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The role of the particle size and distribution and its allied physical characteristics on the transportation of medium and dense phase slurries in South Africa

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APPENDIX C COMPUTER PROGRAMS

›grams included on the disc attached to the rear of this page.

›gram	Language	Description
gham	Basic	Establishes the Bingham flow constants, after an initial estimate from a least squares regression (Bingham fluid)
ld	Basic	Establishes the Yield Pseudoplastic flow constants, after an initial estimate from a least squares regression (Yield Pseudoplastic Fluid)
ilit1	Basic	Program utilised to store, recall and process pressure data collected during tests with the medium phase facility
ility	Basic	Flowrate estimations from the weigh tank utilised in the medium phase test facility
ction	Pascal IV	The "wasp" two phase program utilised for modelling the laminar and turbulent flow of settling and non-settling slurries. The settling characteristics utilises the average pipeflow viscosity (method 1 page 169)

APPENDIX D CALIBRATION OF SENSOR SYSTEMS

Table D.1 Determination of the viscosity of Caltex 15W40 oil using the MVP 1 sensor system

Temperature : 25°C Percentage stress : 45 %
Percentage strain : 25 % File Name : OL 1
Disc Name : Store 3

System Constants					First Principles	
S_D	S_T	Shear stress (Pa)	Strain rate (s^{-1})	Apparent viscosity (mPas)	Strain rate (s^{-1})	Apparent viscosity (mPas)
0,1	,055	7,96	25,0	318,7	24,9	319,6
0,2	,110	15,93	50,0	318,7	49,9	319,1
0,3	,160	23,18	75,0	309,1	75,0	308,7
0,4	,210	30,42	100,0	304,2	100,3	303,3
0,5	,254	36,80	125,0	294,4	125,5	293,0
0,6	,300	43,47	150,0	289,8	150,6	288,5
0,7	,342	49,55	175,0	283,1	175,5	282,2
0,8	,389	56,36	200,0	281,8	199,4	282,6
0,9	,440	63,75	225,0	283,3	225,0	283,2
1,0	,480	69,55	249,7	278,4	251,8	276,2

Table D.2 Determination of the viscosity of Caltex 15W40 oil using the MV 1 sensor system

Temperature : 25°C Percentage Stress : 70 %

Percentage Strain : 50 % File Name : R14

Disc Name : Store 3

System Constants					First Principles	
S_D	S_Γ	Shear stress (Pa)	Strain rate (s^{-1})	Apparent viscosity (mPas)	Strain rate (s^{-1})	Apparent viscosity (mPas)
0,1	0,080	18,03	58,5	308,2	58,5	308,1
0,2	0,158	35,61	117,0	304,3	117,0	304,3
0,3	0,237	53,41	175,5	304,3	175,4	304,5
0,4	0,316	71,22	234,0	304,3	233,9	304,4
0,5	0,394	88,80	292,5	303,6	292,5	303,7
0,6	0,473	106,61	351,0	303,7	350,6	304,0
0,7	0,553	124,64	409,5	304,3	409,1	304,6
0,8	0,632	142,45	468,0	304,3	467,6	307,6
0,9	0,712	160,48	526,5	304,8	526,1	305,0
0,99	0,790	178,06	178,06	304,6	584,2	304,7

System constants : Γ_w = ,3045 * S - ,0205 (Pa)

First principles : Γ_w = ,3047 * S - ,037 (Pa)

Table D.3 Determination of the viscosity of Caltex 15W40 oil using the MV 1 sensor system

Temperature : 25°C
Percentage stress : 45 %
M : 11,7
File Name : R15
Radii Ratio : 1,048
Percentage Strain : 25 %
A : 3,22
Disc Name : STORE 3

System Constants					First Principles	
S_D	S_Γ	Shear stress (Pa)	Strain rate (s^{-1})	Apparent viscosity (mPas)	Strain rate (s^{-1})	Apparent viscosity (mPas)
0,1	,063	9,12	29,2	312,0	29,2	312,0
0,2	,125	18,11	58,5	309,6	58,4	310,0
0,3	,193	27,96	87,7	318,6	87,5	319,4
0,4	,257	37,23	117,0	318,2	116,8	318,7
0,5	,325	47,09	146,2	322,0	146,1	322,1
0,6	,385	55,78	175,5	317,8	175,9	317,0
0,7	,445	64,48	204,7	314,9	202,5	313,6
0,8	,500	72,45	234,0	309,6	234,8	308,4
0,9	,560	81,14	263,2	308,2	264,0	307,3
0,99	,615	89,11	292,2	304,9	293,5	303,5

System constants Γ_w = ,3056 * S + 1,10 (Pa)
First principles Γ_w = ,3038 * S + 1,26 (Pa)

Table D.4 **Determination of the mix rotor calibration using Caltex 151V40 oil**

Temperature	:	25°C	Radii Ratio	:	1,118
Percentage stress	:	35 %	Percentage strain	:	25 %
M	:	5,22	A	:	3,743
File Name	:	R16	Disc Name	:	STORE 3

System Constants					First Principles	
S_0	S_f	Shear stress (Pa)	Strain rate (s^{-1})	Apparent viscosity (mPas)	Strain rate (s^{-1})	Apparent viscosity (mPas)
0,1	0,025	3,27	13,0	250,9	12,8	255,0
0,2	0,058	7,59	26,1	291,1	25,7	294,7
0,3	0,090	11,79	39,1	301,1	39,0	301,8
0,4	0,120	15,72	52,2	301,1	52,3	300,3
0,5	0,150	19,65	65,2	301,1	65,4	300,3
0,6	0,180	23,58	78,3	301,1	78,5	300,3
0,7	0,210	27,51	91,3	301,1	91,6	300,3
0,8	0,240	31,44	104,4	301,1	104,2	301,6
0,9	0,273	35,76	117,4	304,5	117,1	305,1
0,99	0,303	39,69	130,3	304,5	130,7	303,5

System constants : Γ_w = ,3057 * S - ,283 (Pa)

First principles : Γ_w = ,3057 * S - ,303 (Pa)

APPENDIX E TAILS 1 RHEOLOGICAL ANALYSIS

Table E.1 Tails 1 C_w = 60%

Temperature : 25°C Percentage Stress : 10 %
Percentage strain : 50 % File Name : WW1
Disc Name : STORE 6

System Constants					First Principles	
S_D	S_Γ	Shear stress (Pa)	Strain rate (s^{-1})	Apparent viscosity (mPas)	Strain rate (s^{-1})	Apparent viscosity (mPas)
,050	,200	7,48	13,0	573,6	17,4	430,0
,100	,240	8,98	26,1	344,1	34,0	263,9
,200	,295	11,04	52,2	211,5	66,2	166,6
,300	,335	12,53	78,3	160,1	95,7	130,8
,400	,374	13,99	104,4	134,0	122,7	114,0
,500	,410	15,34	130,5	117,5	155,2	98,8
,600	,436	16,31	156,6	104,2	184,4	88,4
,700	,468	17,51	182,7	95,8	209,2	83,7
,800	,495	18,52	208,8	88,7	237,1	78,1
,900	,525	19,65	234,9	83,6	260,1	75,5
,999	,555	20,77	260,7	79,6	286,8	72,4

Γ_w = ,0431 * S + 8,437 (Pa) R = ,9975
66 < S < 286 Γ_{crit} = 10,55 Pa
Γ_w = 4,903 + ,4237 * S + ,6362 (Pa) R = ,9993
17 < S < 286 Γ_{crit} = 6,13 Pa

Table E.2 Tails 1 C_w = 65%

Temperature : 25°C Percentage stress : 100 %

Percentage strain : 100 % File Name : WW2

Disc Name : STORE 6

System Constants					First Principles	
S_D	S_Γ	Shear stress (Pa)	Strain rate (s^{-1})	Apparent viscosity (mPas)	Strain rate (s^{-1})	Apparent viscosity (mPas)
,05	,091	34,06	26,1	1305,0	47,94	710,47
,10	,100	37,43	52,2	717,0	80,37	465,72
,20	,118	44,16	104,4	423,0	138,60	318,61
,30	,134	50,15	156,6	320,2	194,26	258,16
,40	,148	55,39	208,8	265,3	247,54	223,76
,50	,163	61,01	261,0	233,7	301,15	202,59
,60	,176	65,87	313,2	210,3	365,43	180,2
,70	,187	79,99	365,4	191,5	421,70	165,9
,80	,199	74,48	417,6	178,3	477,89	155,8
,90	,209	78,22	469,8	166,5	547,39	142,9

Γ_w = ,086 * S + 32,473 (Pa) R = ,985

138 < S < 610 Γ_{crit} = 40,6 Pa

Γ_w = 24,704 + ,532 * S + ,734 (Pa) R = ,998

47 < S < 610 Γ_{crit} = 30,88 (Pa)

Table E.3 Tails 1 C_w = 70%

Temperature (°C) : 25 Percentage stress (%) : 100

Percentage Strain (%) : 100

File Name : WW 4

Disc Name : STORE 6

System Constants					First Principles	
S_D	S_Γ	Shear stress (Pa)	Strain rate (s^{-1})	Apparent viscosity (mPas)	Strain rate (s^{-1})	Apparent viscosity (mPas)
,05	,353	132,12	26,1	5062,3	38,8	3404,1
,10	,406	151,96	52,2	2911,2	74,4	2040,2
,20	,480	179,66	104,4	1720,9	143,5	1251,2
,30	,530	198,37	156,6	1266,7	209,6	946,3
,40	,575	215,22	208,8	1030,7	269,7	797,8
,50	,614	229,82	261,0	880,5	331,7	692,7
,60	,650	243,29	313,2	776,8	394,0	617,3
,70	,682	255,27	365,4	698,6	462,2	552,2
,80	,710	265,75	417,6	636,3	524,4	506,7
,90	,738	276,23	469,8	587,9	581,9	474,6

Γ_w = ,217 * S + 153,81 (Pa)

209 < S < 581

R = ,9887

Γ_{crit} = 192,3 (Pa)

Γ_w = 76,732 + 9,786 * $S^{4,473}$ (Pa)

39 < S < 581

R = ,9999

Γ_{crit} = 95,91 (Pa)

Table E.4 Derived log 100 Γ_w vs C_v curves

S	A_3*	A_2	A_1	A_0
50	-1,5849E - 5	,002226	,005112	,6999
75	-6,4616E - 6	,001483	,01635	,8799
100	-2,0371E - 6	,0011319	,02121	,9999
150	3,1195E - 6	,0007186	,02639	1,1799
200	3,6145E - 6	,0006768	,02544	1,2999
250	2,7371E - 6	,0007476	,02249	1,3999
300	7,8984E - 6	,0003575	,02866	1,4799
350	-7,2922E - 7	,001021	,01521	1,5399
400	-2,1953E - 6	,0011319	,01197	1,5999

* Equations of the form $y = A(n)\ x^n + \ldots\ldots\ A(0)$

ble E.5 Derived values of log 100 Γ_w and Γ_w

v	Derived log(100Γ_w)								
	50	75	100	150	200	250	300	350	400
0	1,565	1,748	1,860	2,020	2,108	2,170	2,259	2,246	2,277
5	1,971	2,114	2,205	2,337	2,415	2,472	2,543	2,546	2,577
0	2,428	2,530	2,599	2,702	2,769	2,821	2,874	2,895	2,925
5	2,926	2,991	3,041	3,117	3,174	3,220	3,259	3,291	3,321
0	3,451	3,493	3,528	3,584	3,631	3,670	3,703	3,735	3,762
5	3,993	4,029	4,060	4,106	4,144	4,175	4,213	4,225	4,246
0	4,539	4,597	4,635	4,685	4,715	4,735	4,793	4,761	4,773
	Derived Γ_w (Pa)								
0	,367	,56	,725	1,047	1,283	1,481	1,816	1,764	1,895
5	,936	1,301	1,606	2,175	2,602	2,965	3,493	3,522	3,778
0	2,683	3,393	3,980	5,041	5,885	6,627	7,493	7,895	8,426
5	8,436	9,812	11,002	13,109	14,94	16,604	18,179	19,575	20,946
0	28,29	31,128	33,803	38,451	42,826	46,863	50,558	54,353	57,815
5	98,48	107,13	115,031	127,902	139,505	149,712	163,41	168,044	176,522
0	346,238	395,548	432,03	485,11	519,65	543,92	622,23	577,76	593,93

Table E.4 Derived log 100 Γ_w vs C_v curves

S	A_3*	A_2	A_1	A_0
50	-1,5849E - 5	,002226	,005112	,6999
75	-6,4616E - 6	,001483	,01635	,8799
100	-2,0371E - 6	,0011319	,02121	,9999
150	3,1195E - 6	,0007186	,02639	1,1799
200	3,6145E - 6	,0006768	,02544	1,2999
250	2,7371E - 6	,0007476	,02249	1,3999
300	7,8984E - 6	,0003575	,02866	1,4799
350	-7,2922E - 7	,001021	,01521	1,5399
400	-2,1953E - 6	,0011319	,01197	1,5999

* Equations of the form $y = A(n)\ x^n + \ldots\ldots\ A(0)$

e E.5 **Derived values of log 100 Γ_w and Γ_w**

Derived log(100Γ_w)								
50	75	100	150	200	250	300	350	400
1,565	1,748	1,860	2,020	2,108	2,170	2,259	2,246	2,277
1,971	2,114	2,205	2,337	2,415	2,472	2,543	2,546	2,577
2,428	2,530	2,599	2,702	2,769	2,821	2,874	2,895	2,925
2,926	2,991	3,041	3,117	3,174	3,220	3,259	3,291	3,321
3,451	3,493	3,528	3,584	3,631	3,670	3,703	3,735	3,762
3,993	4,029	4,060	4,106	4,144	4,175	4,213	4,225	4,246
4,539	4,597	4,635	4,685	4,715	4,735	4,793	4,761	4,773
Derived Γ_w (Pa)								
,367	,56	,725	1,047	1,283	1,481	1,816	1,764	1,895
,936	1,301	1,606	2,175	2,602	2,965	3,493	3,522	3,778
2,683	3,393	3,980	5,041	5,885	6,627	7,493	7,895	8,426
8,436	9,812	11,002	13,109	14,94	16,604	18,179	19,575	20,946
28,29	31,128	33,803	38,451	42,826	46,863	50,558	54,353	57,815
98,48	107,13	115,031	127,902	139,505	149,712	163,41	168,044	176,522
346,238	395,548	432,03	485,11	519,65	543,92	622,23	577,76	593,93

Table E.6 **Derived values of Γ_w for the original C_w values**

Γ_w (Pa)										
S (s^{-1})		50	75	100	150	200	250	300	350	400
C_v (%)	C_w (%)									
35,7	60	9,98	11,5	12,8	15,2	17,2	19,1	20,8	22,5	24,0
40,8	65	34,1	37,3	40,4	45,7	45,7	55,3	59,7	63,9	67,9
46,4	70	138,7	151,8	163,3	181,4	181,4	209,9		232,7	243,2

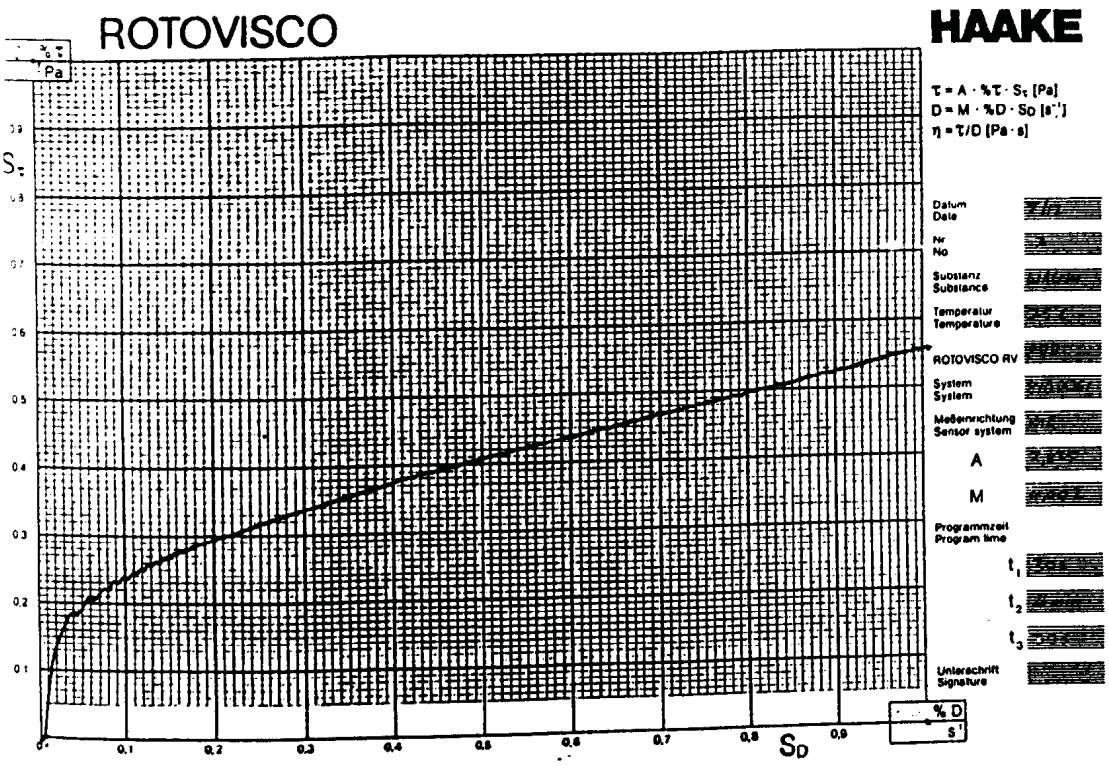


Figure E1 Tails 1 C_w = 60%

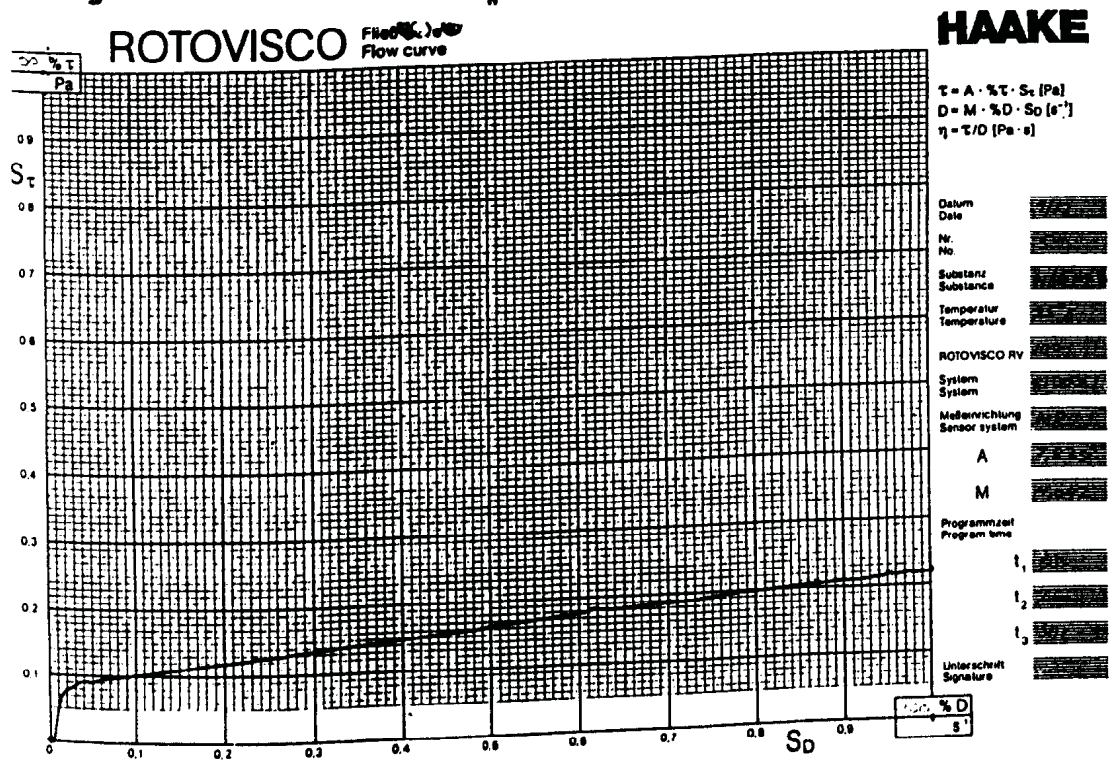


Figure E2 Tails 1 C_w = 65%

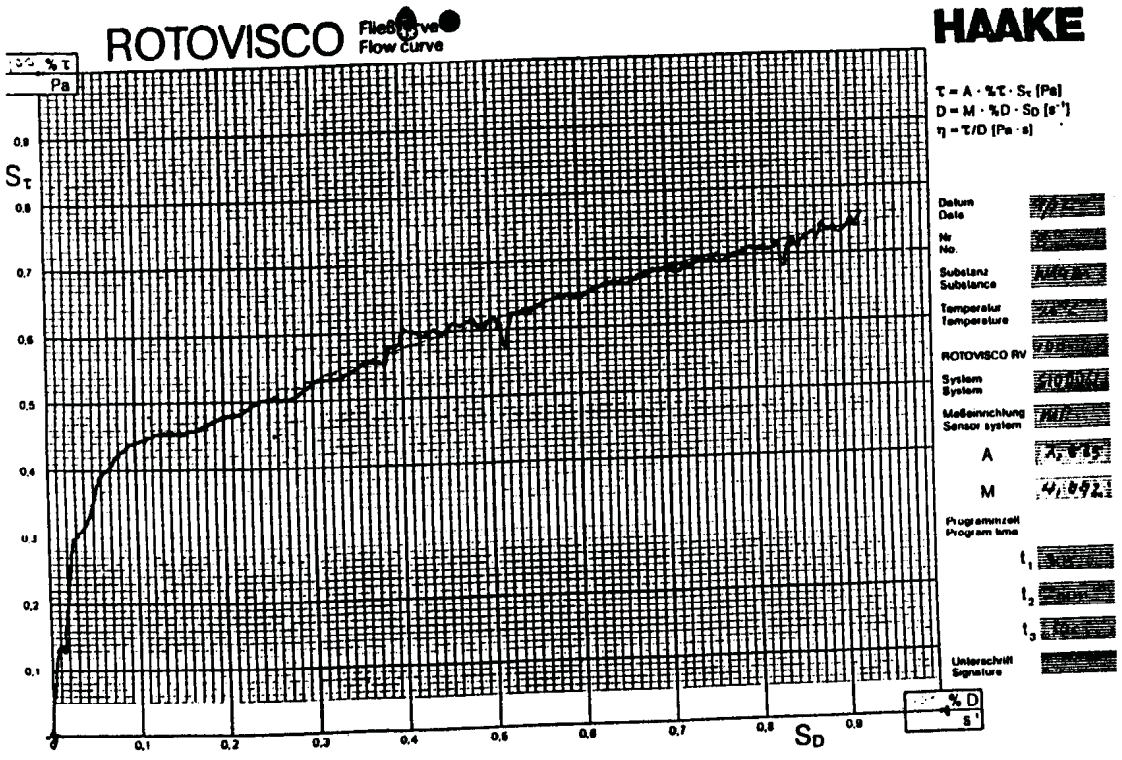


Figure E3 Tails 1 C_w = 70%

APPENDIX F TAILS 2 RHEOLOGICAL ANALYSIS

Table F1 Tails 2 C_w = 40%

Temperature (°C) : 24,75
Percentage Stress (%) : 3
Percentage Strain (%) : 50
File Name : WAGM 52
Disc Name : STORE 3

System Constants					First Principles	
S_D	S_Γ	Shear Stress	Strain Rate (s^{-1})	Apparent viscosity (mPas)	Strain Rate (s^{-1})	Apparent viscosity (mPas)
,05	,055	,61	13,0	47,3	16,9	36,4
,10	,067	,75	26,1	28,8	33,9	22,1
,15	,075	,84	39,1	21,5	47,8	17,5
,20	,085	,95	52,2	18,2	59,1	16,1
,25	,095	,06	65,2	16,3	70,4	15,1
,30	,108	1,21	78,3	15,4	86,6	13,9
,35	,113	1,26	91,3	13,8	99,4	12,7
,40	,127	1,42	104,4	13,6	110,1	12,9
,45	,134	1,50	117,4	12,8	133,5	11,2

Γ_w = 8,037E - 03 * S + ,484 (Pa) R = ,9889
16 < S < 133 Γ_{crit} = ,605
Γ_w = ,449 + ,0119 * S + ,924 (Pa) R = ,9946
16 < S < 133 Γ_{crit} = ,561

Table F2 Tails 2 C_w = 50%

Temperature (°C) : 24,5
Percentage Stress (%) : 3
Percentage Strain (%) : 50
File Name : WAGM 53
Disc Name : STORE 3

System Constants					First Principles	
S_D	S_Γ	Shear Stress (Pa)	Strain Rate (s^{-1})	Apparent viscosity (mPas)	Strain Rate (s^{-1})	Apparent viscosity (mPas)
,05	,150	1,68	13,0	129,0	15,9	105,3
,10	,190	2,13	26,1	81,7	31,2	68,2
,20	,250	2,80	52,2	53,7	60,5	46,3
,30	,300	3,36	78,3	43,0	90,6	37,1
,40	,335	3,76	104,4	36,0	121,6	30,9
,50	,370	4,15	130,5	31,8	149,7	27,7
,60	,400	4,49	156,6	28,6	178,8	25,1
,70	,430	4,82	182,7	26,4	201,6	23,9
,80	,465	5,22	208,8	25,0	228,0	22,8
,87	,485	5,44	227,0	23,9	252,7	21,5

Γ_w = ,0136 * S + 2,016 (Pa)
60 < S < 253
R = ,9962
Γ_{crit} = 2,59 Pa

Γ_w = ,730 + ,194 * $S^{,575}$ (Pa)
16 < S < 253
R = ,9994
Γ_{crit} = ,912 Pa

Table F3 **Tails 2 C_w = 60%**

Temperature (°C) : 25
Percentage Stress (%) : 8
Percentage Strain (%) : 50
File Name : WAGM 54
Disc Name : STORE 3

System Constants					First Principles	
S_D	S_Γ	Shear Stress (Pa)	Strain Rate (s^{-1})	Apparent viscosity (mPas)	Strain Rate (s^{-1})	Apparent viscosity (mPas)
,05	,260	7,78	13,0	596,5	18,3	424,7
,10	,305	9,13	26,1	349,9	34,1	267,4
,20	,382	11,43	52,2	219,1	64,7	176,7
,30	,437	13,08	78,3	167,1	96,3	135,7
,40	,482	14,43	104,4	138,2	125,6	114,8
,50	,526	15,75	130,5	120,6	156,2	100,8
,60	,560	16,76	156,6	107,0	184,7	90,7
,70	,600	17,96	182,7	98,3	213,0	84,3
,80	,630	18,86	208,8	90,3	245,2	76,9
,90	,663	19,85	234,9	84,5	257,9	76,9
1,00	,710	21,26	260,7	81,5	276,4	76,9

Γ_w = ,04237 * S + 9,01 (Pa) R = ,9884
64 < S < 276 Γ_{crit} = 11,26 Pa

Γ_w = 4,88 + ,485 * $S^{.617}$ (Pa) R = ,998
18 < S < 276 Γ_{crit} = 6,10 Pa

Table F4 Tails 2 C_w = 70%

Temperature (°C) : 25,25
Percentage Stress (%) : 80
Percentage Strain (%) : 50
File Name : WAGM 55
Disc Name : STORE 3

System Constants					First Principles	
S_D	S_Γ	Shear Stress (Pa)	Strain Rate (s^{-1})	Apparent viscosity (mPas)	Strain Rate (s^{-1})	Apparent viscosity (mPas)
,05	,410	122,8	13,0	9407,6	23,1	5298,2
,10	,453	135,6	26,1	5197,1	41,1	3293,2
,20	,525	157,2	52,2	3011,6	81,0	1950,0
,30	,556	166,5	78,3	2126,2	150,5	1103,3
,40	,573	171,6	104,4	1643,4	238,2	720,0
,50	,585	175,2	130,5	1342,3	270,2	648,2
,60	,600	179,7	156,5	1147,2	290,2	618,9
,70	,612	183,3	182,7	1003,0	335,2	546,7
,80	,624	186,9	208,8	894,8	342,5	545,5
,90	,638	191,0	234,9	813,2	398,1	479,8
1,00	,646	193,4	260,7	741,8		

Γ_w = ,1056 * S + 148,60 (Pa)
342 < S < 398
Γ_w = 0 + 79,46 * $S^{,144}$ (Pa)
23 < S < 398
Γ_w = 95,82 + 8,678 * $S^{,403}$
23 < S < 398

R = ,96
Γ_c = 0
R = ,9788
Γ_c = 119,7 Pa
R = ,9568
Γ_c = 119,7 Pa

Table F.5 Derived log 100 Γ_w vs C_v curves

S (s^{-1})	A_4	A_3	A_2	A_1	A_0
20		5,9916E-5	-,00375	,1295	,2980
50	1,0556E - 6	-7,516 E-5	,001767	,05093	,69999
75		2,6237E-5	-,001269	,07519	,8793
100		2,4905E-5	-,001169	,07115	,99935
150		2,3247E-5	-,001045	,06562	1,1797
200		2,276 E-5	-,001017	,0632	1,2999
250		1,944 E-5	-,0007699	,05703	1,3999

Table F.6 Derived values of log 100 Γ_w and Γ_w

Derived log (100 Γ_w)							
C_v (%)	20	50	75	100	150	200	250
20,0	1,867	1,992	2,085	2,153	2,260	2,339	2,388
25,0	2,217	2,315	2,375	2,436	2,530	2,599	2,648
30,0	2,423	2,643	2,701	2,754	2,835	2,895	2,942
35,0	2,805	3,008	3,081	3,125	3,192	3,241	3,286
40,0	3,312	3,456	3,535	3,568	3,620	3,657	3,693
45,0	3,991	4,049	4,083	4,103	4,134	4,158	4,178
50,0	4,887		4,745	4,747	4,754	4,762	4,756
Derived log Γ_w (Pa)							
20	,736	,983	1,217	1,425	1,820	2,183	2,443
25	1,342	2,067	2,376	2,732	3,390	3,980	4,448
30	2,665	4,403	5,026	5,677	6,846	7,854	8,756
35	6,392	10,199	12,059	13,346	15,595	17,454	19,333
40	20,541	28,601	34,329	37,056	41,716	45,429	49,365
45	98,08	112,095	121,33	126,86	136,413	144,038	150,894
50	771,79		557,089	559,08	576,64	578,63	571,02

Table F.7 **Derived values of Γ_w for the original C_w values**

Γ_w (Pa)								
S (s^{-1})		20	50	75	100	150	200	250
C_v (%)	C_w (%)							
19,3	40	,68	,87	1,12	1,31	1,68		
26,5	50	1,62	2,57	2,93	3,35	4,12	4,81	5,37
35,1	60	6,5	10,3	12,2	13,	15,7	17,6	19,5
45,6	70	123,3	137,5	144,8	150,7	161,0	169,3	176,2

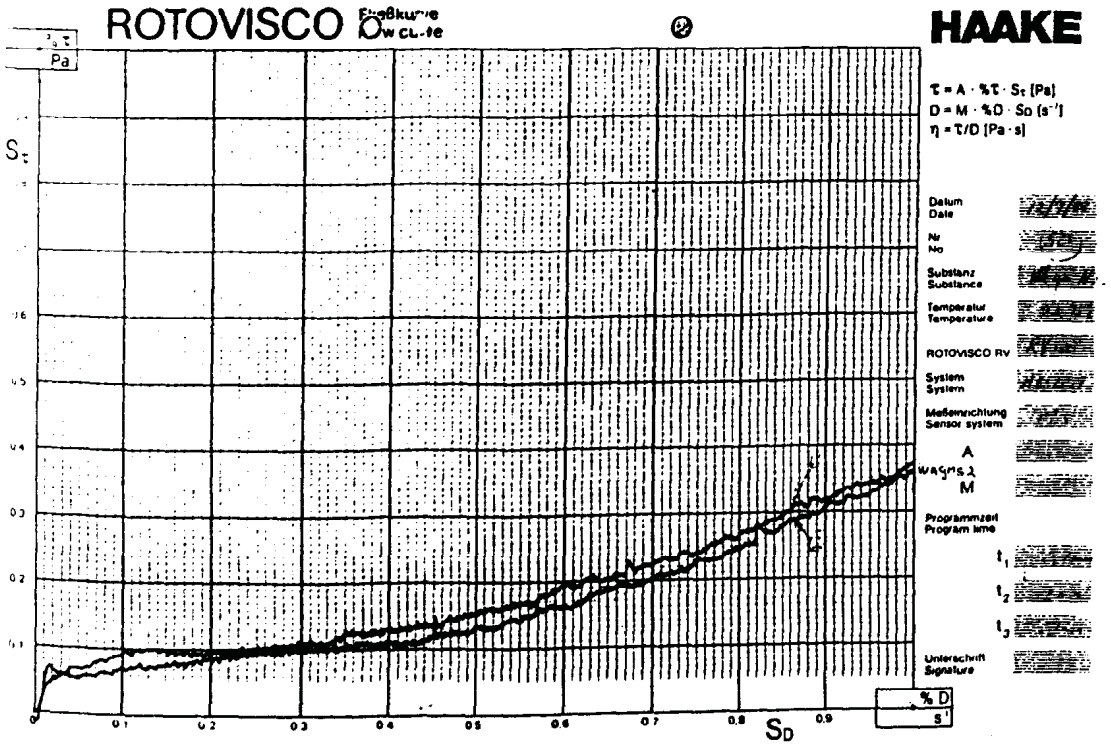


Figure F.1 Tails 2 C_w = 40%

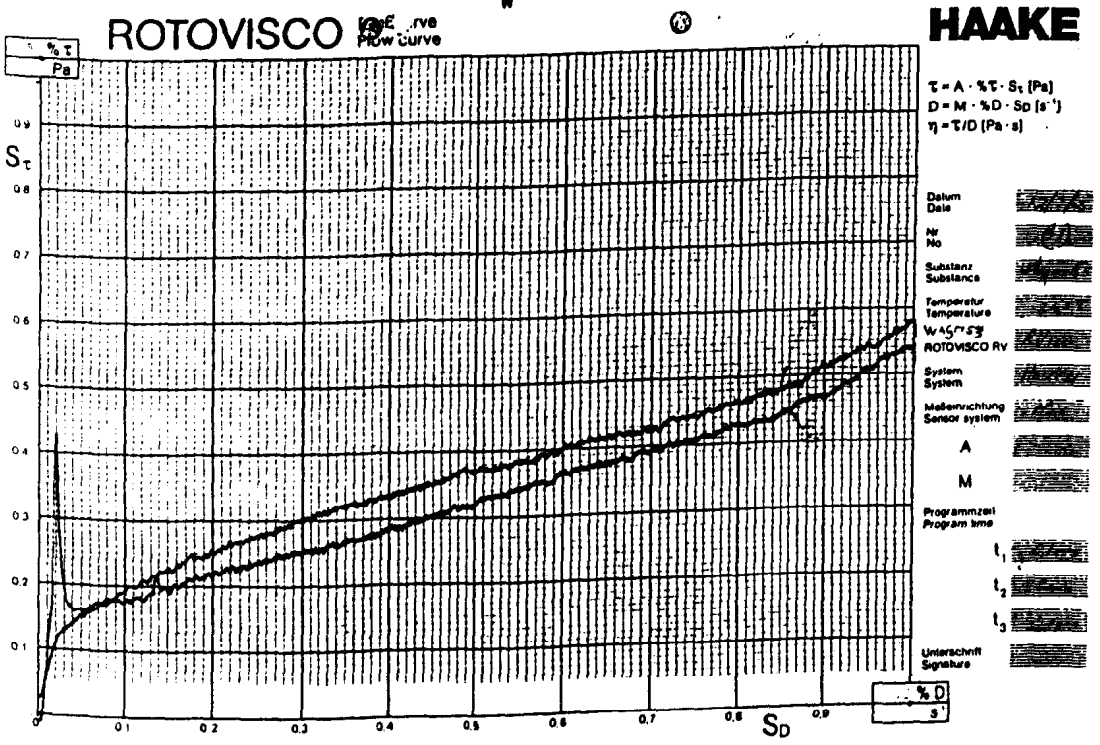


Figure F.2 Tails 2 C_w = 50%

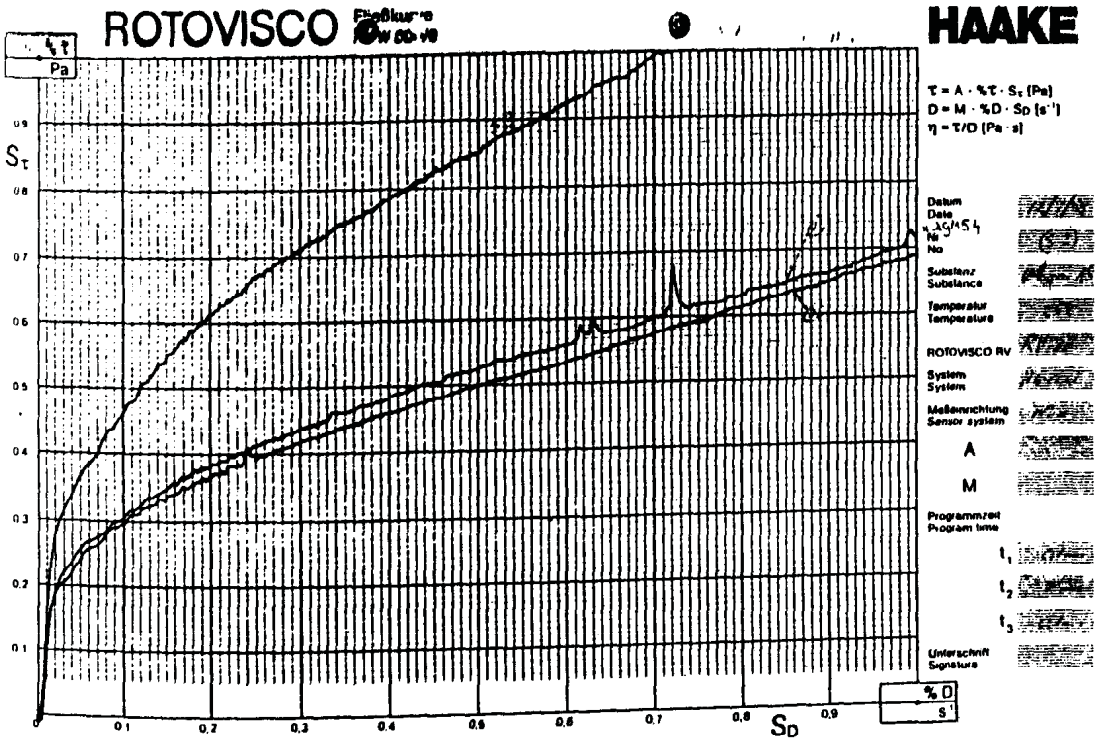


Figure F.3 Tails 2 C_w = 60%

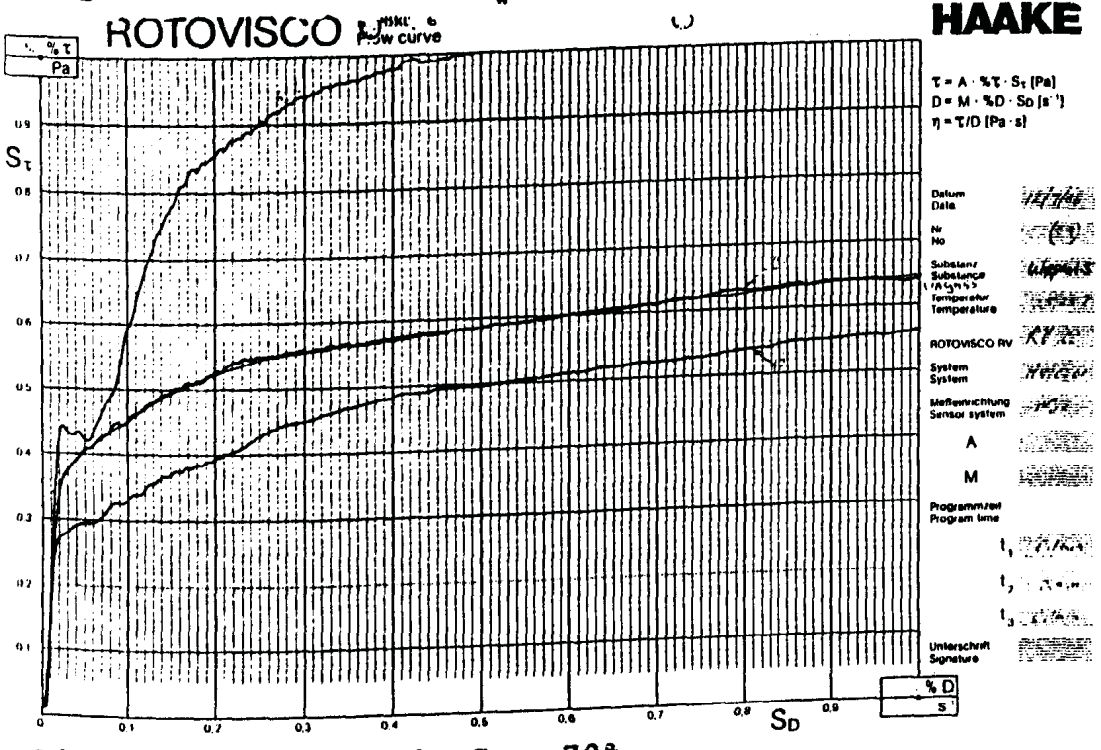


Figure F.4 Tails 2 C_w = 70%

APPENDIX G TAILS 3 RHEOLOGICAL ANALYSIS

Table G.1 Tails 3 C_w = 40%

Temperature (°C) : 25,25
Percentage Stress (%) : 3
Percentage Strain (%) : 50
File Name : R2
Disc Name : STORE 6

System Constants					First Principles	
S_D	S_Γ	Shear Stress (Pa)	Strain Rate (s^{-1})	Apparent viscosity (mPas)	Strain Rate (s^{-1})	Apparent viscosity (mPas)
,050	,043	,48	13,0	36,9	21,9	22,0
,100	,048	153	26,1	20,6	38,3	14,0
,150	,054	,60	39,1	15,4	51,5	11,7
,200	,058	,65	52,2	12,4	76,8	8,4
,250	,060	,67	65,2	10,3	85,0	7,9
,300	,065	,72	78,3	9,3	89,7	8,1

Γ_w = 3,102E - 03 * S + ,428 (Pa) R = ,927
21 < S < 89 Γ_c = ,53 Pa

Γ_w = ,393 + 6,0836E - 03 * $S^{,877}$ (Pa) R = ,980
21 < S < 89 Γ_c = ,49 Pa

Table G.2 Tails 3 C_w = 50%

Temperature (°C) :
Percentage Stress (%) : 3
Percentage Strain (%) : 50
File Name : RES 9
Disc Name : STORE 3

System Constants					First Principles	
S_D	S_Γ	Shear Stress (Pa)	Strain Rate (s^{-1})	Apparent viscosity (mPas)	Strain Rate (s^{-1})	Apparent viscosity (mPas)
,050	,072	,80	13,0	61,9	16,2	49,7
,100	,090	1,01	26,1	38,7	32,9	30,6
,150	,101	1,13	39,1	28,9	47,4	23,8
,200	,115	1,29	52,2	24,7	58,3	22,1
,250	,130	1,45	65,2	22,3	71,6	20,3
,300	,143	1,60	78,3	20,5	86,4	18,5
,350	,155	1,74	91,3	19,0	98,2	17,7
,400	,170	1,90	104,4	18,2	112,5	16,9
,450	,180	2,02	117,4	17,2	125,8	16,0
,500	,195	2,18	130,5	16,7	135,3	16,1

Γ_w = ,01139 * S + ,623 (Pa)
16 < S < 136
R = ,998
Γ_{crit} = ,779 Pa

Γ_w = ,6176 + ,0121 * $S^{.987}$ (Pa)
16 < S < 136
R = ,9985
Γ_{crit} = ,772 Pa

Table G.3 Tails 3 C_w = 60%

Temperature (°C) : 24,5
Percentage Stress (%) : 3
Percentage Strain (%) : 50
File Name : RES 10
Disc Name : STORE 3

System Constants					First Principles	
S_D	S_Γ	Shear Stress (Pa)	Strain Rate (s^{-1})	Apparent viscosity (mPas)	Strain Rate (s^{-1})	Apparent viscosity (mPas)
,050	,252	2,82	13,0	216,8	15,9	177,5
,100	,320	3,59	26,1	137,6	31,3	114,5
,200	,418	4,69	52,2	89,9	60,9	76,9
,300	,500	5,61	78,3	71,7	89,2	62,8
,400	,571	6,41	104,4	61,4	116,3	55,0
,500	,645	7,24	130,5	55,4	141,6	51,1
,600	,720	8,08	156,6	51,6	168,7	47,9
,700	,788	8,84	182,7	48,4	198,0	44,6
,800	,850	9,54	208,8	45,7	222,4	42,9
,900	,925	10,38	234,9	44,2	248,6	41,7
1,000	,985	11,06	260,7	42,4	280,4	39,4

Γ_w = ,0293 * S + 3,013 (Pa)
60 < S < 280
R = ,998
Γ_{crit} = 3,77 Pa

Γ_w = 1,808 + ,1249 * $S^{,763}$ (Pa)
15 < S < 280
R = ,9995
Γ_{crit} = 2,26 Pa

Table G.4 Tails 3 C_w = 70%

Temperature (°C) : 26

Percentage Stress (%) : 40

Percentage Strain (%) : 50

File Name : RES 11

Disc Name : STORE 3

System Constants					First Principles	
S_D	S_T	Shear Stress (Pa)	Strain Rate (s^{-1})	Apparent viscosity (mPas)	Strain Rate (s^{-1})	Apparent viscosity (mPas)
,10	,405	60,63	26,1	2323,2	40,5	1494,0
,20	,460	68,87	52,2	1319,3	76,8	895,9
,30	,508	76,05	78,3	971,3	103,3	736,0
,40	,555	83,09	104,4	795,9	131,7	630,8
,50	,595	89,08	130,5	682,6	158,4	562,1
,60	,640	95,82	156,6	611,8	184,0	520,7
,70	,680	101,80	182,7	557,2	220,2	462,3
,80	,710	106,30	208,8	509,1	260,6	407,8
,90	,737	110,34	234,9	469,7	278,6	395,9
1,00	,773	115,73	260,7	443,8	296,2	390,7

Γ_w = ,2081 * S + 54,337 (Pa) R = ,9889

76 < S < 296 Γ_{crit} = 67,92 Pa

Γ_w = 45,96 + ,7863 * $S^{,7870}$ (Pa) R = ,996

40 < S < 296 Γ_{crit} = 57,45 Pa

Table G.5 Derived log 100 Γ_w vs C_v curves

S (s^{-1})	A_4	A_3	A_2	A_1	A_0
20		5,6616E-5	-,00352	,11299	,2999
50		4,2616E-5	-,00237	,08275	,6999
75		3,831 E-5	-,002038	,07359	,8799
100		3,6822E-5	-,001936	,07032	,9999
150		3,5772E-5	-,001878	,06735	1,1799
200		3,6186E-5	-,001938	,06775	1,2999
250		3,7096E-5	-,002026	,06868	1,3999
300		3,8202E-5	-,002129	,07014	1,4799

Table G.6 **Derived values of log 100 Γ_w and Γ_w**

Derived log 100 Γ_w								
C_v	20	50	75	100	150	200	250	300
25	1,809	1,953	2,044	2,123	2,248			
30	2,050	2,200	2,287	2,361	2,476			
35	2,369	2,520	2,601	2,668	2,77	2,848	2,912	2,964
40	2,81	2,9450	3,014	3,071	3,158	3,225	3,279	3,324
45	3,415	3,507	3,555	3,599	3,667	3,721	3,768	3,806
Derived Γ_w (Pa)								
25	,644	0,897	1,107	1,328	1,773			
30	1,122	1,585	1,939	2,297	2,992			
35	2,344	3,311	3,995	4,658	5,892	7,056	8,172	9,219
40	6,47	8,817	10,34	11,795	14,404	16,788	19,038	21,087
45	26,036	32,194	35,933	39,747	46,496	52,68	58,643	63,992

Table G.7 **Derived values of Γ_w for the original C_w values**

Γ_w (Pa)								
S (s^{-1})		20	50	75	100	150	200	250	300
C_v (%)	C_w (%)								
20,4	40	,42	,58	,72	,87				
27,4	50	,86	1,20	1,48	1,76	2,32			
36,5	60	3,07	4,32	5,17	6,00	7,51	8,92	10,3	11,
47,2	70	55,5	64,1	69,4	75,5	86,4	96,7	106,9	116,

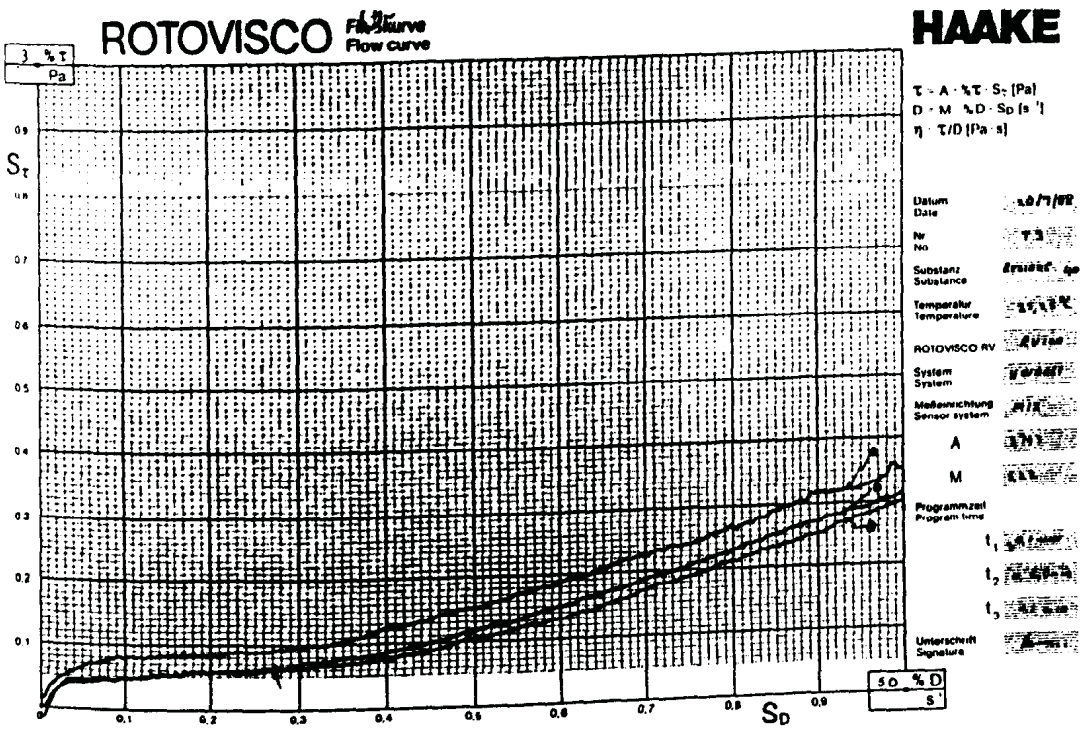


Figure G.1 Tails 3 C_w = 40%

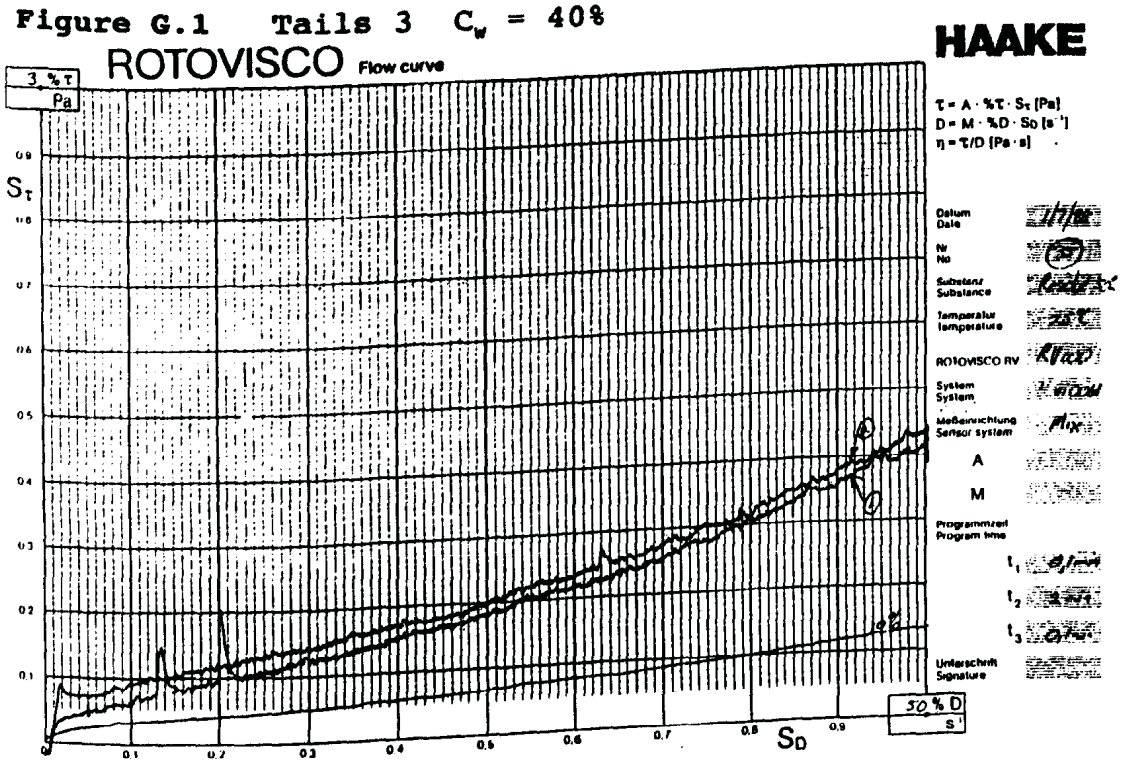


Figure G.2 Tails 3 C_w = 50%

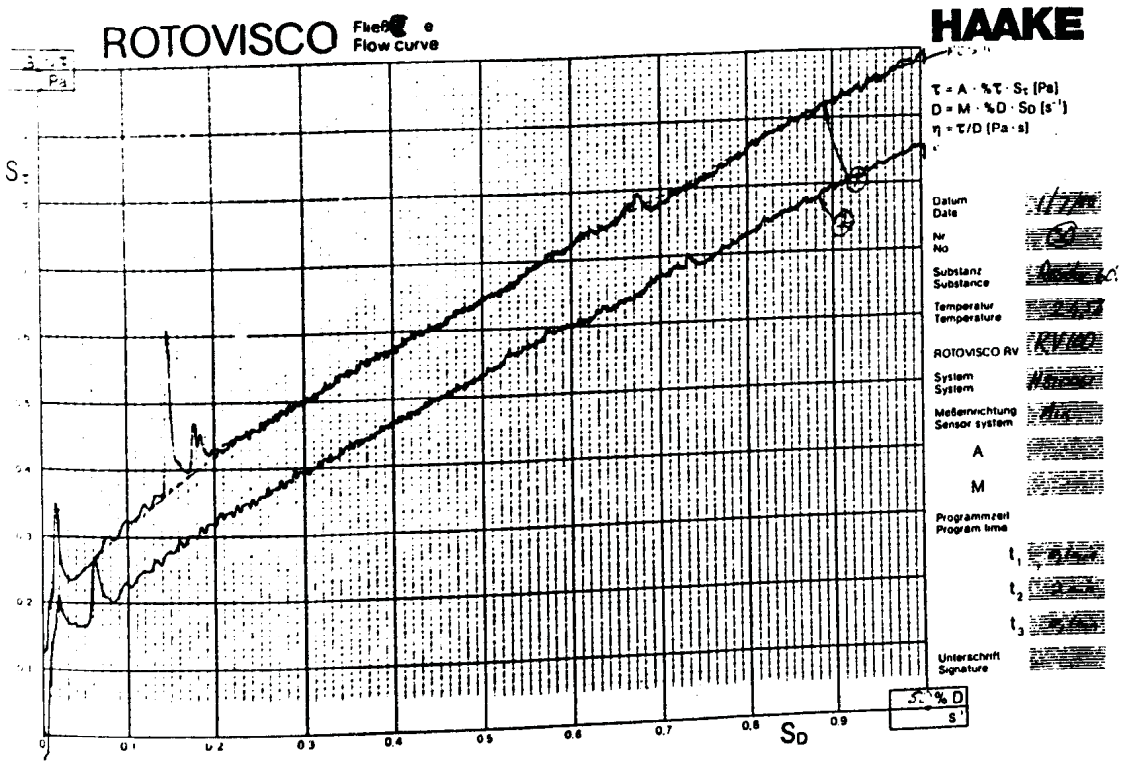


Figure G.3 Tails 3 C_w = 60%

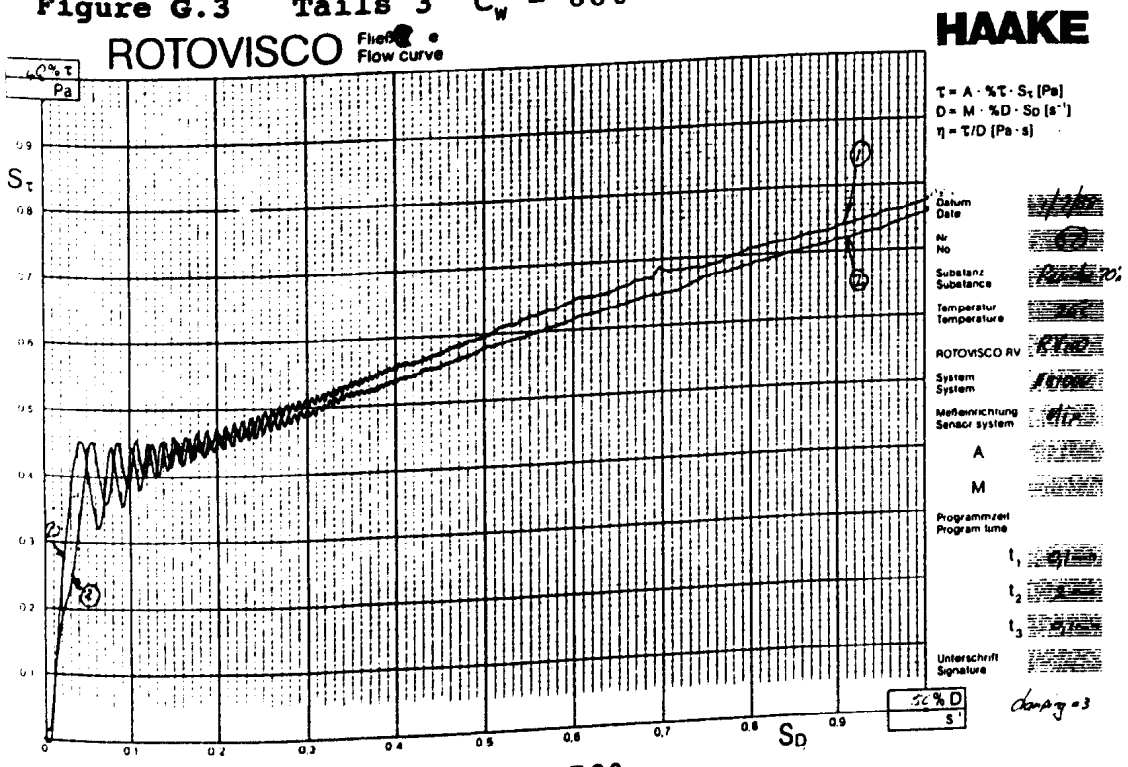


Figure G.4 Tails 3 C_w = 70%

APPENDIX H TAILS 4 RHEOLOGICAL ANALYSIS

Table H.1 Tails 4 C_w = 40%

Temperature (°C) : 25,25
Percentage Stress (%) : 3
Percentage Strain (%) : 50
File Name : DOO 2
Disc Name : STORE 3

System Constants					First Principles	
S_D	S_Γ	Shear Stress (Pa)	Strain Rate (s^{-1})	Apparent viscosity (mPas)	Strain Rate (s^{-1})	Apparent viscosity (mPas)
,50	,075	,84	13,0	64,5	16,7	50,3
,100	,092	1,03	26,1	39,5	32,2	32,0
,150	,108	1,21	39,1	30,9	45,7	26,5
,20	,122	1,36	52,2	26,2	62,1	22,0
,25	,131	1,47	65,2	22,5	77,8	18,8
,30	,142	1,59	78,3	20,3	90,6	17,5
,35	,151	1,69	91,3	18,5	106,1	15,9
,40	,160	1,79	104,4	17,2	117,7	15,2
,45	,170	1,90	117,4	16,2	129,4	14,7
,50	,180	2,02	130,5	15,4	143,0	14,1

Γ_w = 8,953E - 03 * S + ,759 (Pa)
16 < S < 143
R = ,991
Γ_{crit} = ,949 Pa

Γ_w = ,4716 + ,0582 * $S^{,658}$ (Pa)
16 < S < 143
R = ,998
Γ_{crit} = ,589 Pa

Table H.2 Tails 4 C_w = 40%

Temperature (°C) : 25,25
Percentage Stress (%) : 3
Percentage Strain (%) : 50
File Name : DOO 6
Disc Name : STORE 3

System Constants					First Principles	
S_D	S_Γ	Shear Stress (Pa)	Strain Rate (s^{-1})	Apparent viscosity (mPas)	Strain Rate (s^{-1})	Apparent viscosity (mPas)
,10	,300	3,36	26,1	129,0	32,2	104,3
,20	,377	4,23	52,2	81,0	62,0	68,1
,30	,455	5,10	78,3	65,2	88,3	57,8
,40	,523	5,87	104,4	56,2	115,9	50,6
,50	,590	6,62	130,5	50,7	142,4	46,5
,60	,655	7,35	156,6	46,9	170,0	43,2
,70	,715	8,02	182,7	43,9	197,5	40,6
,80	,775	8,70	208,8	41,6	224,5	38,7
,90	,832	9,34	234,9	39,7	251,2	37,1
1,00	,890	9,99	260,7	38,3	277,1	36,0

Γ_w = ,0257 * S + 2,911 (Pa)
32 < S < 277
R = ,9991
Γ_{crit} = 3,64 Pa

Γ_w = 2,111 + ,0629 * $S^{.8597}$ (Pa)
32 < S < 277
R = ,9995
Γ_{crit} = 2,63 Pa