Simulation of Transfer and Distribution of Thermally Hydrolyzed Sludge with AFT Fathom™

CASE STUDY

Thermally Hydrolyzed Sludge

Water & Wastewater Industry

Applied Flow Technology

Jacobs CH2M
Sacramento, California, USA
Platinum Pipe Award Honorable Mention - Use of software features and model creativity

Dan Robillard, a Mechanical Engineer with Jacobs CH2M, successfully used AFT Fathom™ to model and simulate the transfer and distribution of thermally hydrolyzed sludge (THS) to digesters at a San Francisco, California, USA area wastewater plant.

This project reflects an expansion where a thermal hydrolysis system and five digesters were being added on to the existing plant. The goal was to provide sizing calculations for the piping, pumps, and control valves for the digester feed and cooling system.

> "A key to proving the operation concept for this system was being able to model with three different non-Newtonian fluids"

AFT Fathom was successfully used to model a system which processes and combines two sludges: a thermally hydrolyzed sludge (THS) which was diluted before being combined with a digester sludge (DS). The sludges have different rheology but were all modeled as Power Law non-Newtonian fluids.

A key to proving the operation concept for this system was being able to model with three different non-Newtonian fluids, with one of them being regulated with flow control valves to ensure an even split between the four operating digesters (see Figure 1). Figure 2 shows a table of results of various scenarios.

Modeling the thermally hydrolyzed sludge (THS) loop:
THS from flash tanks is diluted with water to a total solids (TS) concentration of approximately 10% and then pumped to a THS loop and heated to a minimum temperature of 165°F (74°C). Variable-speed pumps adjust to maintain a flow rate between 120-130 gpm (27-30 m3/hr) in each section of pipeline between the THS take-off to each digester as well as between the THS feed point from the flash tanks. A flow meter measures the flow and maintains a velocity of 3 ft/s (1 m/s) to keep solids from settling out and prevent THS from solidifying in the pipeline.

Modeling the feed control for the digester units:
Each primary digester has a single feed line that branches off from the THS loop. A pneumatically operated flow control valve evenly divides the flow to each digester under normal operating conditions. One flow control valve is designated as the most open valve and remains at a designated percent open set point. The other flow control valves will adjust as needed to maintain their flow control set points while evenly distributing the flow.

Modeling the THS cooling system:
The digested sludge (DS) is conveyed from each digester using adjustable-speed cooling heat exchanger (HEX) pumps. DS is mixed with THS and then flow to a set of heat exchangers to cool the sludge mixture. As the incoming THS flow rate varies, the pumps vary their speed to maintain a set flow rate of 380 gpm (86 m3/hr) through the HEXs. See Detail in Figure 1.

AFT began incorporating non-Newtonian fluids into software products in the late 1990's, primarily due to a specific request from (formerly) CH2M Hill. We are proud to see these features come full-circle in case studies such as this. We are honored to contribute any way we can to help build city infrastructure around the world.

Jacobs CH2M provides a full spectrum of services including scientific, technical, professional, construction- and program-management for business, industrial, commercial, government and infrastructure sectors. They take on clients' most complex infrastructure and natural resource problems, creating new pathways for human progress. Partnering with governments, cities and businesses in more than 50 countries, they tap into deeply integrated capabilities across their organization to meet clients biggest challenges.

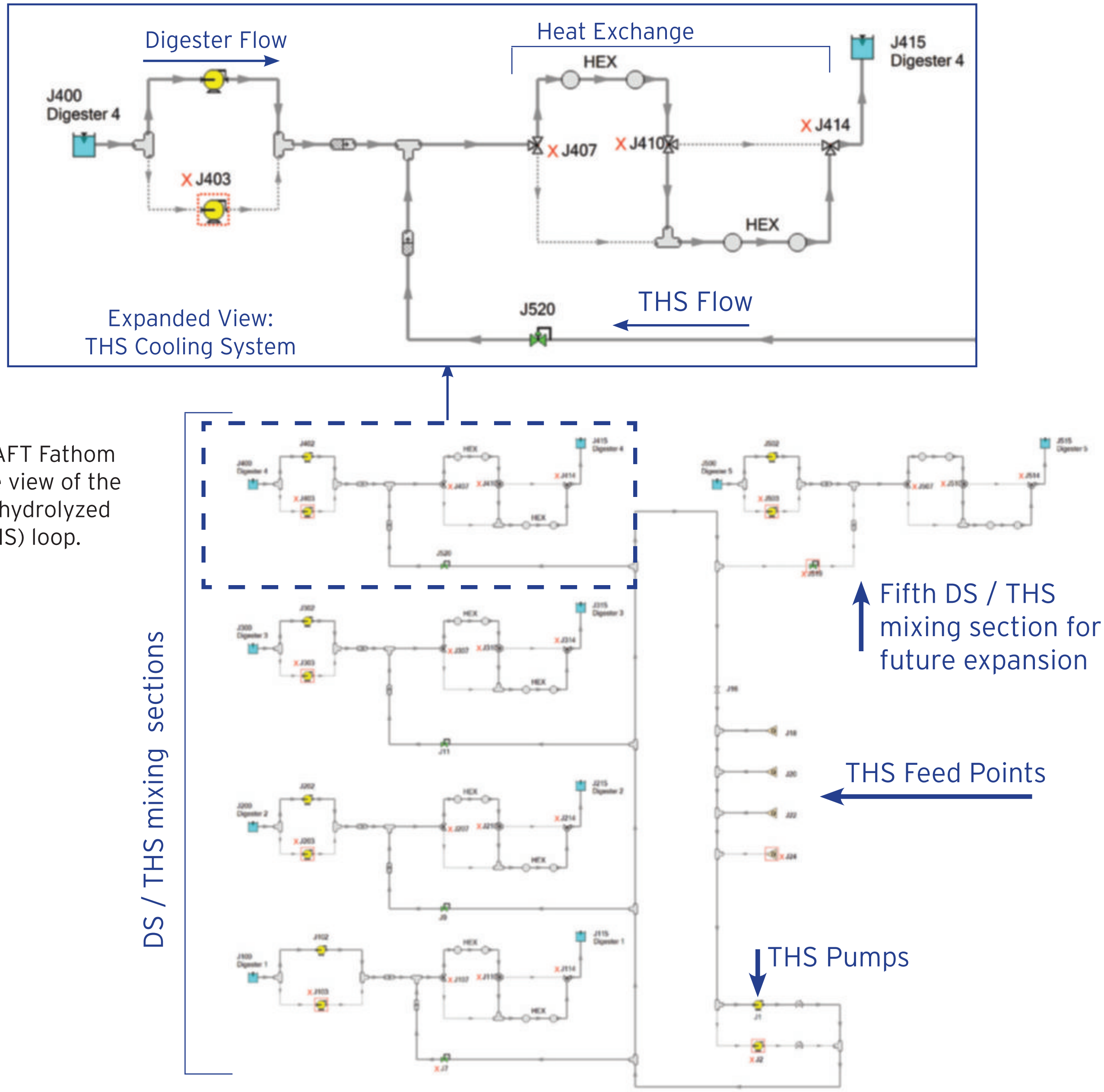

Figure 1 - AFT Fathom workspace view of the thermally hydrolyzed sludge (THS) loop.

	water | max THS feed			water | min THS feed			sludge | average flow conditions			sludge | max THS feed			sludge | min THS feed			sludge | min THS feed, no design factors		
	flow (gpm) / (m^3/hr)	TDH (ft/m)	speed % or % open	flow (gpm) / (m^3/hr)	TDH (ft) / (m)	speed % or % open	flow (gpm) / (m^3/hr)	TDH (ft/m)	speed % or % open	flow (gpm) / (m^3/hr)	TDH (ft/m)	speed % or % open	flow (gpm) / (m^3/hr)	TDH (ft/m)	speed % or % open	flow (gpm) / (m^3/hr)	TDH (ft/m)	speed % or % open
THS Loop Pump	460 / 104	6.3 / 1.9	51	275 / 62	3.7 / 1.1	40[a]	335 / 76	23 / 7.0	67	460 / 104	36 / 11.0	86	275 / 62	30 / 9.1	71	275 / 62	21 / 6.4	61
Digester 1																		
Pump	300 / 68	12.5 / 3.8	58	345 / 78	14.4 / 3.4	64	330 / 75	21 / 6.4	72	298 / 68	26 / 7.9	76	345 / 78	26 / 7.9	79	345 / 78	21 / 6.4	73
THS FCV	82 / 19		36	35 / 8		62	50 / 11		45	82 / 19		51	35 / 8		36	35 / 8		39
Digester 2																		
Pump	300 / 68	12 / 3.7	58	345 / 78	12.4 / 3.8	61	330 / 75	21 / 6.4	71	298 / 68	25 / 7.6	75	345 / 78	26 / 7.9	78	345 / 78	21 / 6.4	76
THS FCV	82 / 19		55	35 / 8		38	50 / 11		43	82 / 19		49	35 / 8		34	35 / 8		37
Digester 3																		
Pump	300 / 68	14.9 / 4.5	62	345 / 78	15.4 / 4.7	65	330 / 75	24 / 7.3	75	298 / 68	30 / 9.1	80	345 / 78	30 / 9.1	83	345 / 78	25 / 7.6	77
THS FCV	82 / 19		74	35 / 8		60	50 / 11		64	82 / 19		69	35 / 8		53	35 / 8		57
Digester 4																		
Pump	300 / 68	15.8 / 4.8	63	345 / 78	16.4 / 5.0	67	330 / 75	24 / 7.3	76	298 / 68	31 / 9.4	81	345 / 78	32 / 9.7	85	345 / 78	34 / 10.3	87
THS FCV	82 / 19		80	35 / 8		80	50 / 11		80	82 / 19		80	35 / 8		80	35 / 8		80

Figure 2 - Results summary of the digester sludge feed recirculation