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Study of Twelve basic principles related to the bath height change based on measurements and the quick and accessible monitoring in the pot line.

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Abstract: bath control is one of the most basic principles for controlling Aluminum production pots using the Hall–Héroult method. The electrolyte is the environment for production chemical reactions. It is possible to control chemical composition changes, improve efficiency and increase production by controlling the changes, but there are many variables for the bath height, and it is necessary to know the cause of the changes and the appropriate action to improve the conditions in the situation.

Nowadays, control of this operation is not easy continually due to the effort for increasing amperage, the high speed of production and increase the number of operational pots.

Therefore, the decision support software is needed to simplify and accelerate the work. However, the design of the software needs to clarify the circumstances of each decision and define a specific model for each action. In this paper, we have been discussed 12 basic principles related to the bath height change based on measurements and the quick and accessible monitoring in the pot line.

These suggestions are based on the experience gained from analyzing a large amount of data and adapting them to the problems encountered in D20 technology over a period of 7 years that may be changed in other technologies depending on the design of the pot. However, it has been tried to offer the same principles applicable for other technologies.

Keywords: “Bath height aluminium smlter;”

Introduction

South Hormoz Co. was established in 1990 in Bandar Abbas,(Metal Industry Special Zone) with the aim of a total production of 330,000 MT per year.(in 3 phases) The First phase development was planned in two parts (with each part comprising 120 cells), in order to produce 110,000 MT on the basis of domestic resources and Iranian experts as well as cooperation of foreign manufacturers.

Phase 1 was initially commissioned with 6 pots in 1997, with a gradual increase up to 120 pots by 2002, at which point the production capacity reached 55,000 MT per year. The second part of phase 1 commenced in 2003 and completed in 2005, with a further 120 pots, achieving the desired 110,000 MT capacity.

In 2006, executive operations started for Phase 2 (Hormozal), with a primary investment of EU 400 million and 2000 milliard Rls with the target to commission an additionally 228 pots. Phase 2 was completed significantly ahead of schedule, in just 40 months. A further development was commissioned in 2009, and Hormozal presently has a capacity of 170 active pots The production plan for Almahdi and Hormozal for coming year is 180,000 MT that gradually till the end of next year will reach the nominal capacity of 253,000 MT After assigning Almahdi Hormozal Aluminum Complex to Geno Ferro Alloys it is planed that new Phase with the advanced technology of 600KA with a Power Plant of 2000 Mw to be constructed in near future in the complex to increase the final capacity up to 1 million MT per year

Figure 1-Almahdi-south Hormoz aluminium Smlter

Metal and Bath height control is one of the few basic variables in pot operation directly affected by employees. This procedure sets out the controls to be exercised.

Metal and Bath height is measured by the Supervisor or Cell Technician / Operator with a standard measuring rod on the tap end of the pot measurement is carried out by using 40 cm short rod fixed with Spirit Level and measurement is done from Deck Plate level.

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Experimental Procedure

Bath temperature

Corrective actions for a `Cold Pot' are :

- Raise the voltage.
- Skip or delay a break.
- . Consider an extra tap to get the heat generating zone closer to the cathode. Take care not to lower anodes on to ledge.
- Check bath level for addition.

Reasons for a `Hot pot' are:

- Overtapping.
- Operating on higher voltage than normal.
- Anode problems.
- High bath level and drop in AlF3 %.

Mesearments

a-Anode Current Distribution

Uniform anode current distribution (C.D) is important in pot operation since it directly influences :

- Current efficiency.
- Anode performance.
- Energy consumption.
- Stability of pot.

Non uniform current distribution often indicates excessive metal pad turbulance which lowers the current efficiency. Anode performance is adversely affected when some anodes are forced to carry higher current while others are carrying less. The ones with high current passing through them are easily air oxidised or cracked. In the worst cases there is a stub burn off. The pot voltage requirement for stability increases if the C.D is non uniform. This, together with lower current efficiency pushes up the energy consumption per unit of production. The pot stability is generally lower when C.D is uneven and chances of the pot turning sick are greater.

We indirectly measure the current in an anode rod by measuring the voltage drop on a length of the anode rod. We measure the anode C.D by probing each anode rod with a millivolt probe with a 15.0 centimetre distance between the forks. Uniform millivolt readings on all anode rods indicate a good current distribution. The standard deviation of the millivolt values gives a quantitative measure of the C.D uniformity.

Process Control checks and reports the current distribution of a sample number of pots every week. These represent the overall quality of anode current distribution across the line. In addition, the current distribution is checked by the operator to diagnose a noisy pot or anode problems.

Major factors on which anode current distribution depends are :

- Accuracy of anode setting.
- Condition of cathode bottom and metal pad turbulance.
- Anode problems (spikes, burn offs, cracked anodes etc.)
- Anode cathode distance.

Adequate control on each of these factors is essential to ensure conformance of anode current distribution to the target. Good operating practices concerning anode setting, clean pot bottoms and prompt attention to anode problems assist in maintaining uniform current distribution. Proper selection and control of anode cathode distance is also important.

b.Shell temperature

1-Pyro digital meter or fluke thermometer and extension arm with tips or equivalent.

Check the instrument before use. Make necessary connections.

2. Place the surface probe on the outside of the shell such that the height indicator mark on extension arm coincides with the top of catwalk, to reach the metal bath interface. Record the temperature when the reading is steady.

3. Repeat the measurement at specified locations on both upstream and downstream sides and record.

4. In case of excessive bath deposits are seen on the measurement location, measurement may be done on the adjacent collector bar locations. Such a change to be recorded.

c. Noise Amplitude

The noise amplitude is defined as the average amplitude of the raw resistance over the normal noise amplitude measurement period. This measurement period is divided equally into a number of raw noise ranges sub-periods. These two parameters are set so that a sub-period spans the period of a typical metal pad wave for the CD20 cell. The range of the raw resistance in each sub-period is calculated, the average of these is the noise amplitude. Note that the noise amplitude is converted to voltage for reporting purposes.

These suggestions are based on the experience gained from analyzing a large amount of data and adapting them to the problems encountered in D20 technology over a period of 7 years that may be changed in other technologies depending on the design of the pot. However, it has been tried to offer the same principles applicable for other technologies

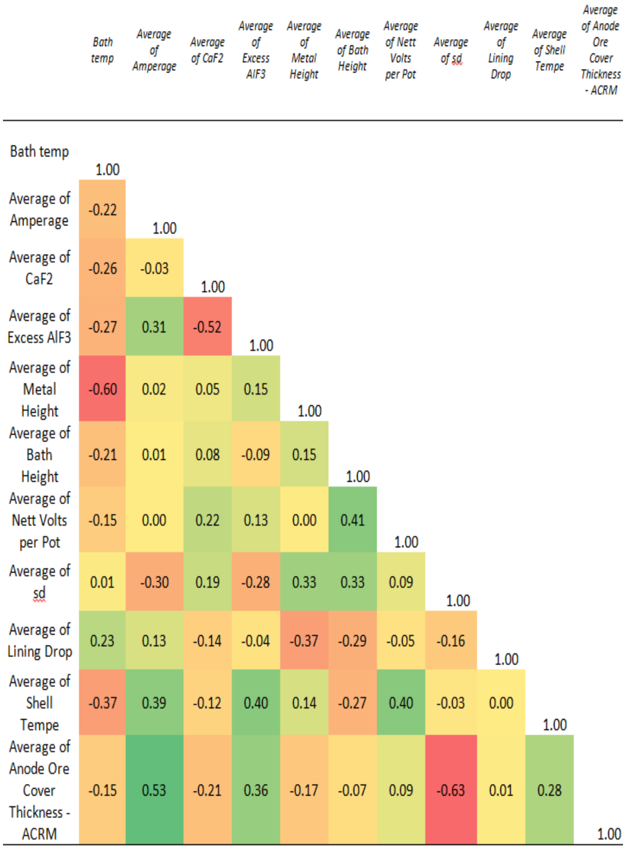
Results and Discussion

First stage

Find the acceptable range and operational range for the 7 variables discussed including the following

1-Bath temperature

The benchmark is temperature-appropriate design that has the highest efficiency and performance.

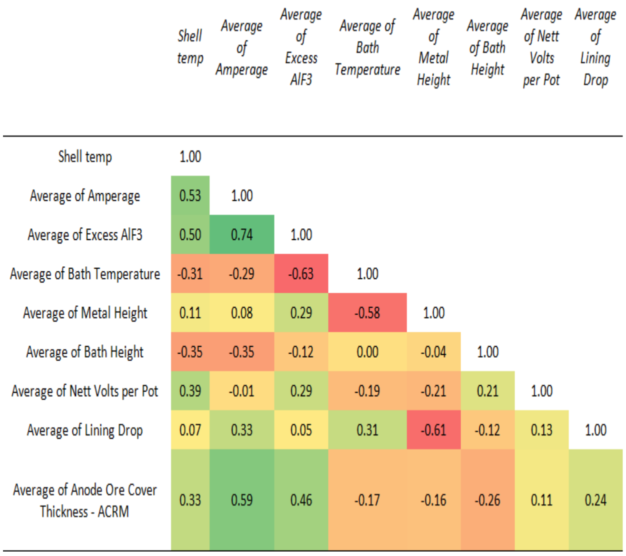


	Bath temp	Average of Amperage	Average of CaF2	Average of Excess AlF3	Average of Metal Height	Average of Bath Height	Average of Nett Volts per Pot	Average of sd	Average of Lining Drop	Average of Shell Tempe	Average of Anode Ore Cover Thickness - ACRM
Bath temp	1.00										
Average of Amperage	-0.22	1.00									
Average of CaF2	-0.26	-0.03	1.00								
Average of Excess AlF3	-0.27	0.31	-0.52	1.00							
Average of Metal Height	-0.60	0.02	0.05	0.15	1.00						
Average of Bath Height	-0.21	0.01	0.08	-0.09	0.15	1.00					
Average of Nett Volts per Pot	-0.15	0.00	0.22	0.13	0.00	0.41	1.00				
Average of sd	0.01	-0.30	0.19	-0.28	0.33	0.33	0.09	1.00			
Average of Lining Drop	0.23	0.13	-0.14	-0.04	-0.37	-0.29	-0.05	-0.16	1.00		
Average of Shell Tempe	-0.37	0.39	-0.12	0.40	0.14	-0.27	0.40	-0.03	0.00	1.00	
Average of Anode Ore Cover Thickness - ACRM	-0.15	0.53	-0.21	0.36	-0.17	-0.07	0.09	-0.63	0.01	0.28	1.00

Figure 2- Find the acceptable range and operational range for the 7 variables discussed including bath temperature

۲-shell temperature

It is adapted to the effective variables and design of the pot.



	Shell temp	Average of Amperage	Average of Excess AlF3	Average of Bath Temperature	Average of Metal Height	Average of Bath Height	Average of Nett Volts per Pot	Average of Lining Drop
Shell temp	1.00							
Average of Amperage	0.53	1.00						
Average of Excess AlF3	0.50	0.74	1.00					
Average of Bath Temperature	-0.31	-0.29	-0.63	1.00				
Average of Metal Height	0.11	0.08	0.29	-0.58	1.00			
Average of Bath Height	-0.35	-0.35	-0.12	0.00	-0.04	1.00		
Average of Nett Volts per Pot	0.39	-0.01	0.29	-0.19	-0.21	0.21	1.00	
Average of Lining Drop	0.07	0.33	0.05	0.31	-0.61	-0.12	0.13	1.00
Average of Anode Ore Cover Thickness - ACRM	0.33	0.59	0.46	-0.17	-0.16	-0.26	0.11	0.24

Figure 3- Find the acceptable range and operational range for the shell temperature

3-Bath height

The goal was to maintain the idle height, which was 18 cm in this study.

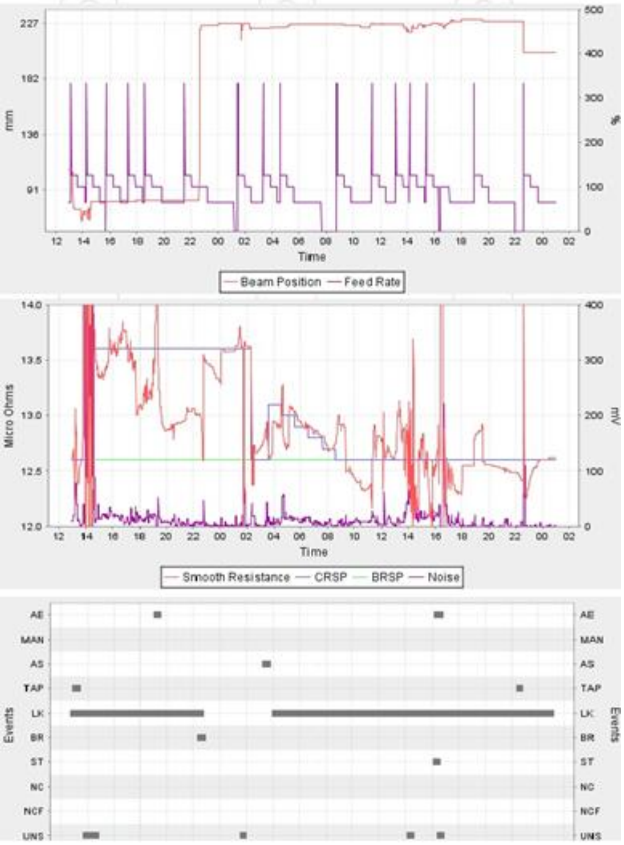
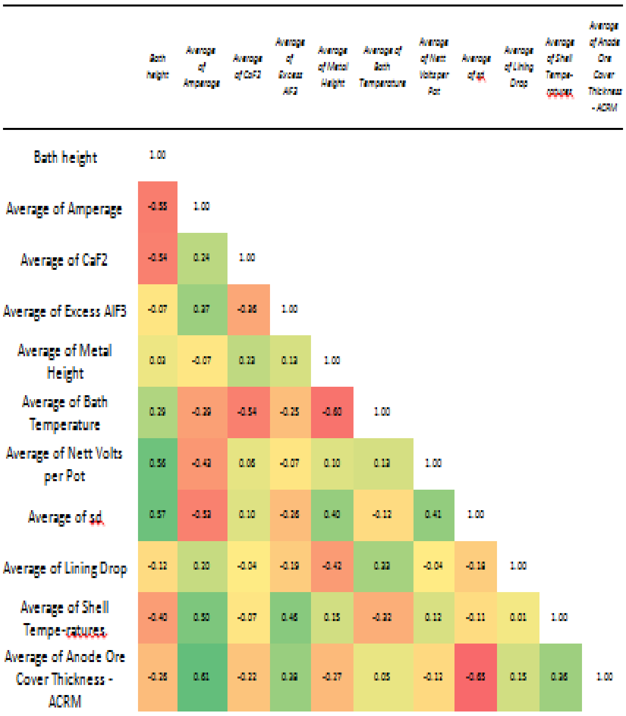


Figure 4-pot with height bath-software IPOT

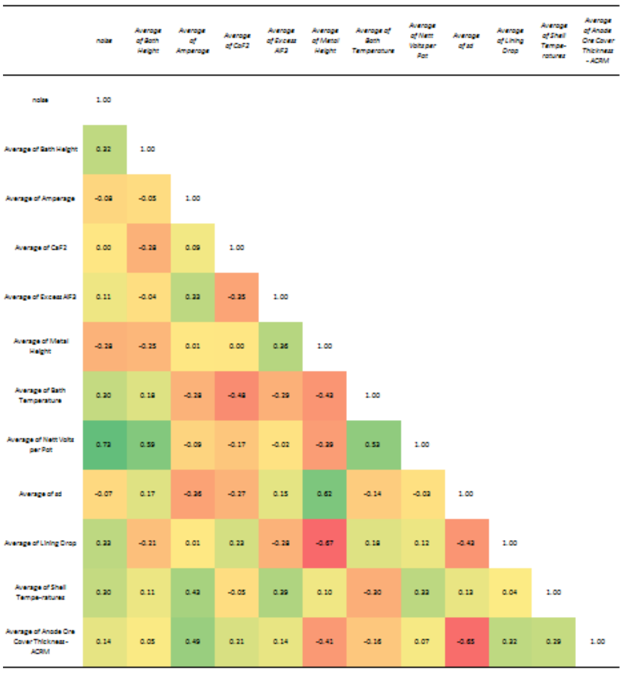


	Bath height	Average of Amperage	Average of CaF2	Average of Excess AlF3	Average of Metal Height	Average of Bath Temperature	Average of Nett Volts per Pot	Average of sd	Average of Lining Drop	Average of Shell Tempe-ratures	Average of Anode Ore Cover Thickness - ACRM
Bath height	1.00										
Average of Amperage	-0.55	1.00									
Average of CaF2	-0.54	0.24	1.00								
Average of Excess AlF3	-0.07	0.37	-0.36	1.00							
Average of Metal Height	0.03	-0.07	0.23	0.13	1.00						
Average of Bath Temperature	0.29	-0.39	-0.54	-0.25	-0.60	1.00					
Average of Nett Volts per Pot	0.56	-0.43	0.06	-0.07	0.10	0.13	1.00				
Average of sd	0.57	-0.53	0.10	-0.26	0.40	-0.12	0.41	1.00			
Average of Lining Drop	-0.12	0.20	-0.04	-0.19	-0.42	0.33	-0.04	-0.18	1.00		
Average of Shell Tempe-ratures	-0.40	0.50	-0.07	0.46	0.15	-0.22	0.12	-0.11	0.01	1.00	
Average of Anode Ore Cover Thickness - ACRM	-0.26	0.61	-0.22	0.38	-0.27	0.05	-0.12	-0.65	0.15	0.36	1.00

Figure 5- Find the acceptable range and operational range for the shell temperature WITH BATH HEIGHT

3-Noise

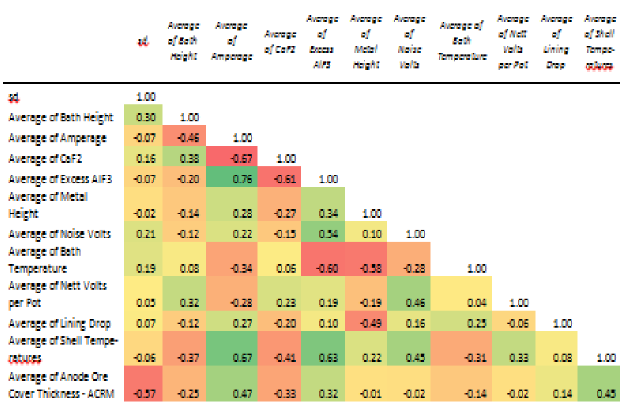
A cell with a fluctuating voltage. The fluctuations are typically caused by incorrect anodes setting or a turbulent metal pad



	noise	Average of Bath Height	Average of Amperage	Average of CaF2	Average of Excess AlF3	Average of Metal Height	Average of Bath Temperature	Average of Nett Volts per Pot	Average of sd	Average of Lining Drop	Average of Shell Tempe-ratures	Average of Anode Ore Cover Thickness - ACRM
noise	1.00											
Average of Bath Height	0.22	1.00										
Average of Amperage	-0.08	-0.05	1.00									
Average of CaF2	0.00	-0.28	0.09	1.00								
Average of Excess AlF3	0.11	-0.04	0.33	-0.35	1.00							
Average of Metal Height	-0.28	-0.25	0.01	0.00	0.36	1.00						
Average of Bath Temperature	0.30	0.18	-0.28	-0.48	-0.29	-0.43	1.00					
Average of Nett Volts per Pot	0.73	0.59	-0.09	-0.17	-0.02	-0.39	0.53	1.00				
Average of sd	-0.07	0.17	-0.36	-0.27	0.15	0.62	-0.14	-0.03	1.00			
Average of Lining Drop	0.33	-0.21	0.01	0.23	-0.28	-0.67	0.18	0.12	-0.43	1.00		
Average of Shell Tempe-ratures	0.30	0.11	0.43	-0.05	0.39	0.10	-0.30	0.33	0.13	0.04	1.00	
Average of Anode Ore Cover Thickness - ACRM	0.14	0.05	0.49	0.21	0.14	-0.41	-0.16	0.07	-0.65	0.32	0.29	1.00

Figure 6- Find the acceptable range and operational range for the NOISE

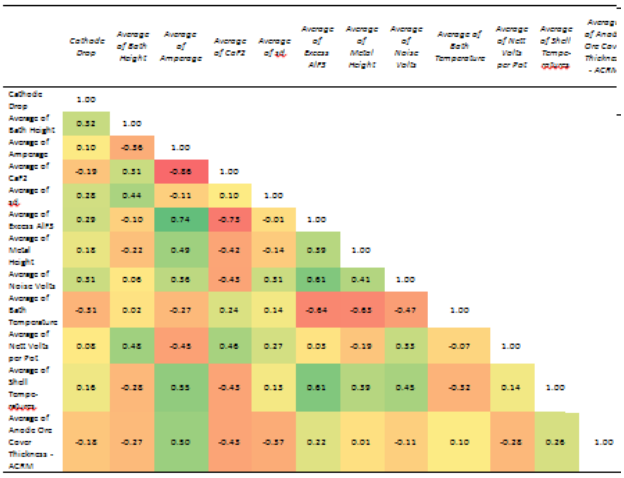
5-Standard division of anode current distribution



	sd	Average of Bath Height	Average of Amperage	Average of CaF2	Average of Excess AlF3	Average of Metal Height	Average of Noise Volts	Average of Bath Temperature	Average of Nett Volts per Pot	Average of Lining Drop	Average of Shell Temperatures
sd	1.00										
Average of Bath Height	0.30	1.00									
Average of Amperage	-0.07	-0.46	1.00								
Average of CaF2	0.16	0.38	-0.67	1.00							
Average of Excess AlF3	-0.07	-0.20	0.76	-0.61	1.00						
Average of Metal Height	-0.02	-0.14	0.28	-0.27	0.34	1.00					
Average of Noise Volts	0.21	-0.12	0.22	-0.15	0.54	0.10	1.00				
Average of Bath Temperature	0.19	0.08	-0.34	0.06	-0.60	-0.58	-0.28	1.00			
Average of Nett Volts per Pot	0.05	0.32	-0.28	0.23	0.19	-0.19	0.46	0.04	1.00		
Average of Lining Drop	0.07	-0.12	0.27	-0.20	0.10	-0.49	0.16	0.25	-0.06	1.00	
Average of Shell Temperatures	-0.06	-0.37	0.67	-0.41	0.63	0.22	0.45	-0.31	0.33	0.08	1.00
Average of Anode Ore Cover Thickness - ACRM	-0.57	-0.25	0.47	-0.33	0.32	-0.01	-0.02	-0.14	-0.02	0.14	0.45

Figure 7- Find the acceptable range and operational range for the anode current distribution

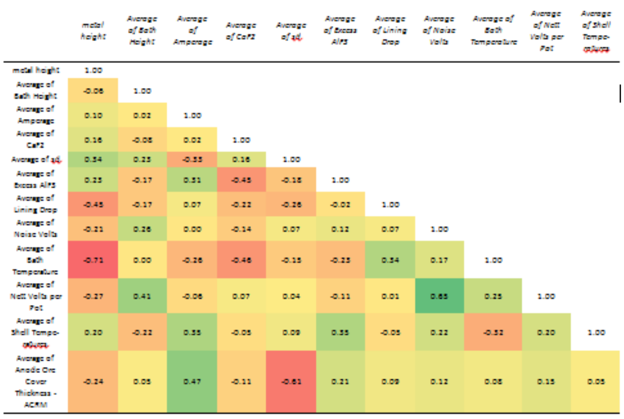
6-Cathode drop



	Cathode Drop	Average of Bath Height	Average of Amperage	Average of CaF2	Average of sd	Average of Excess AlF3	Average of Metal Height	Average of Noise Volts	Average of Bath Temperature	Average of Nett Volts per Pot	Average of Shell Temperatures	Averag of Anod Ore Cov Thickne - ACRM
Cathode Drop	1.00											
Average of Bath Height	0.52	1.00										
Average of Amperage	0.10	-0.56	1.00									
Average of CaF2	-0.19	0.51	-0.86	1.00								
Average of sd	0.28	0.44	-0.11	0.10	1.00							
Average of Excess AlF3	0.29	-0.10	0.74	-0.75	-0.01	1.00						
Average of Metal Height	0.18	-0.22	0.49	-0.42	-0.14	0.59	1.00					
Average of Noise Volts	0.31	0.06	0.36	-0.45	0.31	0.61	0.41	1.00				
Average of Bath Temperature	-0.31	0.02	-0.27	0.24	0.14	-0.64	-0.65	-0.47	1.00			
Average of Nett Volts per Pot	0.08	0.48	-0.45	0.46	0.27	0.05	-0.19	0.35	-0.07	1.00		
Average of Shell Temperatures	0.16	-0.28	0.55	-0.45	0.15	0.61	0.39	0.45	-0.32	0.14	1.00	
Average of Anode Ore Cover Thickness - ACRM	-0.18	-0.27	0.50	-0.45	-0.37	0.22	0.01	-0.11	0.10	-0.28	0.26	1.00

Figure 8- Find the acceptable range and operational range for the cathode drop

7-Metal Height



	metal height	Average of Bath Height	Average of Amperage	Average of CaF2	Average of sd	Average of Excess AlF3	Average of Lining Drop	Average of Noise Volts	Average of Bath Temperature	Average of Nett Volts per Pot	Average of Shell Temperatures
metal height	1.00										
Average of Bath Height	-0.06	1.00									
Average of Amperage	0.10	0.02	1.00								
Average of CaF2	0.16	-0.06	0.02	1.00							
Average of sd	0.34	0.25	-0.33	0.16	1.00						
Average of Excess AlF3	0.25	-0.17	0.31	-0.45	-0.18	1.00					
Average of Lining Drop	-0.45	-0.17	0.07	-0.22	-0.26	-0.02	1.00				
Average of Noise Volts	-0.21	0.26	0.00	-0.14	0.07	0.12	0.07	1.00			
Average of Bath Temperature	-0.71	0.00	-0.26	-0.46	-0.15	-0.25	0.34	0.17	1.00		
Average of Nett Volts per Pot	-0.27	0.41	-0.06	0.07	0.04	-0.11	0.01	0.65	0.25	1.00	
Average of Shell Temperatures	0.20	-0.22	0.35	-0.05	0.09	0.35	-0.05	0.22	-0.32	0.20	1.00
Average of Anode Ore Cover Thickness - ACRM	-0.24	0.05	0.47	-0.11	-0.61	0.21	0.09	0.12	0.08	0.15	0.05

Figure 9- Find the acceptable range and operational range for the metal height

Second stage

12 Decisions based on the change of 7 variables

1-pot with voltage problem

raw	parameter	1
1	Bath Height	↑
2	Bath Temp	↑
3	Shell Temp	↑
4	Noise	↓
5	SD CD	↓
6	Cathod Drop	↓
7	Metal Height	↓

2-pot with Not feeding AlF_3

raw	parameter	2
1	Bath Height	↓
2	Bath Temp	↑
3	Shell Temp	↓
4	Noise	↓
5	SD CD	↓
6	Cathod Drop	↓
7	Metal Height	↓

3-Pot with too much fed AlF_3

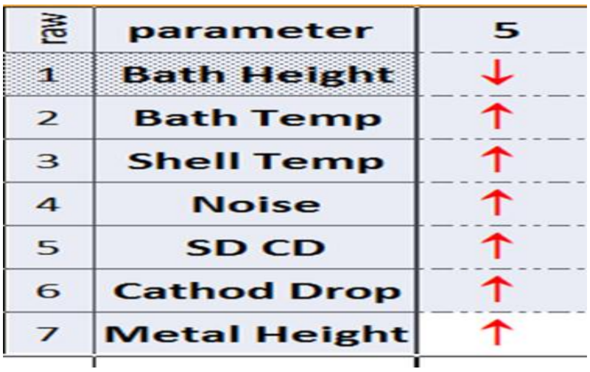
raw	parameter	3
1	Bath Height	↑
2	Bath Temp	↓
3	Shell Temp	↑
4	Noise	↑
5	SD CD	↑
6	Cathod Drop	↑
7	Metal Height	↓

4-pot with low voltage and low temperature

raw	parameter	4
1	Bath Height	↓
2	Bath Temp	↓
3	Shell Temp	↓
4	Noise	↑
5	SD CD	↑
6	Cathod Drop	↑
7	Metal Height	↑

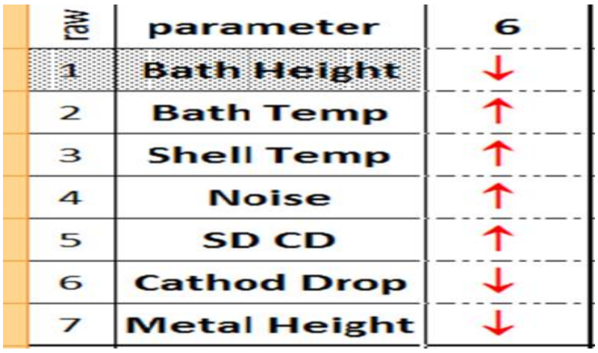
Conclusion

5-muky pot



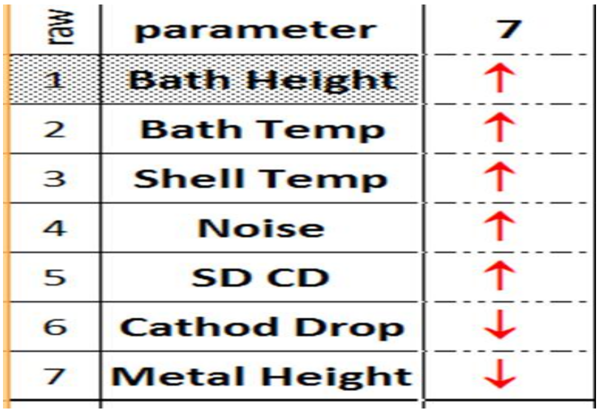
raw	parameter	5
1	Bath Height	↓
2	Bath Temp	↑
3	Shell Temp	↑
4	Noise	↑
5	SD CD	↑
6	Cathod Drop	↑
7	Metal Height	↑

6-pot with Low thickness ledge



raw	parameter	6
1	Bath Height	↓
2	Bath Temp	↑
3	Shell Temp	↑
4	Noise	↑
5	SD CD	↑
6	Cathod Drop	↓
7	Metal Height	↓

7-pot with high amperage

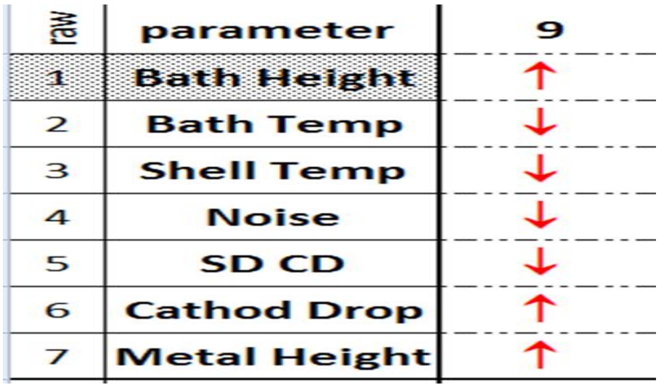


raw	parameter	7
1	Bath Height	↑
2	Bath Temp	↑
3	Shell Temp	↑
4	Noise	↑
5	SD CD	↑
6	Cathod Drop	↓
7	Metal Height	↓

8- crust or anode fallen off in electrolyte

raw	parameter	8
1	Bath Height	↑
2	Bath Temp	↓
3	Shell Temp	↓
4	Noise	↑
5	SD CD	↑
6	Cathod Drop	↑
7	Metal Height	↑

9-pot with thermal balance not ok



raw	parameter	9
1	Bath Height	↑
2	Bath Temp	↓
3	Shell Temp	↓
4	Noise	↓
5	SD CD	↓
6	Cathod Drop	↑
7	Metal Height	↑

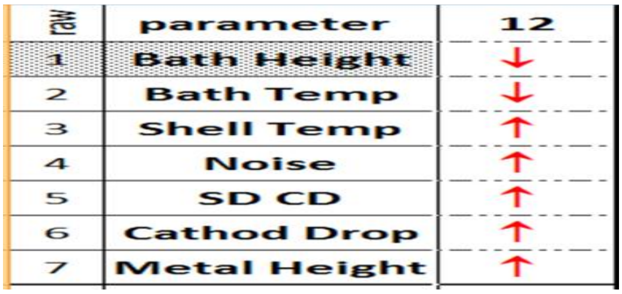
10-pot with high superheat and with height bath

raw	parameter	10
1	Bath Height	↑
2	Bath Temp	↑
3	Shell Temp	↑
4	Noise	↑
5	SD CD	↑
6	Cathod Drop	↑
7	Metal Height	↑

11-pot with spike

raw	parameter	11
1	Bath Height	↑
2	Bath Temp	↑
3	Shell Temp	↑
4	Noise	↓
5	SD CD	↑
6	Cathod Drop	↓
7	Metal Height	↓

12-pot with high spar



raw	parameter	12
1	Bath Height	↓
2	Bath Temp	↓
3	Shell Temp	↑
4	Noise	↑
5	SD CD	↑
6	Cathod Drop	↑
7	Metal Height	↑

Conclusion

the decision support software is needed to simplify and accelerate the work. However, the design of the software needs to clarify the circumstances of each decision and define a specific model for each action. In this paper, we have been discussed 12 basic principles related to the bath height change based on measurements and the quick and accessible monitoring in the pot line.

These suggestions are based on the experience gained from analyzing a large amount of data and adapting them to the problems encountered in D20 technology over a period of 7 years that may be changed in other technologies depending on the design of the pot. However, it has been tried to offer the same principles applicable for other technologies.

raw	parameter	1	2	3	4	5	6	7	8	9	10	11	12
1	Bath Height	↑	↓	↑	↓	↓	↓	↑	↑	↑	↑	↑	↓
2	Bath Temp	↑	↑	↓	↓	↑	↑	↑	↓	↓	↑	↑	↓
3	Shell Temp	↑	↓	↑	↓	↑	↑	↑	↓	↓	↑	↑	↑
4	Noise	↓	↓	↑	↑	↑	↑	↑	↑	↓	↑	↓	↑
5	SD CD	↓	↓	↑	↑	↑	↑	↑	↑	↓	↑	↑	↑
6	Cathod Drop	↓	↓	↑	↑	↑	↓	↓	↑	↑	↑	↓	↑
7	Metal Height	↓	↓	↓	↑	↑	↓	↓	↑	↑	↑	↓	↑
possibility	changing 1 pot	volt Adder brsp hugae cover	FLORIDE FEEDER MUST CHECK	FLORIDE FEEDER MUST CHECK bath Spar Check	LOW VOLTAGE lose conection heat lost	MUCK	WEAK SIDE WALL FREEZE	HIGH ENERGY HEAT BALANCE	crust cover BREAKES from ANODE FALL	HEAT BALANCE	Crust Cover BREAK from HIGH ENERGY	SPIKE	very high Spar
	changing pot line	conection check ACRM grain size check line safe eart cable check	raw material moisture Dry scuber gas circuletion ftp back filter damage	Alf3 density secondry alumin florin back filter chock	Check line power	alpha in Al2o3 Check Al2o3 grain size check	start up with low back wall bath tapping more wrong	crash cover grain size check current density cover new anode with delay	Anode Spect Check Line air Presure crain wrench check	reduse Crash cover Size increas Al2o3 in Crash cover increas Alumina size Alpha in alumin Chec k	line Amper is hight Anode density is Hight check Anode air reactivity	check anode dust check duct suction damper check dry scruber main fan presure	Check all raw material Cao Check raw material silo
action		REDUCE VOLT REMOVE (Adder OR AM) dccu check	INCREASE AlF3 addition	SODA ADD cryolite Add	INCREASE brsp dccu check VOLT Adder	(REDUCE METAL OR OFF TAP) (CATHOD SURFACE RECK)	CRYOLITE ADD CRASHED BATH ADD	REDUCE ENERGY INCREASE METAL HEIGHT dccu check	INCREASE VOLTAGE bath tap	DAMPER CHECK CC CHECK BATH TAP REDUCE VOLTAGE TOP ANODE COVER	BATH TAP REDEUCE VOLTAGE CRYOLITE ADD	SPIKE REOVE	add cryolite

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