Retort system troubleshooting: a re-commissioning case study

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My Background

Engineer (Mechatronics)

Manufacturing experience – SPC / Lean / Six Sigma

Food industry project work across sectors

Machine design, process development, product development, project management

Thermal Processing specific

- “Approved Person”
- 2012 George Alexander Foundation Fellow – travelled to USA, Canada, UK, France to study

Background

- Our client invested in a new retort a few years ago

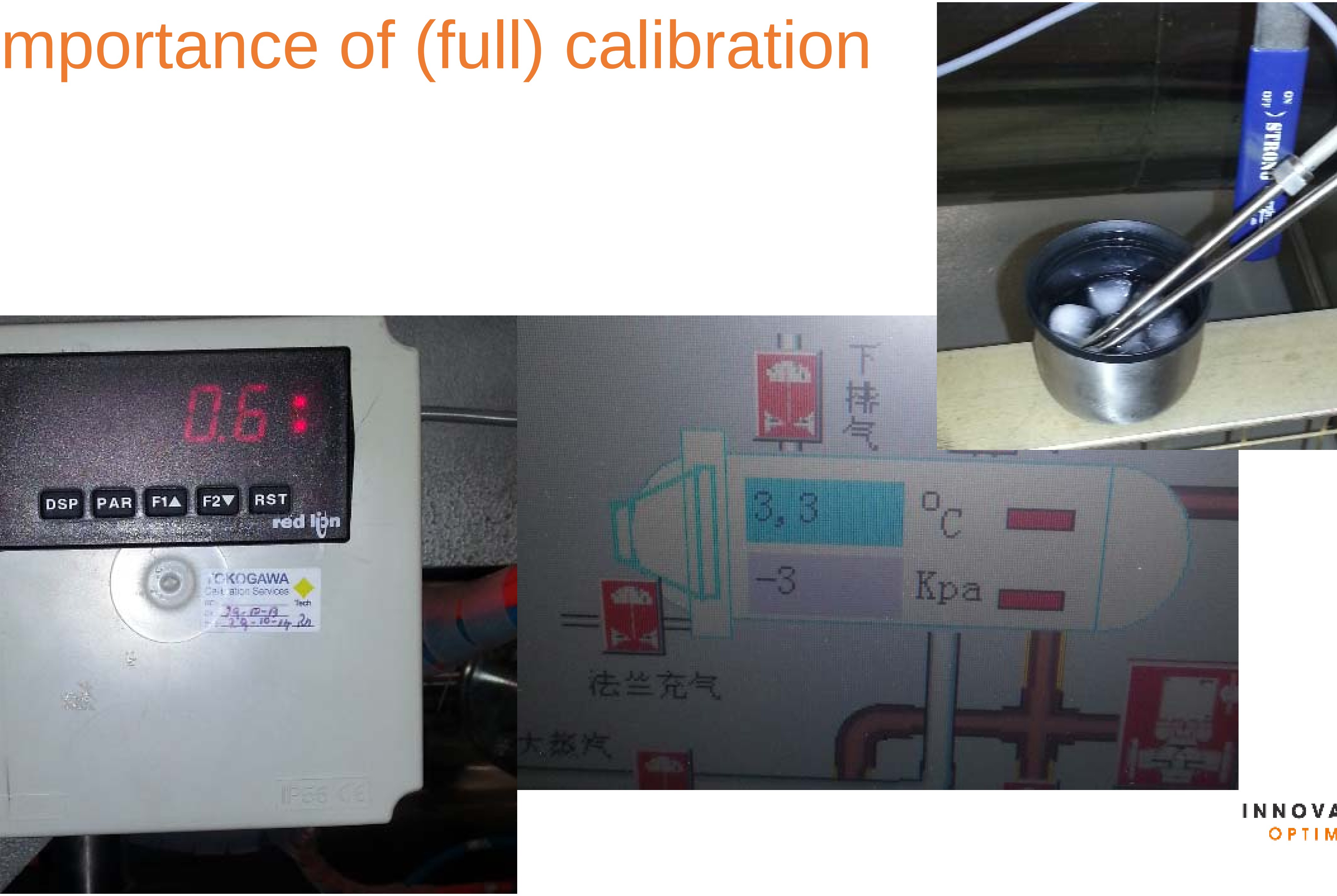
Called us with a few problems

- Thermometers giving different readings
- Inconsistent quality – unhappy customers
- Gone back to using old manual saturated steam retorts.

mportance of (full) calibration

Visited the factory – ran the retort up to 115c and found this

mportance of (full) calibration



mportance of (full) calibration

Dry well calibrator to generate known temperatures and found:

'Hockey Puck' had failed

Converts RTD to 4-20mA signal

Fairly linear error ~2.8 out

Take-home message

Be weary of RTDs – they can fail in believable ways

Be sure that calibration is of the whole system

Make sure operators check thermometers against each other

Looking in to other issues

Taking a Statistical Process Control approach to the problems looks at variation in the process:

1) "Common Causes" - sometimes referred to as nonassignable, normal sources of variation. It refers to many sources of variation that consistently acts on process. These types of causes produces a stable and repeatable distribution over time.

2) "Special Causes" - sometimes referred to as assignable sources of variation. It refers to any factor causing variation that affects only some of the process output. They are often intermittent and unpredictable.

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Significance of variation in thermal processes

Reference	Product	Can size	Obtained by	Cv
Hayakawa et al 1988	Spaghetti in tomato sauce	211x 300	Experiment	67.0%
Hayakawa et al 1988	Spaghetti in tomato sauce	307x 409	Experiment	28.5%
Powers et al 1962	Snap beans	Jar	Experiment	27.5%
Powers et al 1962	Peas	US No.2 cans	Experiment	26.9%
Powers et al 1962	Peas puree	US No.2 cans	Experiment	35.8%
Powers et al 1962	Blackeye peas (hot soak)	US No.2 cans	Experiment	16.3%
Powers et al 1962	Blackeye peas (cold soak)	US No.2 cans	Experiment	35.5%
Powers et al 1962	Pimentos	US No.2½ cans	Experiment	57.4%
Wang et al	Bentonite	211 x 300	Experiment	21.9%
Wang et al	Bentonite	211 x 300	Prediction	24.7%
Wang et al	Bentonite	307 x 409	Experiment	24.9%
Wang et al	Bentonite	307 x 409	Prediction	23.4%

VARIABILITY: COEFFICIENT OF VARIATION Cv = standard deviation/mean x 100

Sources of Variation?

Raw material?

Product fill / piece size?

Viscosity of sauce?

Process time/temperature?

CUT?

Equipment changes?

CUT main source of variation

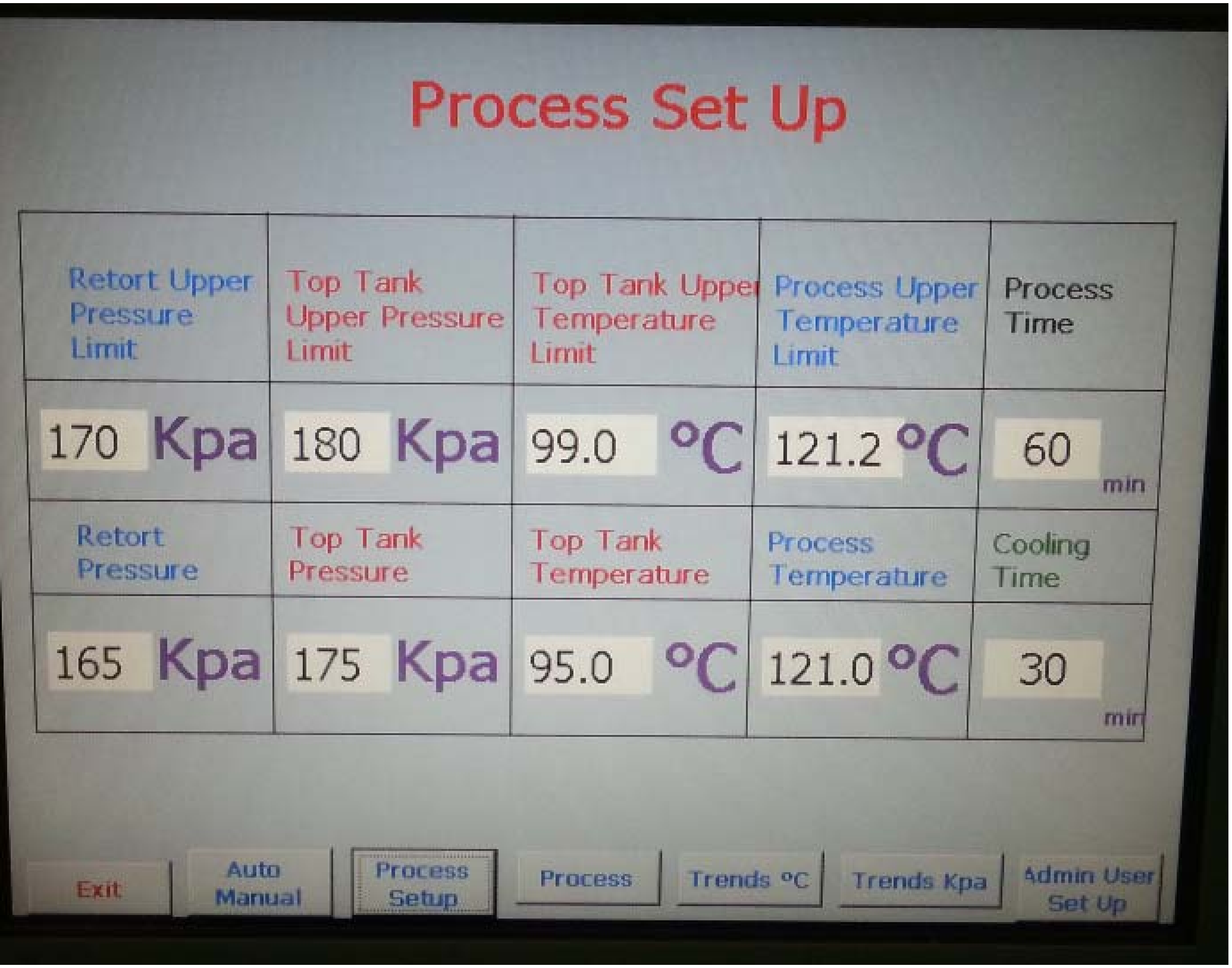
Found that CUT in validation was 37 minutes.

In practice, usually about half this and sometimes around 5-6 minutes!

A bit counter intuitive – but faster CUT (better machine performance) is less safe, so process time must be increased by the ‘saved time’

This means the process time was being increased by up to 32 minutes – about double.

CUT main source of variation

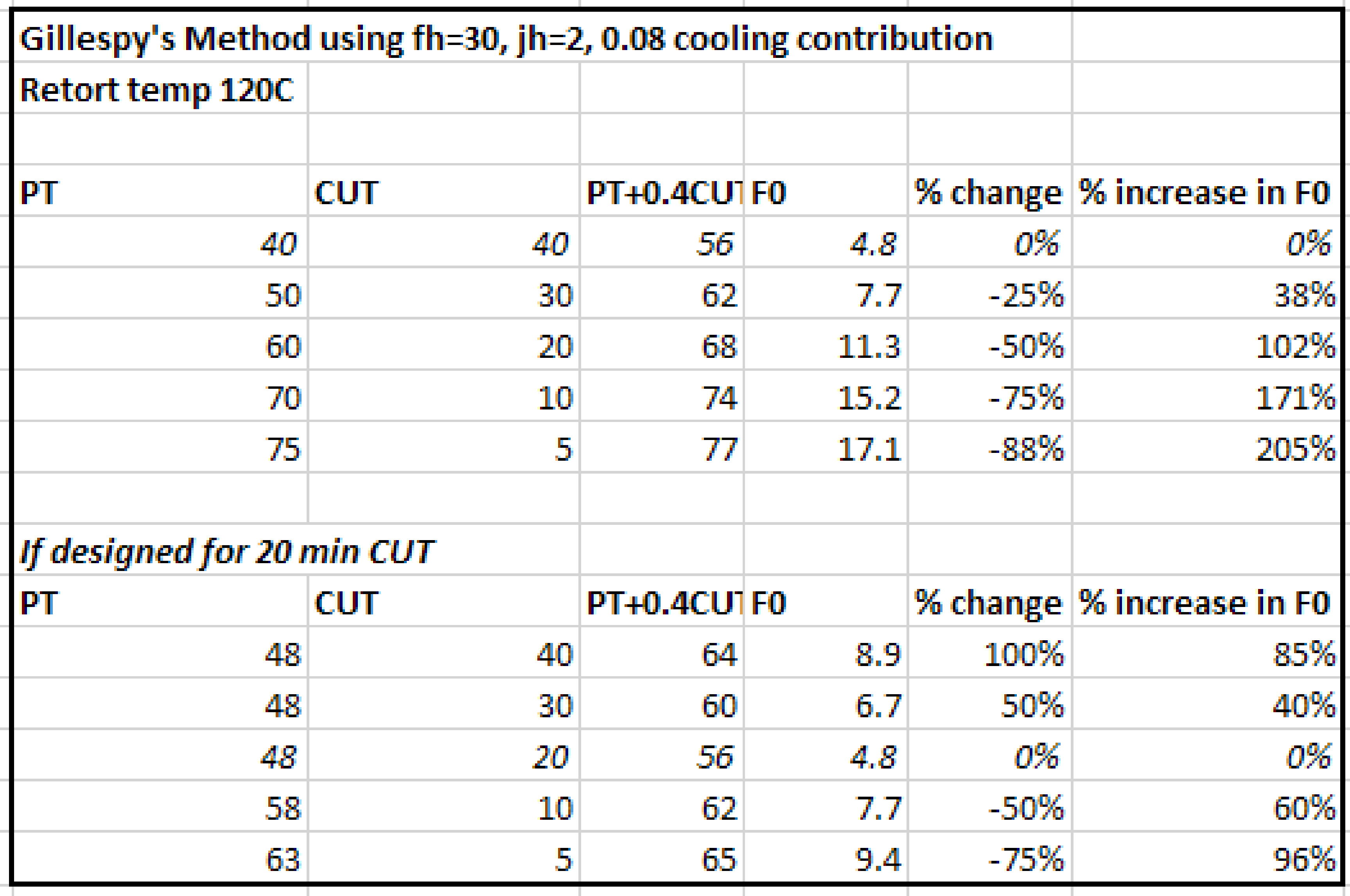


Process Set Up

Retort Upper Pressure Limit	Top Tank Upper Pressure Limit	Top Tank Upper Temperature Limit	Process Upper Temperature Limit	Process Time
170 Kpa	180 Kpa	99.0 °C	121.2 °C	60 min
Retort Pressure	Top Tank Pressure	Top Tank Temperature	Process Temperature	Cooling Time
165 Kpa	175 Kpa	95.0 °C	121.0 °C	30 mi

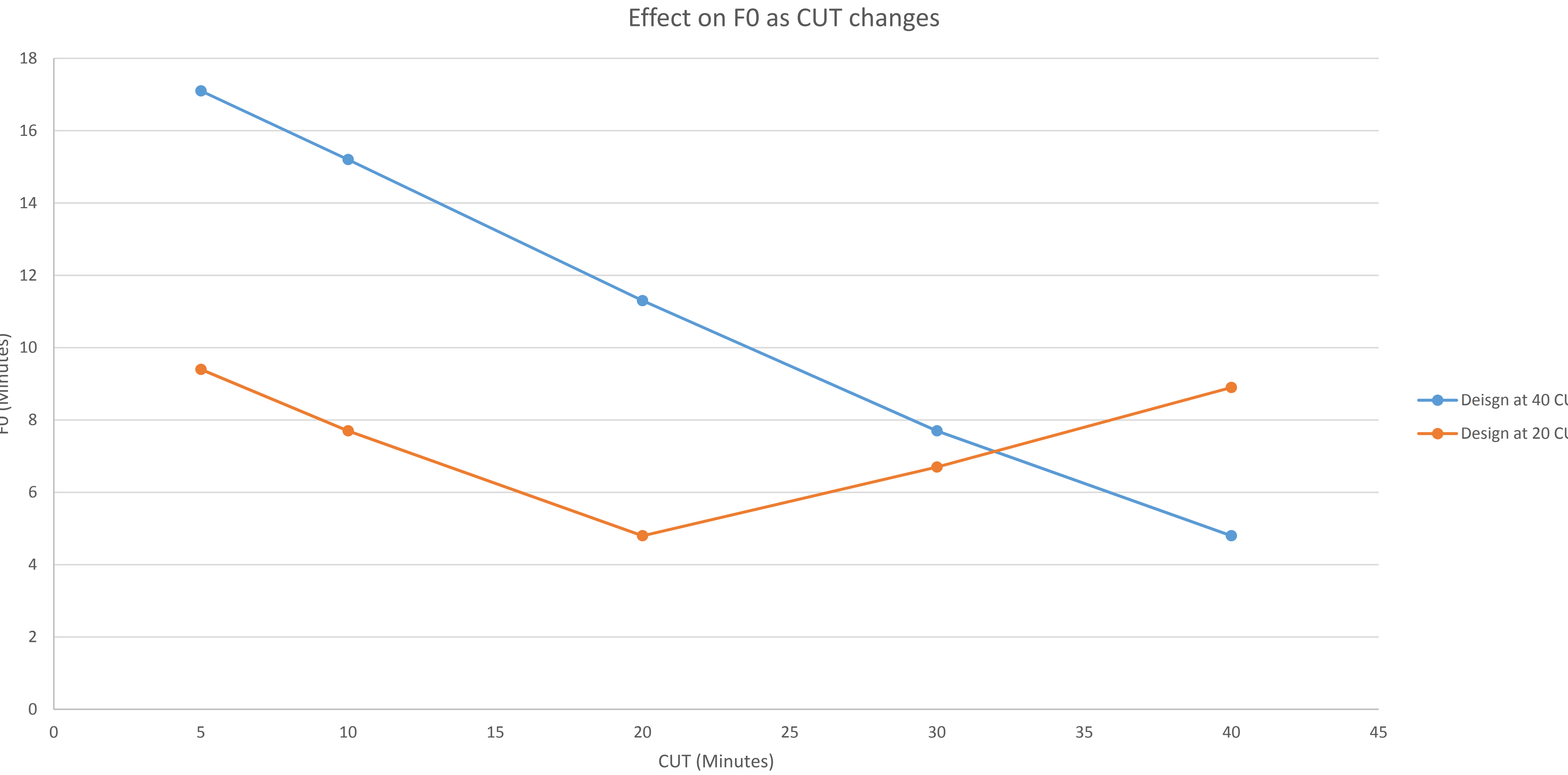
Very simple CUT settings on this re

Change in F0 as CUT varies



Gillespy's Method using fh=30, jh=2, 0.08 cooling contribution					
Retort temp 120C					
PT	**CUT**	**PT+0.4CUT**	**F0**	**% change**	**% increase in F0**
40	*40*	*56*	*4.8*	*0%*	*0%*
50	30	62	7.7	-25%	38%
60	20	68	11.3	-50%	102%
70	10	74	15.2	-75%	171%
75	5	77	17.1	-88%	205%
If designed for 20 min CUT					
PT	**CUT**	**PT+0.4CUT**	**F0**	**% change**	**% increase in F0**
48	40	64	8.9	100%	85%
48	30	60	6.7	50%	40%
48	*20*	*56*	*4.8*	*0%*	*0%*
58	10	62	7.7	-50%	60%
63	5	65	9.4	-75%	96%

Change in F0 as CUT varies



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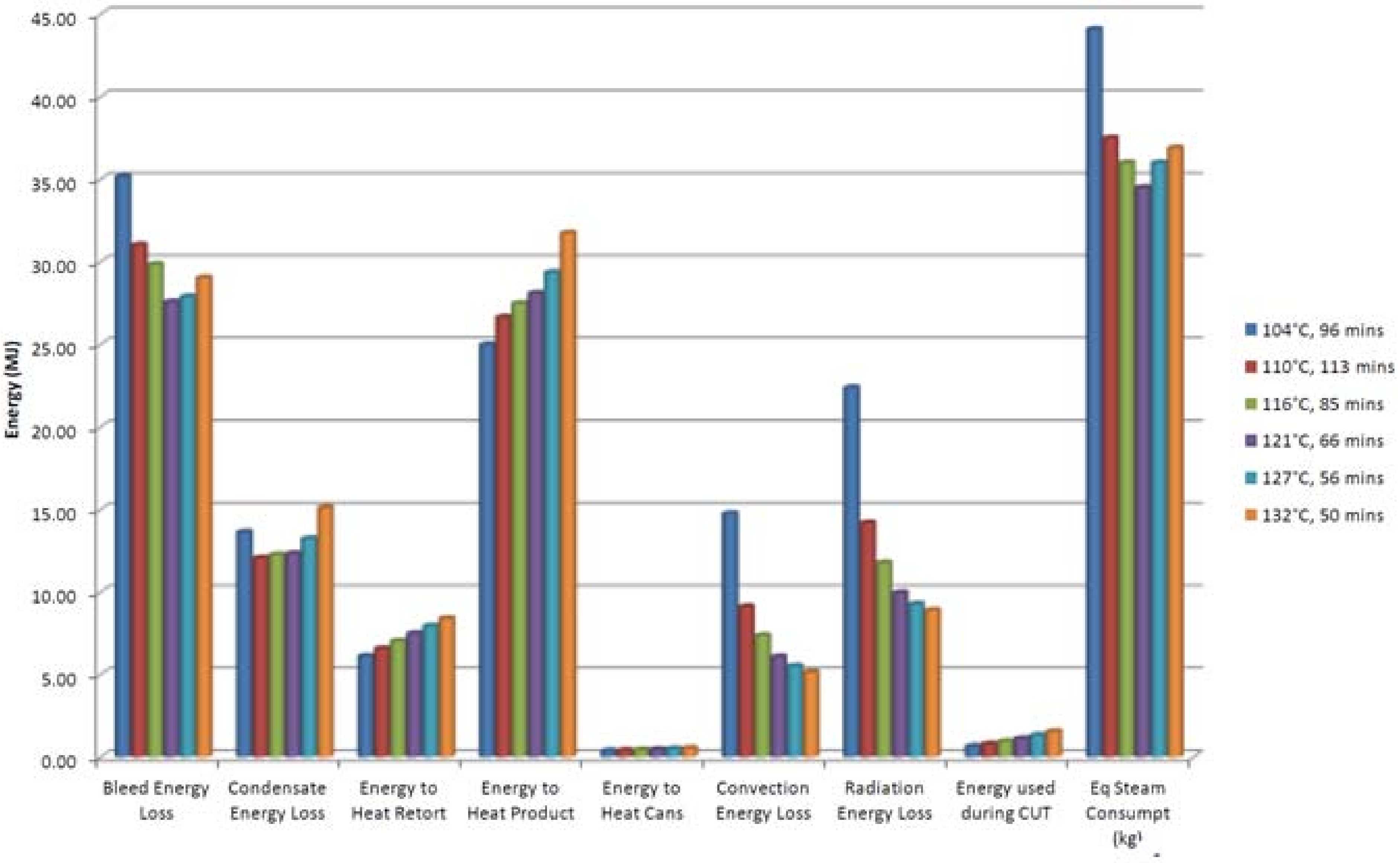
Energy use study (steam)



Ref. JA Barreiro, CR Perez and C Guariguata
J Food Engineering 3 (1984) 27 - 37

How to fix CUT?

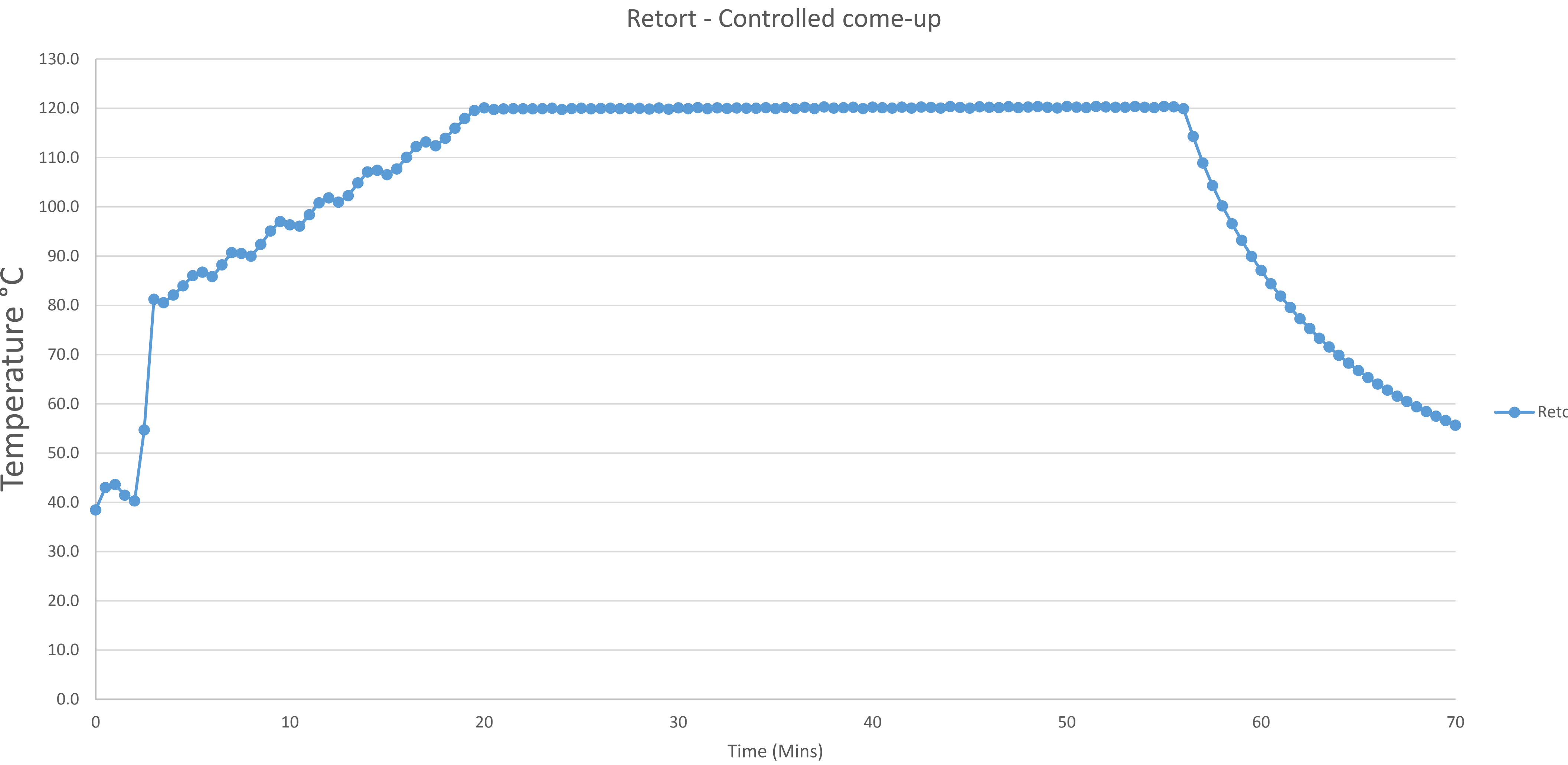
Slow down CUT (when loaded lightly)

- Fill the rest of the retort with water cans
- Control system limit steam supply

Speed up CUT (for validation / full load)

- Increase steam capacity
- Only run with partial loads
- Increase pre-heat temperature
- Use real product for validation

Control system solution to CUT



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entonite

rous aluminium silicate comprised principally
e clay mineral montmorillonite.

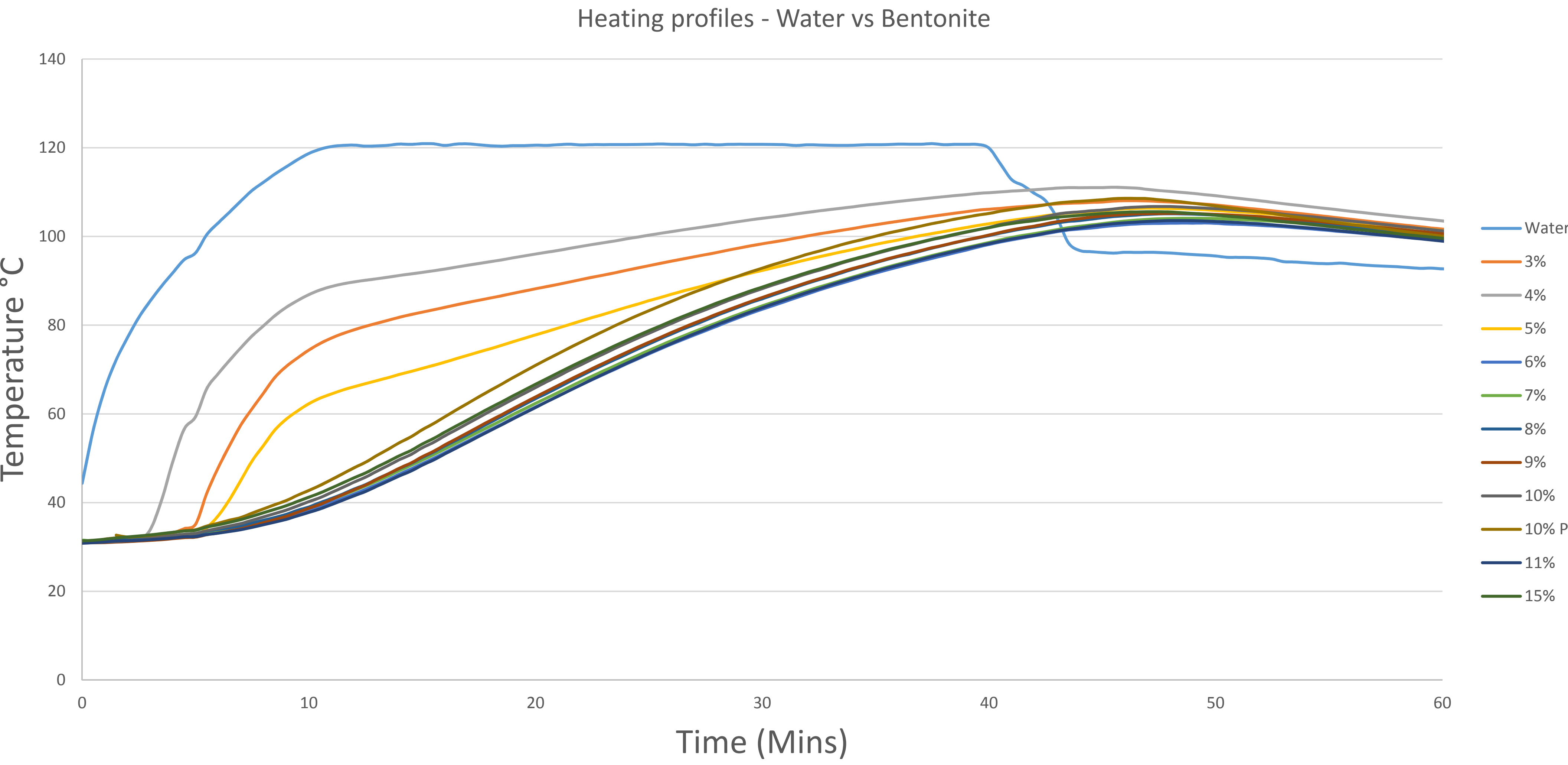
cally used in drilling / civil applications.

used for purifying wine amongst other things

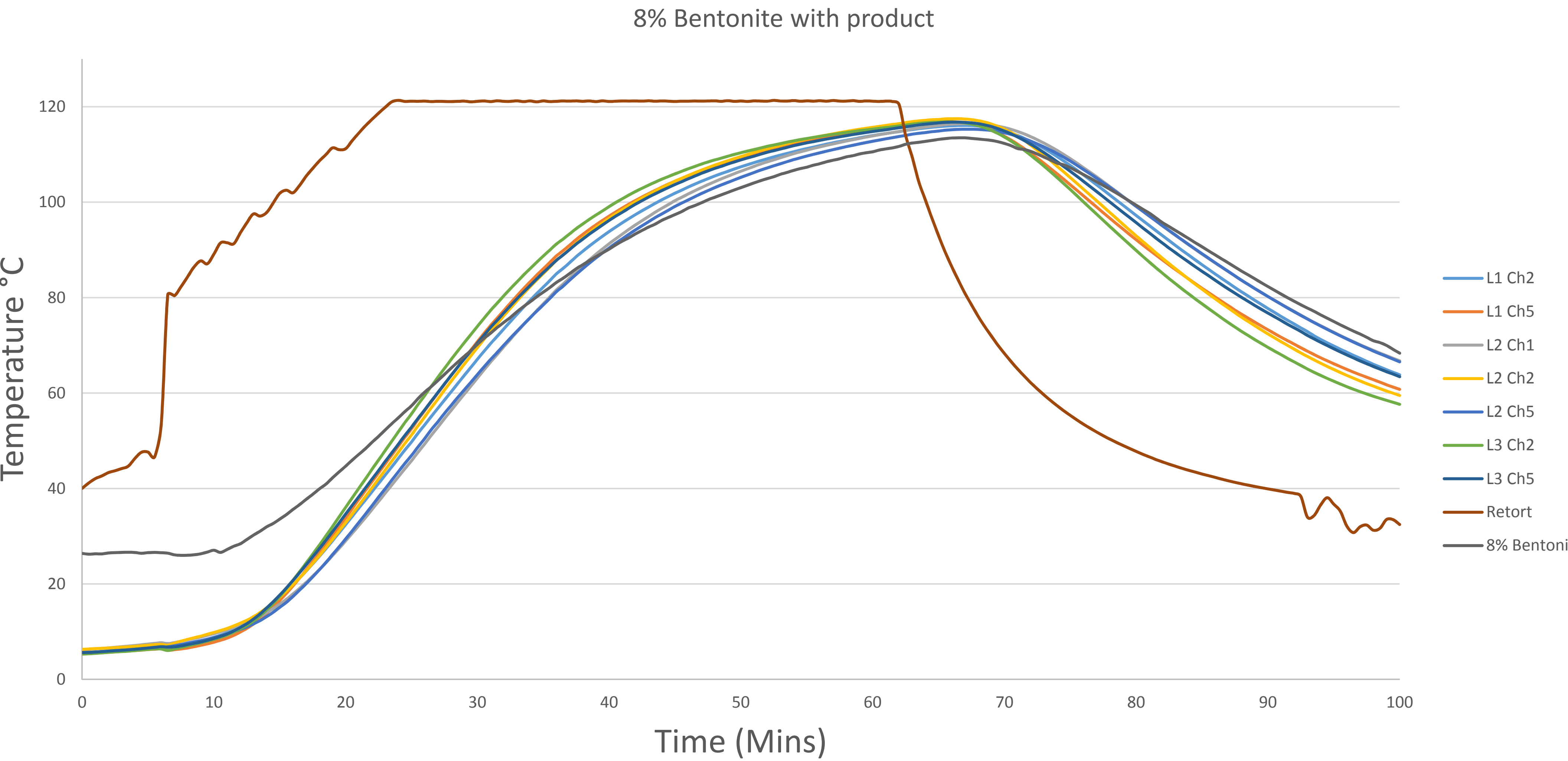
tively low cost (under $100 for enough to
his retort)

to simulate product heating

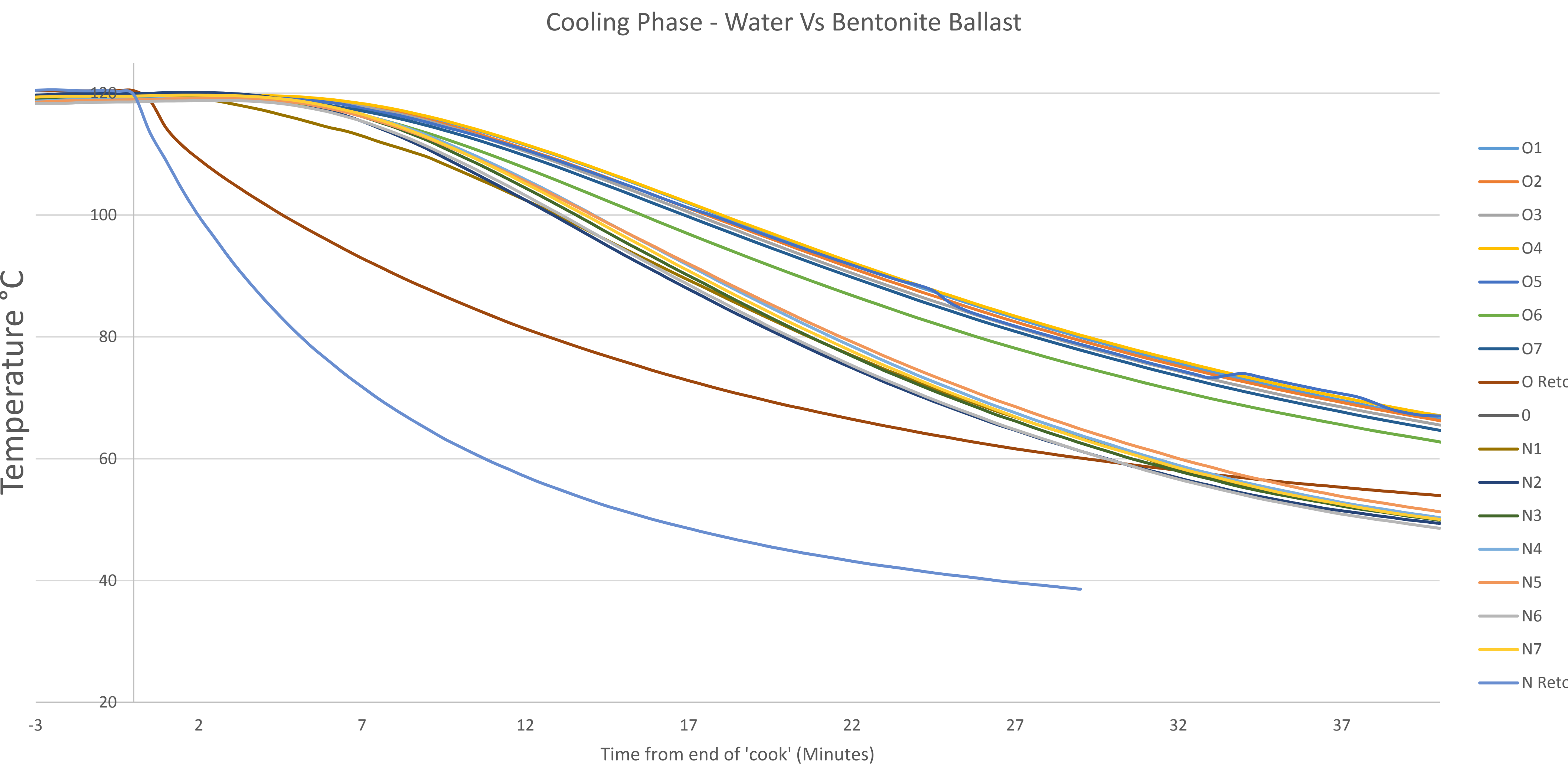
Bentonite


Heating profiles - Water vs Bentonite
140
120
100
80
60
40
20
0
Temperature °C
0
10
20
30
40
50
60
Time (Mins)
Water
3%
4%
5%
6%
7%
8%
9%
10%
10% P
11%
15%

Bentonite


8% Bentonite with product
Temperature °C
Time (Mins)
0
20
40
60
80
100
120
0
10
20
30
40
50
60
70
80
90
100
L1 Ch2
L1 Ch5
L2 Ch1
L2 Ch2
L2 Ch5
L3 Ch2
L3 Ch5
Retort
8% Bentoni

Vhat about cooling phase?



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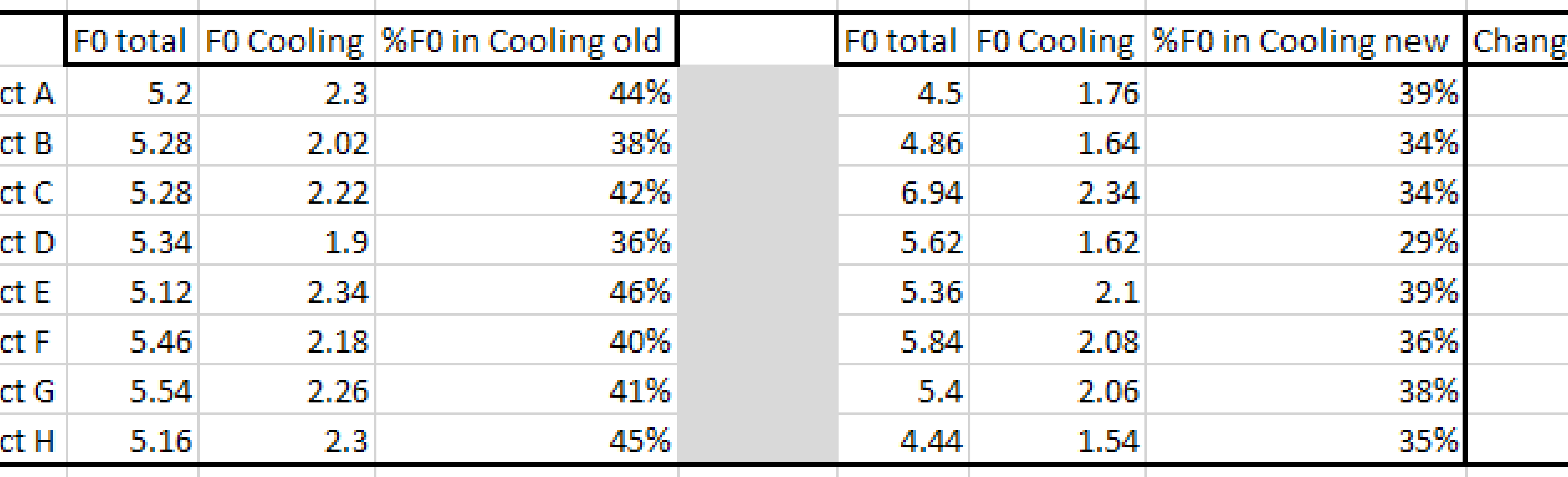
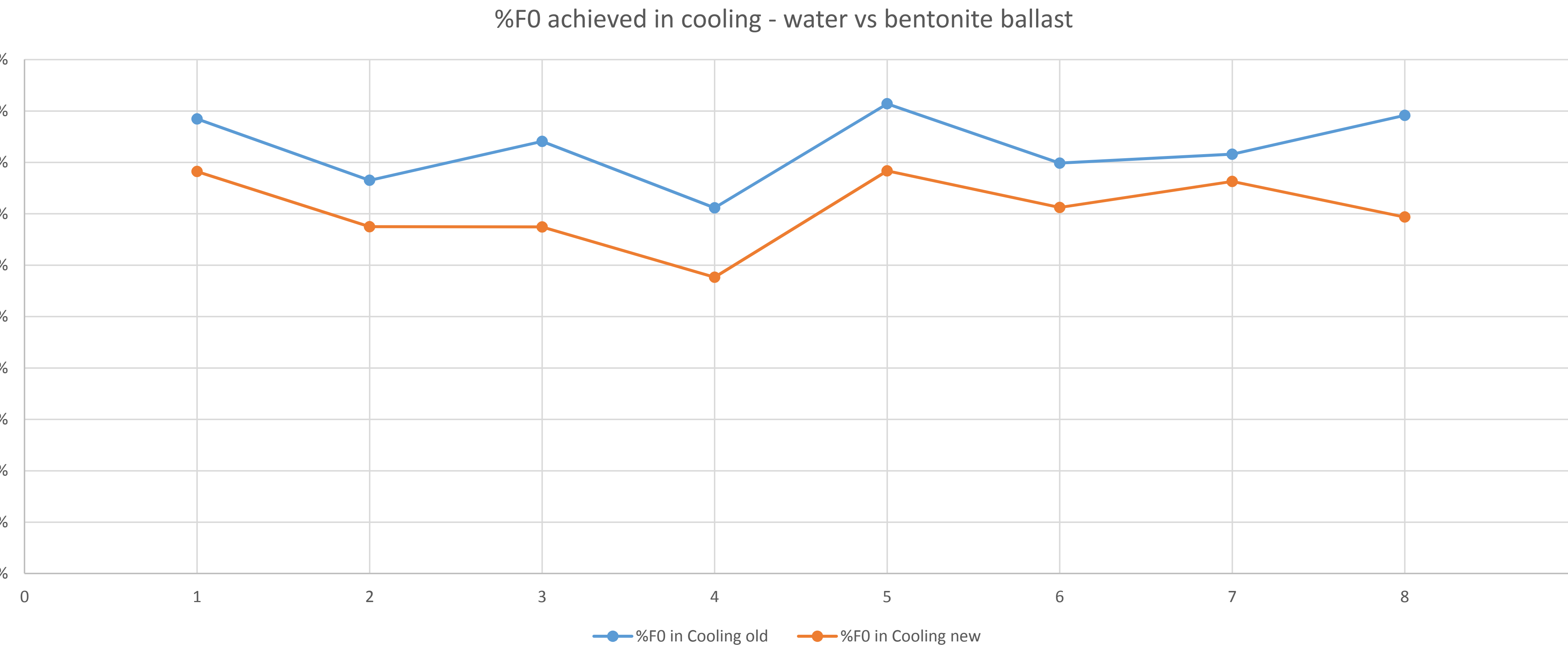
Vhat about cooling phase?



	F0 total	F0 Cooling	%F0 in Cooling old		F0 total	F0 Cooling	%F0 in Cooling new	Chang
ct A	5.2	2.3	44%		4.5	1.76	39%	
ct B	5.28	2.02	38%		4.86	1.64	34%	
ct C	5.28	2.22	42%		6.94	2.34	34%	
ct D	5.34	1.9	36%		5.62	1.62	29%	
ct E	5.12	2.34	46%		5.36	2.1	39%	
ct F	5.46	2.18	40%		5.84	2.08	36%	
ct G	5.54	2.26	41%		5.4	2.06	38%	
ct H	5.16	2.3	45%		4.44	1.54	35%	

Graphically



%F0 achieved in cooling - water vs bentonite ballast

Pump Replacement..

r cooling water and spray circulation replaced at the same time
ve contributed to better cooling

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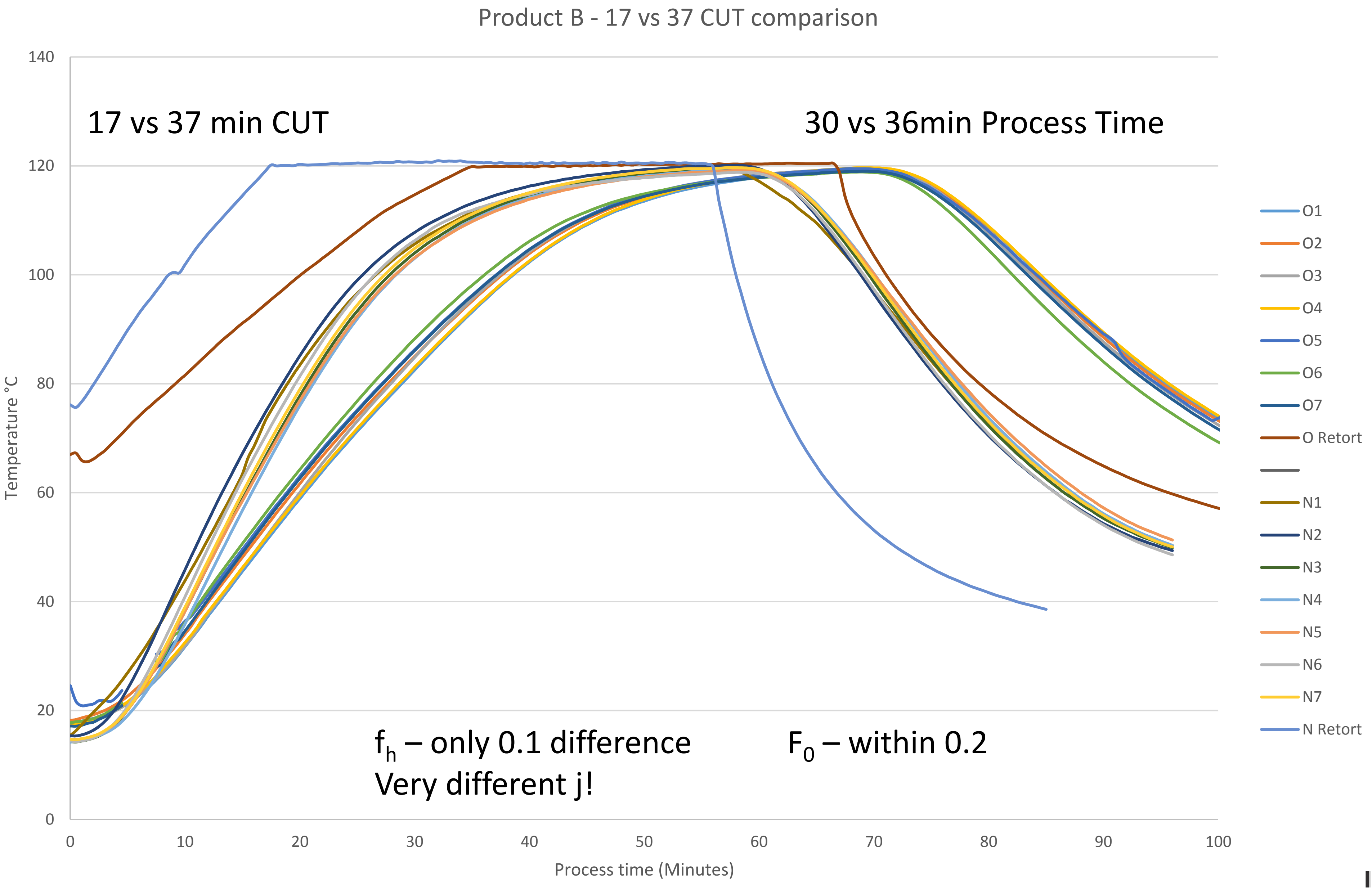

17 vs 37 min CUT

30 vs 36min Process Time

f_h – only 0.1 difference
Very different j!

F_0 – within 0.2

Take-home message

Ballast load can have significant impact on CUT (as can switching between convection and conduction heating product)

This can have huge impact on quality

If relying on cook in the cooling phase, be aware cooling rate changes

More Information?

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