials that did not get fully utilised in the primary digester – extract maximum value from your substrate.

Secondary sludges in waste water treatment / food and drink waste / undigested fractions of feedstocks
Features of controlled hydrodynamic cavitation

Process intensification technology
Breaks down lignocellulose
Deals with recalcitrant materials
Drastically reduces particle size of treated substance
Multiple treatment positioning, feedstock pre-treatment or mid process
Low maintenance simple design
Multiple machines can be used to reduce feedstock and manufacturing costs and treat effluent waste waters leaving the site – DOUBLE WIN
Can also be utilised for bio-diesel production and oil refining
A range of sizes available to suit your plant and requirements
Environmentally friendly, efficient and economical in its application
Benefits of cavitation for biogas plant operation

- Reduce feedstock costs or increase biogas production
- Ability to digest high lignin feed stocks – utilise straw
- Add value to secondary sludges and biosolids
- Decrease problematic floating layer – important when dealing with grass and straw (crust reduction in digester)
- Increased availability of cellular juices
- Acceleration of hydrolysis & the anaerobic digestion process
- Reduce retention time in digester
- Increased pumpability of substrate
- Reduced plant downtime due to blockages
- Reduction in $\text{H}_2\text{S}$ levels when using grass as feedstock
CaviMax containerised unit fitted out in factory
CaviMax factory fitout photos
CaviMax onsite photos
A CaviMax C150 Biomass Disintegrator treating a floating layer in a primary digester of a biogas plant with CHP and biomethane gas to grid plant in Scotland, current data is a 15% increase in biogas and reduced viscosity, there is visual improvement of the digestate
CaviMax service & callout

Time is money, our ethos is to minimise downtime, so we provide the following:-

• Full UK coverage service and maintenance division
• CaviMax service & maintenance plan
• Remote dial in problem identification worldwide
• Controls and sensors readily available in most countries worldwide, easily replaceable and automatically programmed once integrated into the CaviMax system
• Critical spares onsite with CaviMax
• Training provided for onsite maintenance team
• Camera and audio steam from CaviMax container to UK team to help guide the onsite team
Process intensification technology
- simply do more with less -

“Get more bang for your buck...FIT A CAVIMAX”
Send us a sample to cavitate or book The CaviLab, our laboratory scale test rig to see what process or BMP (Biochemical Methane Potential) uplift you can achieve with a CaviMax machine so we can calculate payback period.
CaviMax: Hydrodynamic Cavitation Technology

Suitable for all sectors: biogas production, biodiesel production, oil refining, extractions, wastewater treatment, food waste management (waste to energy) and energy efficiency in the agrofood industry

Variety of sized machine available to suit your requirements, we can provide a fully integrated containerised system, or we can work with your team to integrate the Rotocav Cavitator into your system

Save money and provide environmental benefit (through either using less materials, cleaning up your effluent or both) at the same time for maximum benefit

Please include Hydrodynamic Cavitation in your innovative technology evaluations
Team CaviMax have years of experience in planning, designing, building, operating, managing and maintaining biogas / biomethane plants, come discuss your plant with us to see how we can CaviMaximise your biogas production

Owen Yeatman – Director
Matt Powell - Director
Emma Greenwood – Business Development Manager

www.cavimax.co.uk

CaviMax are members of the World Biogas Association, ADBA - Anaerobic Digestion and Bioresources Association and the Circular Economy Club