

ESDU SPE-M8-1

Stirred vessel fouling tests – Sept. 08 update

Unamended
Issue 1 Oct 2008





CRUDE OIL FOULING RESEARCH

SUB-PROJECT E:

STIRRED VESSEL FOULING TESTS

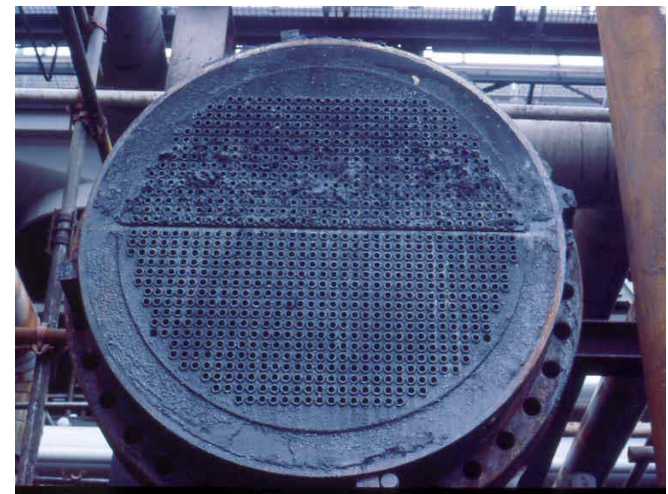
Prof Barry Crittenden - Principal Investigator,

Dr Mengyan Yang - Research Associate,

Andrew Young - PhD Student,

Ben Firth - Undergraduate Summer Placement Internee,

CROF Meeting - 25th September 2008



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Design and Development

Additional Variables Introduced :

- Agitator Diameter - 2 inverted cups (A & B)

A = 60mm ID, B = 38mm ID

Increase Re Number Range

- Surface Character - 3 fingers (A,B & C)

Comparable Adhesion Studies



A

170 hrs

$R_a \approx 20 \mu\text{m}$

Mild Steel EN3b



B

80 hrs

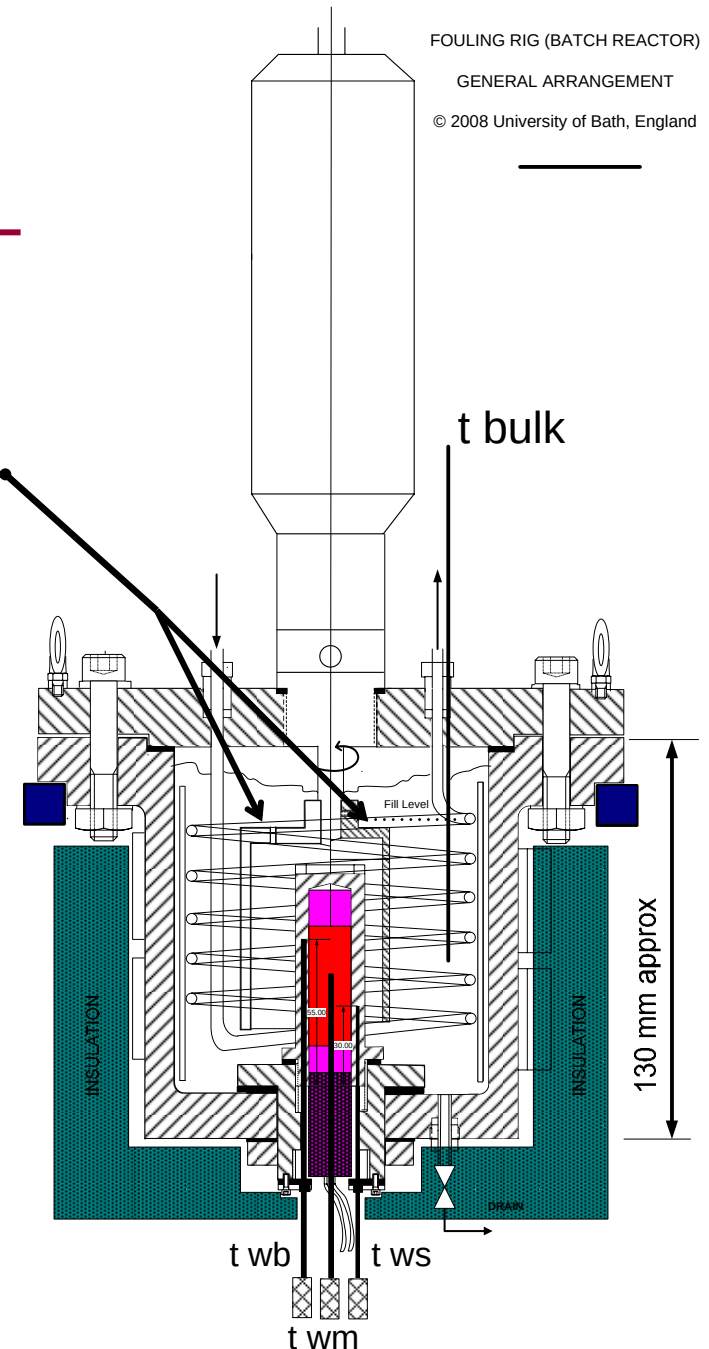


C & Heat X Tube

0 hrs

$R_a \approx 8 \mu\text{m}$

Mild Steel EN3b



NB Based on Paul Eaton's Patented Concept 1984

Significant Fouling History – Post 1st April 2008

Run # contd	Specimen	Date	Finger	Cup	Run	twb	Heat Flux	Power +/- 5	N +/-15	Fouling Rate	tbulk +/- 1	Note	
					Run hrs	°C	kW m ⁻²	Watts	Rpm	m ² K kJ ⁻¹ (*10 ⁻⁶)	°C hr ⁻¹	°C	
19	ExxonMobil	21st May	A	B	4	385	106	500	500	7.4	2.68	260	
20	ExxonMobil	21st May	A	B	1	404	116	550	500	13.8	5	260	i
-	WILSON PLOTS (paratherm)	10th June	A	B	30	350			100 - 2000			200	
21a,b,etc	ExxonMobil	June	B	B	18	various		various	various		none	260	
22	Petronas(DS)	24 June	B	B	4	309	63	300	600		none	240	
23		25 June	B	B	4	320	85	400	600		low	240	
24		26 June	B	B	4	330	106	500	600	2.7	1	240	ii
25a,b,etc	ExxonMobil	July	B	B	25	various		various	various		none	260	
26		21 July	B	B	6.6	327	106	500	300		none	150	
27		22 July	B	B	6	340	116	550	200		none	150	
28		23July	B	B	4	391	127	600	200		low	270	iii, iv
29	Petronas (B)	5 & 11 Aug	A	A	1+4	390	106	500	200	3.94	1.419	260	*N.F.
30		12	A	A	4	409	116	550	200	4.72	1.87	260	*N.F.
31		12	A	A	4	422	127	600	200	4.67	2.014	260	*N.F.
32		13	A	A	4	404	108	510	400	1.51	0.603	260	N.F.
33		13	A	A	4	413	116	550	400	-	-	260	N.F.

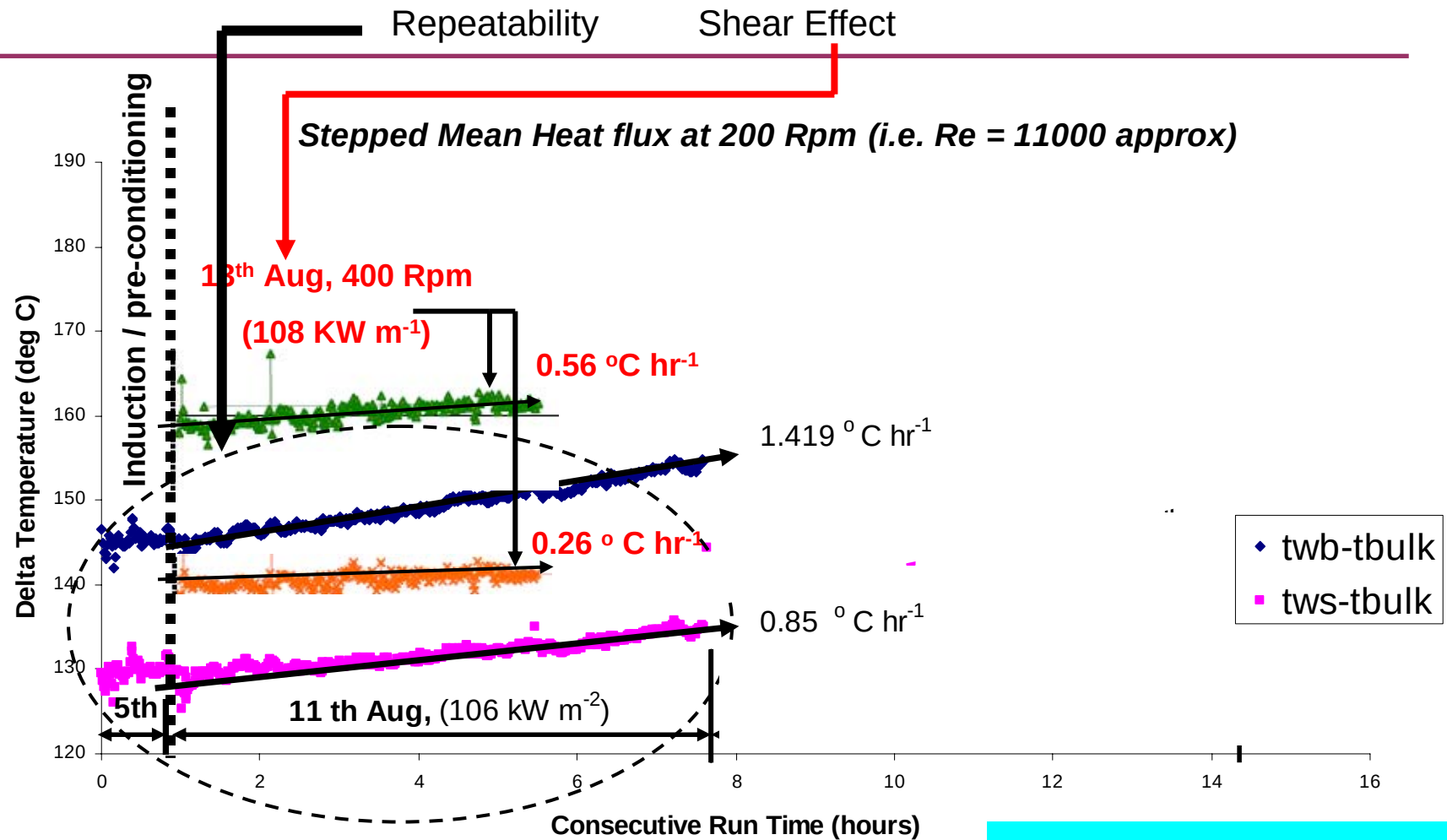
Preparation Procedure

Finger cleaned - Ethanol, Para-Xylene, Acetone – Brushed
 Pre Filtered samples - 25 micron mesh
 Sparged with air @ 10psi and test Rpm for 30mins
 Runs Usually Stepped
 Vessel Pressures 20 barg

Notes :

- i. TGA (2) analysis
- ii. Asymptotic Fouling observed
- iii. Finger Supplied to Imperial College
- iv. TGA (3) analysis
- * Repeat run of 25th Feb 2008
- N.F. Not Filtered

Typical Fouling Run - August 2008

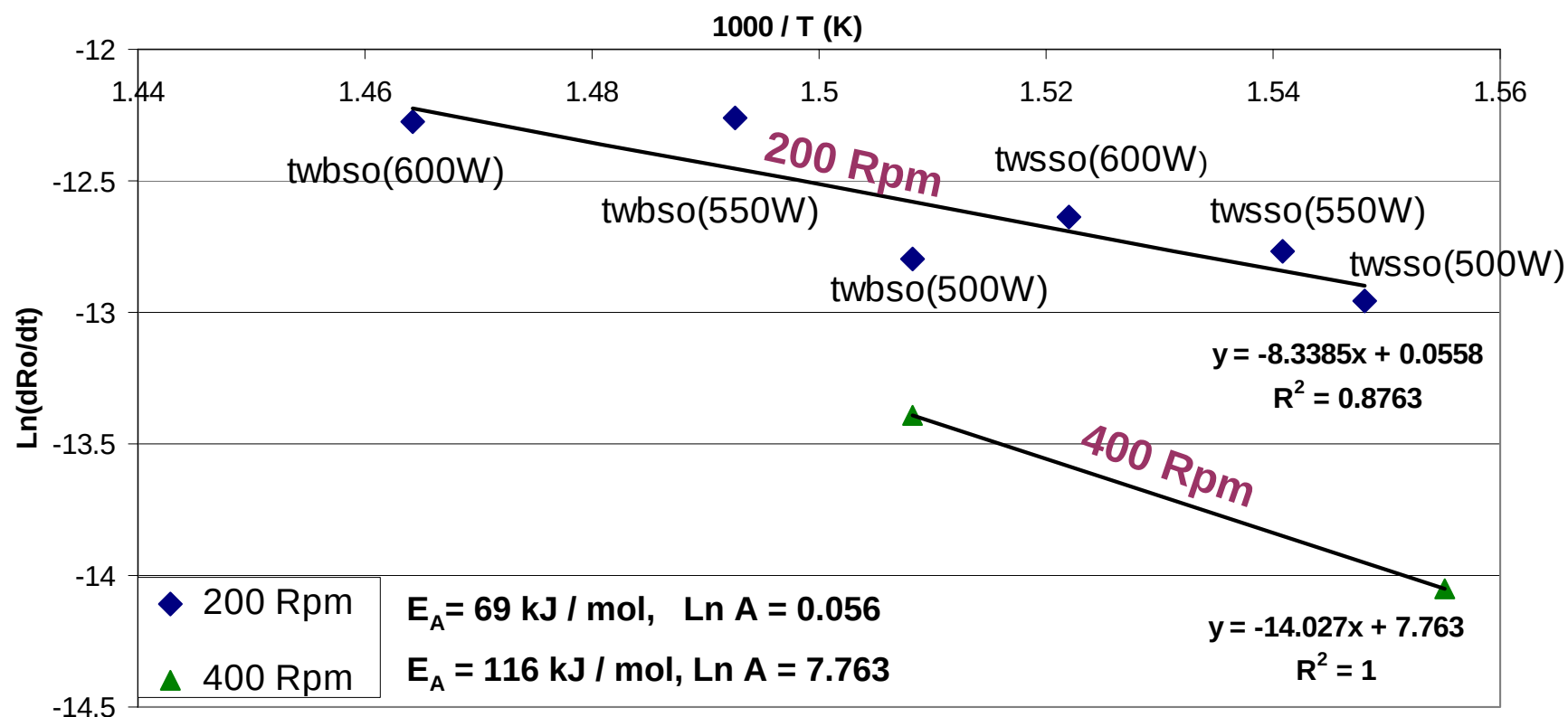


t bulk(Nominal) = 260 °C

Comparable Run to 26th Feb 2008 (within experimental error)

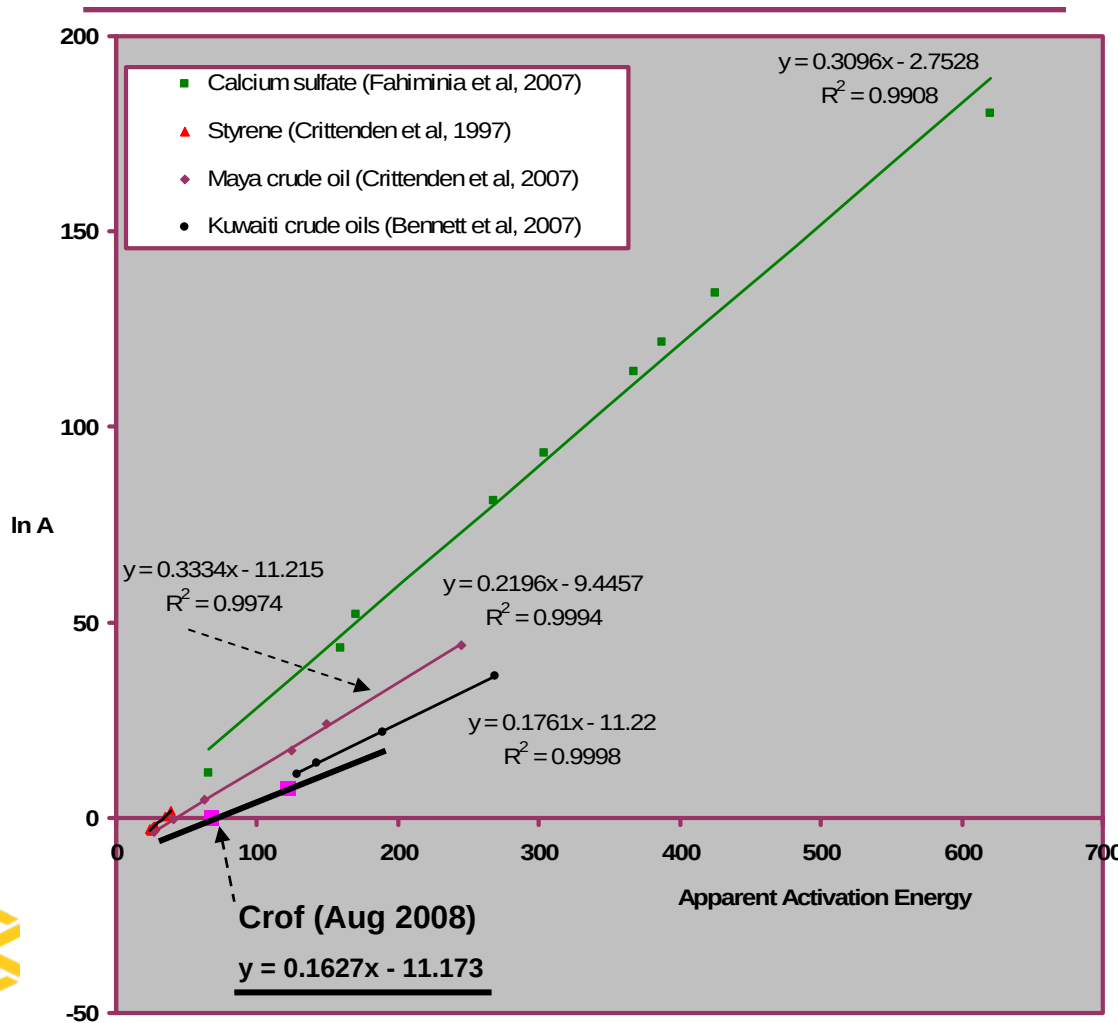
Reaction Analysis - Arrhenius Plots

Petronas (B) (August) - 200 & 400 Rpm



Reaction Analysis

COMPENSATION PLOTS



$$\ln A = aE_A + b$$

$$\left. \frac{dR_f}{dt} \right|_{t=0} = A \exp \left(-E_A / RT_{SO} \right)$$

$$\left. \frac{dR_f}{dt} \right|_{t=0} = \exp \left(E_A \left(a - \frac{1}{RT_{SO}} \right) + b \right)$$

Velocity-independent fouling

$$T_{SO} = \frac{1}{aR}$$

$T_{SO} = 96^\circ\text{C}$ for polystyrene deposition

$T_{SO} = 124^\circ\text{C}$ for CaSO_4 scaling

$T_{SO} = 287^\circ\text{C}$ for Maya crude oil fouling

$T_{SO} = 425^\circ\text{C}$ for Kuwaiti crude oil coking

isokinetic temperature = 407.5°C ,
Bennett et al, 2007

Collaboration with Chris Bennett of HTRI (AIChE, New Orleans)

Fouling Analysis

COMSOL Predicted Shear Stress v Fouling Rate
(Based on twb position constant surface temperature - 390°C)

