

*RESULTS OF  
DIFFERENT GLASS SERVICE GFM TOOLS  
FOR SEED COUNT FORECASTS*

*Part 3*

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## *Introduction*    **The use of numerical tank models in the industry**

**Numerical tank models can help the industry in different ways**

*Monitoring temperatures not shown by thermocouples*

*Showing melts movement in the tank with critical pathes*

**All that helps to understand the tank and optimise him  
but: only rather coarse details can be seen and some  
„fantasy“ or precognition is necessary**

**However.. the ultimate goal of simulations are**

**reliable quality forecasts**

**... and one of the main issues here are bubbles**

*History*

## **Investigated cases with different seed count**

**RRT5 TC21**

**2 cases with different seed counts**








**TV-panel tank (no longer existing)**

**Good documentation**


**Input values for chemical fining available**

## Results of quality forecasts at part 2 with the *GS GFM*

### Time-temperature analysis

		2004 2.2 BI/t	2002 3.2 BI/t	
<i>Temp. [oC]</i> (Melt)	min Temp.	1275	1290	
	av. Temp.	1390	1402	
<i>Time [ h ]:</i>	min RT	5.03	3.98	
<i>Quality No.</i> „[ h ]+[oC]“	min MID	1.58	1.45 $10^6$	
	av. MID	15	18 $10^6$	
<i>Bubble Growth</i> [ mm x RT ]	min BG	22	25	
	av. BG	261	417	

### Physical „fining“

[ % ] Bubbles (large <0.4mm) in throat	7.4	9.2	
[ % ] Bubbles (small >0.4mm) in throat	57.0	54.6	

# Results of quality forecasts with the *GS GFM*

## *Fining simulation tools Part 2*

2004 2.2 Bl/t

2002 3.2 Bl/t

### 1) *Bubble growth (modified)*

[ %] *Func1* Bubbles in throat

[ %] *Func2* Bubbles in throat

2.8

3.6

13.3

18.7



### 2) *Bubble tracer – redox*

[ %] Bubbles in throat

[ %] *30% less CO2*

3.12

7.98

10.22

12.06



### 3) *Bubble tracer + redox*

[ %] Bubbles in throat

[mm] Largest Ø in thr.

0.19

1.14

0.5

0.7



# BUT

- **The bubble growth function has to be lowered considerably**
- **At the redox simulations much lower diffusion values have to be used**

## New simulations with GS Gfm V 4.19

**Two important changes in the newest release of GS.GFM are :**

- **a further enhanced forced bubbling model**

>> *Looking for the differences in temperature and time-temperature history*

- **a new bubble growth model**

>> *Using the new model at the updated cases*

In this presentation we concentrate on the bubble growth method

# Results of updated simulations: Differences bottom temperature model - tank

old	2002	-10	4	17	10	-11	8	26		6	10
	GFM 4.17										
	2004	23	15	9	4	-14	-6	9		6	9

new	2002	-13	1	11	4	-15	4	22		2	9
	GFM 4.18										
	2004	21	13	6	-3	-19	-11	3		1	11

The temperature distribution with the new forced bubbling model

is **similar** to the older calculations

**without any assumptions about the correction factor**








# New results of quality forecasts with the *GS GFM* *Part 3*


## Time-temperature analysis

2004 2.2 Bl/t

2002 3.2 Bl/t

<i>Time [ h ]:</i>	<b>min RT</b>	<b>6.17</b>	<b>4.43</b>	
<i>Temp. [oC]</i> (Melt)	<b>min Temp.</b>	<b>1275</b>	<b>1285</b>	
	<b>av. Temp.</b>	<b>1387</b>	<b>1400</b>	
<i>Quality No.</i> „[ h ]+[oC]“	<b>min MID</b>	<b>1.87</b>	<b>1.60</b>	$10^6$ 
	<b>av. MID</b>	<b>15</b>	<b>18</b>	$10^6$ 

## Physical „fining“

[ % ] <b>Bubbles (D 0.4mm) in throat</b>	<b>5.0</b>	<b>5.7</b>	
[ % ] <b>Bubbles (D 0.2mm) in throat</b>	<b>55</b>	<b>52</b>	

## Changes of the bubble growth model

*Many small blisters in container glass indicates that there are cold paths, without any gas exchange*

**GFM can show that too ... by the following modifications**

- **New measurements for flint and green glass with more realistic sulfate concentrations**
- **Linear extrapolation of measurement towards lower temperatures**
- **Introducing a lower limit for the bubble growth**

## Results with the modified bubble growth model

### Quality numbers from RT-module in Graph 2D

Calculation by *GS*

		flint	green
<i>Bubble Growth</i>	min BG	-0.014	-0.035
[ mm x RT ]	av. BG	8,1	3.4

Calculation for TC21 cases

( TV-Screen glas )

( with the measured values for flint glas )

<i>Bubble Growth</i>	min BG
[ mm x RT ]	av. BG

2004

2002

4.1

3.0

25.6

22.2



The values for the TV-glass are much higher as for the container glasses.

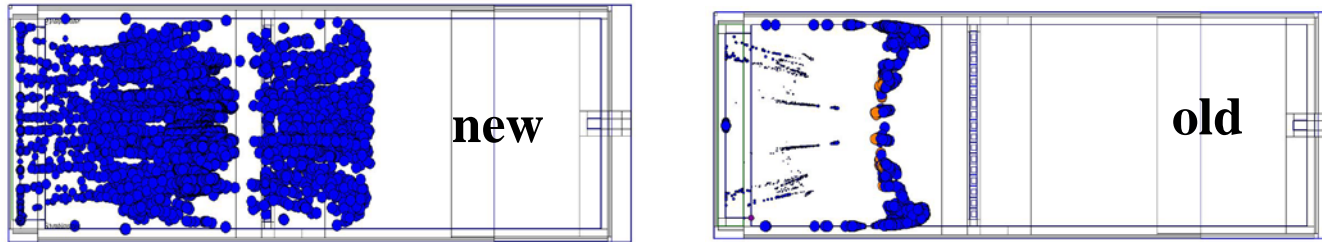
**But that fits to reality.**

Seed counts at TV-screen glass are much lower compared to container glass.

## Results with the modified bubble growth model

### Bubble tracing in the trajectory module

There are **NO** bubble growth measurements for the invested TV screen glass.  
 We used the flint glass values given in the database as default  
 With these value we got (again) no bubbles in the throat .....but



The situation looks much more hopeful as at the old bubble growth model  
 With roughly 10 times lower values we got the following results :

<u>Calculation for TC21 cases</u>	<i>( with the adjusted values for flint glas )</i>	
( TV-Screen glas )	<b>2004</b>	<b>2002</b>
<i>% bubbles in throat</i>	<b>1.6</b>	<b>2.6</b>



## Summary

**With the the evaluation of the time temperature history and physical fining alone in the invested cases no clear quality ranking was possible.**

**Only the Bubble-growth method gave clear results, calculated as number in *Graph 2d* or as seed count in *Trajectories*.**

**But for the bubble tracing in *Trajectories* the default values have to be lowered again. For special glasses extra measurements are advised**

**The bubble growth method seems to be a relative easy way to replace the many and very difficult measurements of solubility and diffusivity of the fining gases by a single measurement**

*Remark*

*BUT ...reboil effects during REfining can only be simulated by a full redox simulation*

*Thank you very much  
for your attention,*

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