Desai Zimmerman Fluidic Oscillator in Wastewater Aeration

For a full-scale continuously operating WWTP

Wastewater treatment accounts for approximately 1-2% of the total energy output in the UK , with aeration accounting for 50-75% of the energy costs involved in the system. Globally- 0.7-1% of total energy used for this sector in Europe ,3-5% in Asia, 3% in the US, 4-5% if agriculture is included , with demand increasing by 20% in a decade.Desai and Zimmerman have a novel no-moving part, no electrical part, fluidic device capable of energy efficient microbubble generation.

A simplified schematic of the aeration-basin is seen in Figure 1.

Figure 1 A blower is used to supply the gas. Typically, sparger basins seen below (in different combinations or types – typically EPDM rubber with membrane slits or ceramic spargers) are utilised to provide the aeration requirement. The proxy for measuring this aeration is termed as the mass transfer coefficient (MTC). The higher the MTC, the faster is the rate, and therefore the blower use (power) is reduced. The fluidic oscillator is introduced in between the blower (air-supply) and sparger basin, increasing the MTC, and therefore reducing the energy utilised. Different scales and sizes can be designed and implemented seen in picture on right.

The Desai-Zimmerman Fluidic Oscillator(DZFO) can be designed for various sizes, used as retrofit/newbuild and has been tested for several sites at different scales in the last 18months. Out of the several trials, an example is showcased here. An installation of the DZFO was led by Dr. Michael Hines , Chief Engineer , with project overview by Dr. Pratik Desai ,for Wessex Water, for a 2,400 m^3/h system. The test was carried out as part of Aqua Bulla (the water division of Perlemax, soon to be a separate entity). Figure 2 shows the installation taking place as well as the installed unit.

Figure 2 Installation of the DZFO on site- Retrofit installation as a valve in between blower and sparger to switch the gas.

There were two phases of the system. 1.Installation/Commissioning and 2. Operation over longer period of time by WW.

Appropriate frequency of a fluidic oscillator can get the smallest bubble size possible but even without any frequency tuning, the bubble size is smaller than conventional oscillation due to the change in bubble formation characteristics as seen in (3).

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1. **Installation and Commissioning :** Without any frequency optimisation, the installation and comissioning procedure carried out by Dr. Hines resulted in a 90% increase in MTC, corresponding to 43% reduction in blower power as seen in Figure 3. Another test carried out during the commissioning was that for the same conditions, nearly 81% increase in liquid influent could be treated, at 18% reduction in blower power. This is extremely interesting as in developing countries, new basin builds cost upwards of £3Mn, whereas doubling this capacity, negates the need for a new build (reducing concrete, material, CAPEX requirement, and significantly reducing OPEX). The ROI is immediate if this is considered.

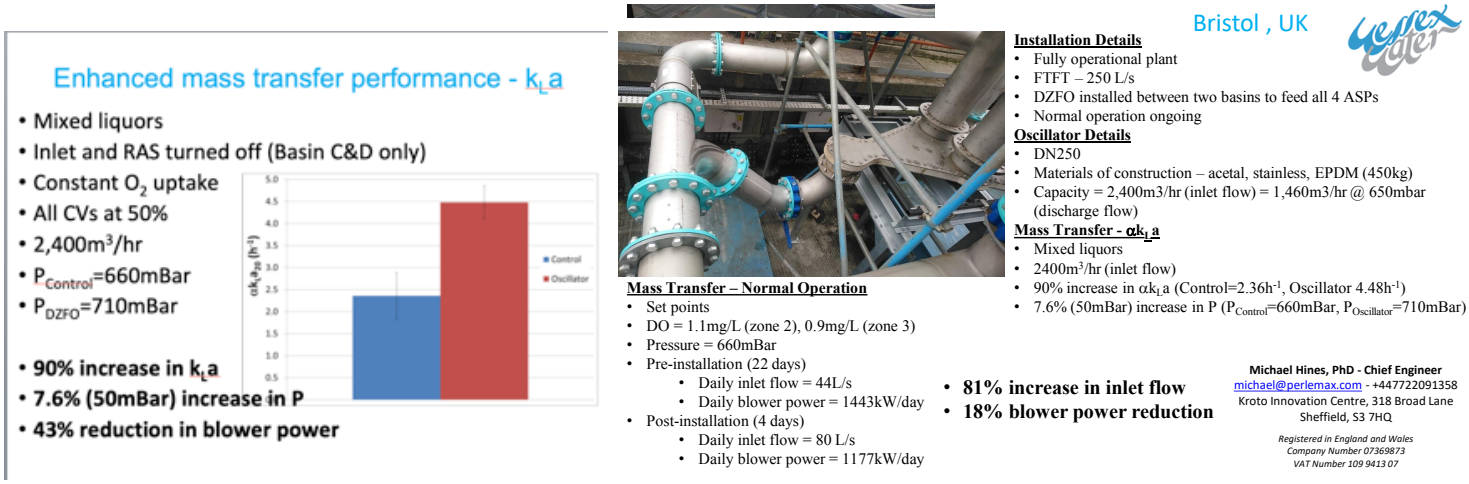

Figure 3 Installation and Commissioning performance by AquaBulla/Perlemax–Dr. Hines, on WW site. 90% increase in MTC corresponds to 43% reduction in blower power. Another test carried out during the commissioning was that for the same conditions, nearly 81% increase in liquid influent,> liquid-treated, at 18% reduction in blower power.

2. **Operation in a Running Treatment Plant over a longer period of time by Wessex Water :** A continuously operating plant can have several problems due to inappropriate instrumentation or problems with the site or operator. Whilst this is completely normal it is difficult to carry out proper R&D in a continuously operating system which is a distressed asset without significant site updates. The site had 8y old spargers. The site has been under continuous operation for the past 2.5y. There were some operational difficulties due to a reorganisation in the enduser company and some issues relating to the control system in place as well as higher flow and set point pressure used during the trial for the installation. MLSS, liquid influent, and other parameters would be different. Despite these issues, which would be considered suboptimal in many ways and fairly skewed against the installed DZFO system (this was not intentional on their part , it was during two re-orgnisations and site staff changes), **26%-38% reduction in blower power** was obtained!

For 2 series of months, September 2018 and January 2019, 15 day ON-OFF trials were conducted, with DZFO ON for 15 days and DZFO OFF for 15 days by the team at Wessex Water. They wanted to gather data to compare the performance at similar conditions (albeit for the January trial, due to significant increase in MLSS (2-3 fold increase), a different performance metric was obtained). This also showed a 30% performance improvement.

Below are examples for installations based on performance obtained – savings potential for various installations:

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Cost Reduction in terms of Operating Expenditure Reduction

Example below for new build installation:

DZFO System (New Build)	Coarse Bubble Aeration System	Fine Bubble Aeration System
Process Air 525 scfm	Process air 2,210 scfm	Process air 1,050 scfm
Unit Blower Size 1@60 HP	Unit blower size 2 @ 125 HP	Unit blower size 2 @ 60 HP
Blower Electrical 517 kWh/day	Blower electrical 2,050 kWh/day	Blower electrical 1,034 kWh/day
Annual aeration power cost …. $19,000/year @$0.10/kWh	Annual aeration power cost …. $75,000/year @ $0.10/kWh	Annual aeration power cost…. $38,000/year @ $0.10/kWh

Example of a Retrofit Installation:

Example Site Retrofit – Basin has Air Flow = 15,000m^3/hr

This would have associated Blower Power= 250kW

Annual Power Consumption = 2,190MW

Annual Electricity Cost for Operation = £219.22K

Assuming Electricity Cost = 10p/kWh

Blower reduction with DZFO installation= 30% - *cf.* trials such as Wessex Water

Yearly Savings with DZFO = 766.5MW = £73K

20y life results in approx.£1.4Mn in savings on electricity per installation of this size.

Other non-confidential trials or projects –Chile, Sweden (IVL), Vancouver / Denver-Colorado (MV and DC water) and Australia (Bribie Isl.)

Happy to discuss installation possibilities – please contact me at pratik@perlemax.com for more questions