How to estimate the effect of increasing rejects in stock preparation for side stream applications - Process model approach

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Outline

1. Why do modern mills need process modelling tools?
2. Towards a framework for process modelling in paper mills
3. Design and structure of process models
4. Use of process models
5. Case study - Increased rejects in stock preparations

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Influencing processes in paper mills

- Influencing the production
  - Automatic controls
  - Manual inputs by operators

↓

Manual entries are affected by decisions of the mill operators

↓

Decisions are based on process data from DCS:s and in most cases on additional laboratory data.

http://www.papierundtechnik.de/pt/live/fachartikel/pspic/bild1/7/Abb_4_PLT_4344dcaa64e87.jpg

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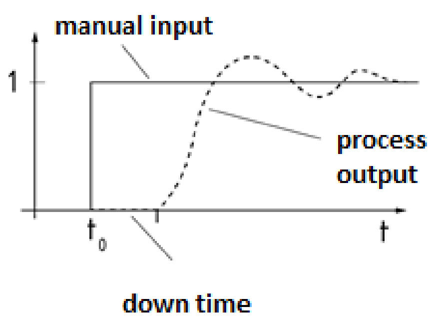
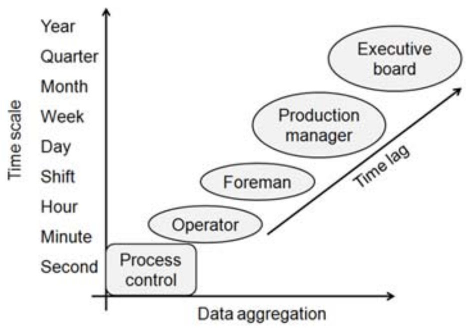
Skipping time lags – Advantages of process models

- Both manual inputs and the process of data aggregation cause a time lag in paper mills.

<u>Advantages of process models:</u>

- Prediction of both process and quality parameters
- Supporting sustainability indicator calculation
- Assessment of sidestream applications





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Aim of process modelling

- Detection of the current status of selected processes (separation processes + dispersion) based on process data
- Prediction of material properties and raw material consumption by target simulation
- The output data from the developed tools can be used to calculate both the sustainability indicators and the paper qualities.

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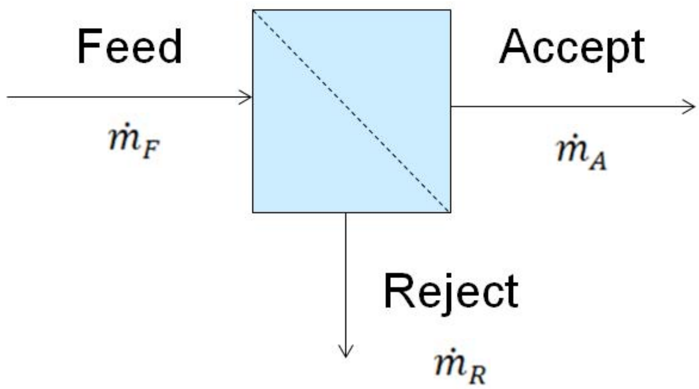
State of the art – Process modelling tools

- balancing of mass flows within a separation process and definition of reject rates



$$\dot{m}_F = \dot{m}_R + \dot{m}_A$$

$$RR_m = \frac{\dot{m}_R}{\dot{m}_F}$$

Basic data structure of the models (1)

Components	Symbol
Long Fibre Fraction	LF
Short Fibre Fraction	SF
Fibre Fines	FS
Minerals	ASH
Large Stickies (> 1 mm)	ADH_L
Medium Size Stickies (0.5…1 mm)	ADH_M
Small Stickies (< 0.5 mm)	ADH_S
Specific dirt spec area for particles < 100 µm	SPEC_S
Specific dirt spex area for particles > 100 µm	SPEC_L

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Basic data structure of the models (2)

Quality properties	Symbol
Schopper Riegler Value	SR
Water Retention Value	WRV
ERIC Value	ERIC
Brightness	R457

Ressource data	Symbol
Energy consumption	EC
Process water consumption	PWC
Fresh water consumption	FWC

Processes to be modelled within REFFIBRE

- Modelling of processes of relevance for the industrial partners which have an impact on both the value chain and the properties of the paper produced

Coarse Screening	Separation of coarse contaminants, staples and flakes
Fine Screening	Separation of fine contaminants, macro stickies and dirt specks
Flotation deinking	Separation of organic & inorganic fines, ink and micro stickies

Dispersing	Refining of dirt particles, highly energy-intensive process

Modelling of the single separation element (2)

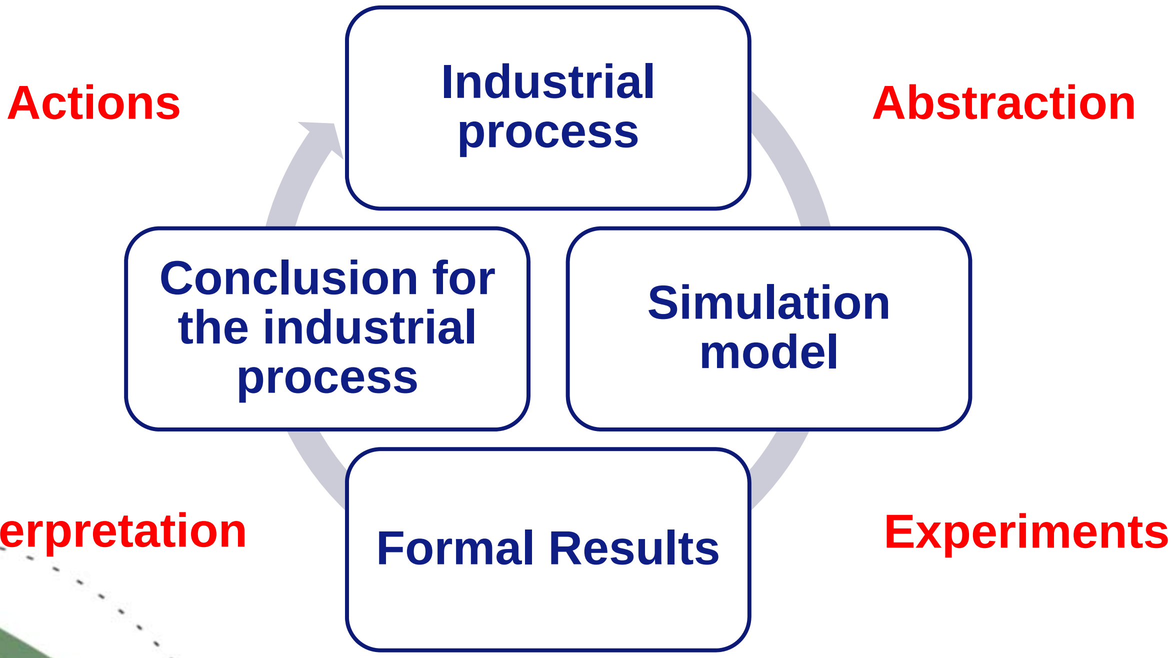
- Material flows in paper mills are a heterogenous mixture of components $w_{i,X}$.
- Components behave differently in separation devices → Definition of the component-specific separation efficiency

$$E_R = \frac{w_{i,R} * \dot{m}_R}{w_{i,F} * \dot{m}_F}$$

- Calculation of the device-specific screening index α for each component

$$E_R = {RR_m}^{\alpha}$$

The Process of Modelling



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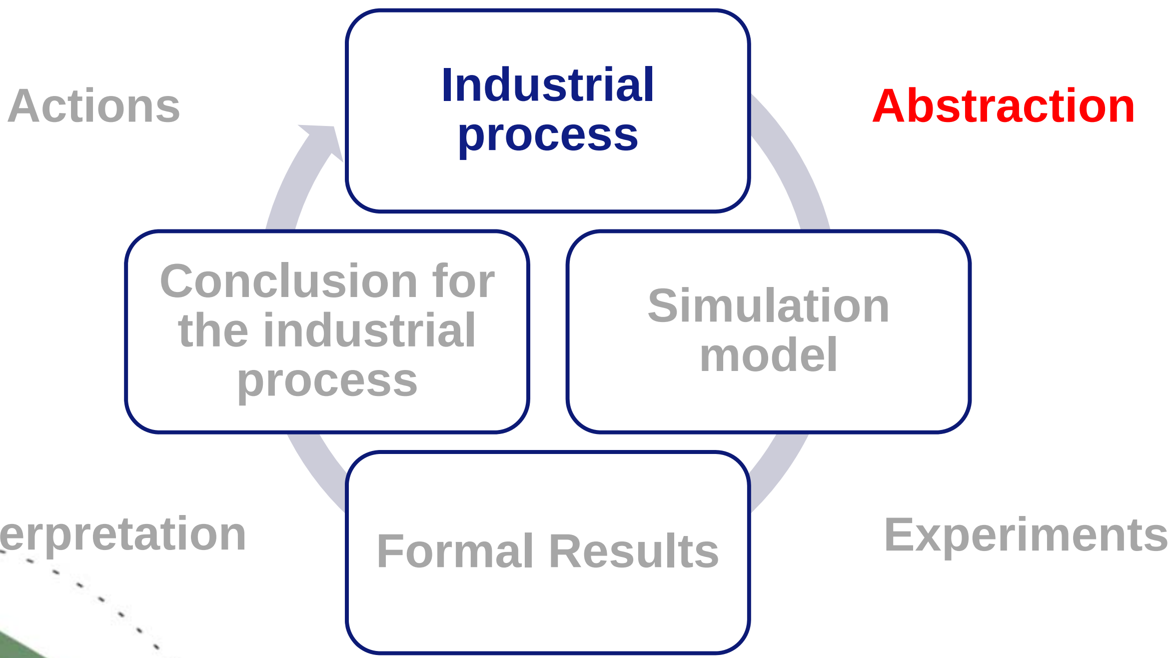

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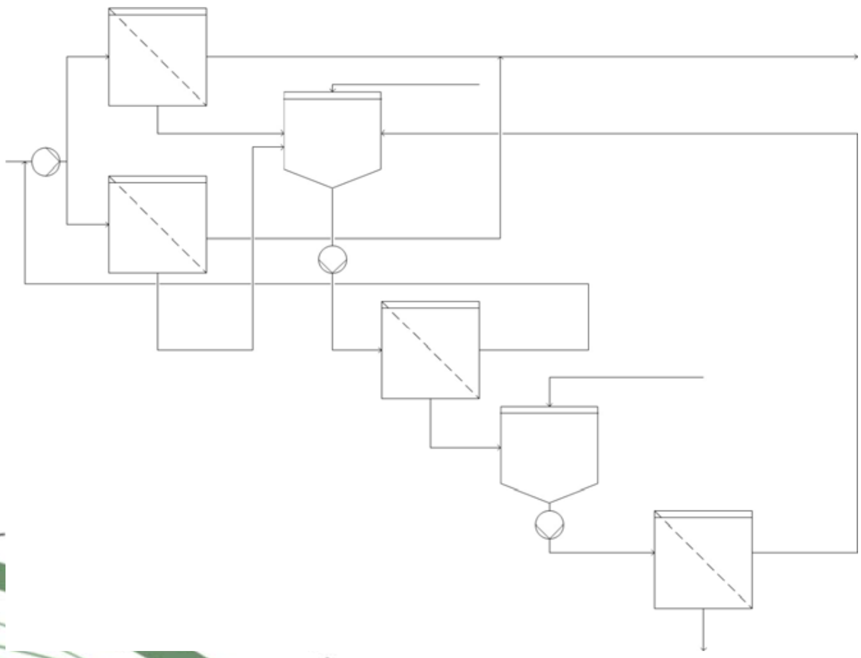
Abstraction of a separation process



- Material flow balances according to VDI 3925 for all components entering and exiting processes.
- Calculation of quality properties by usage of the material composition.
- Balacing ressource consumption and emission for a total process.

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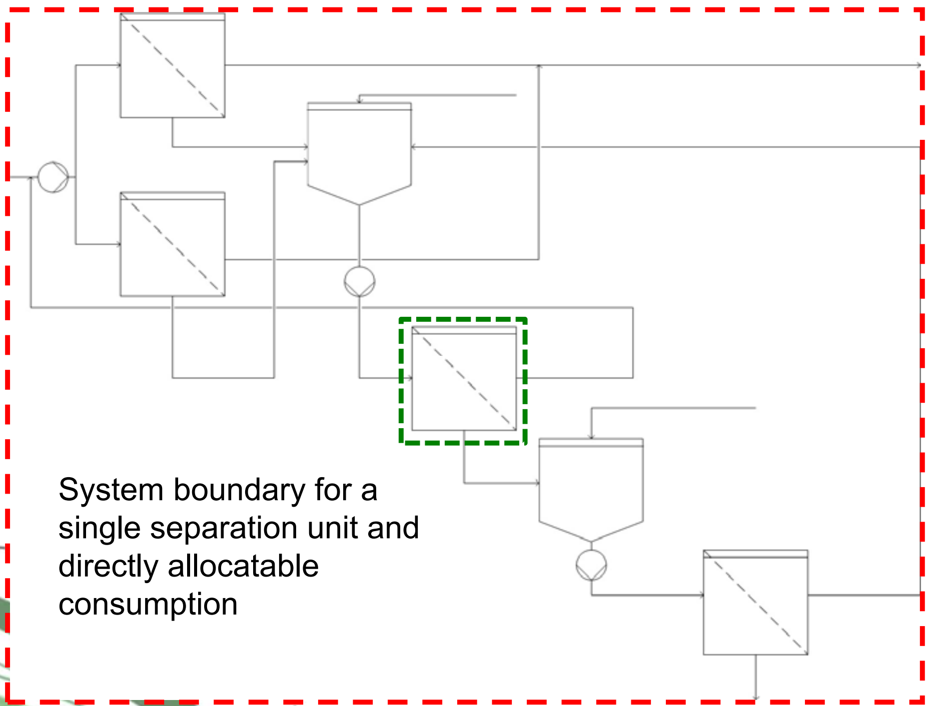
Definition of system boundaries



System boundary for accounting resource consumption within a process and for non-allocatable consumption

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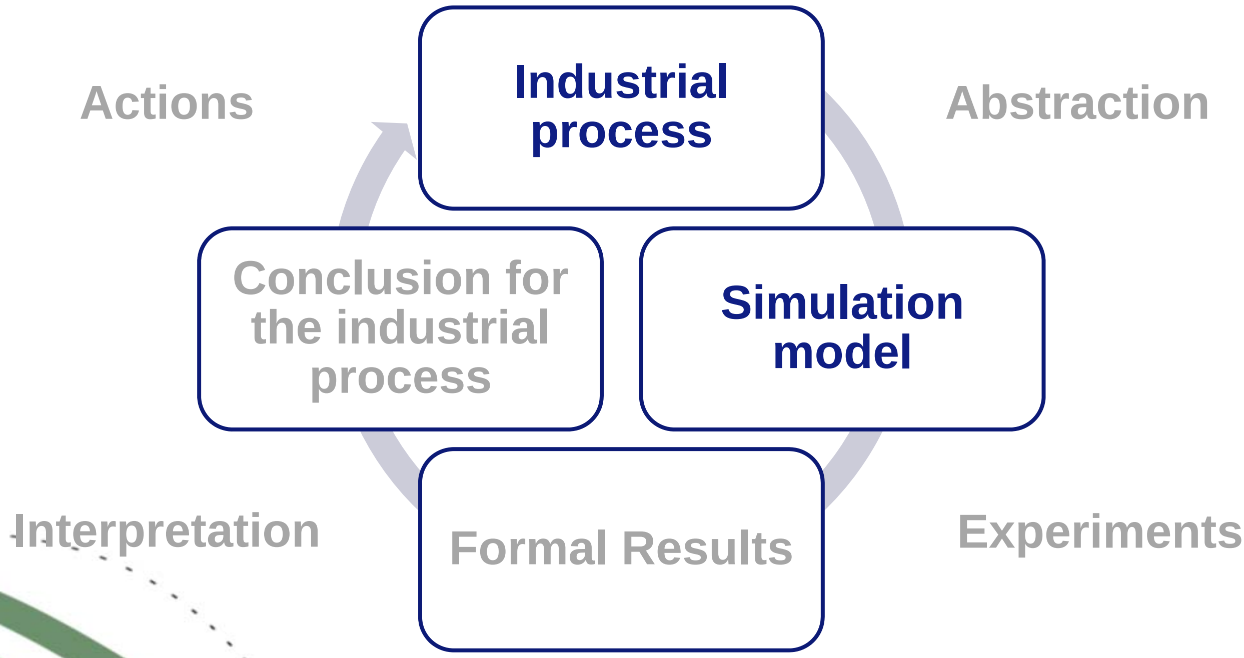

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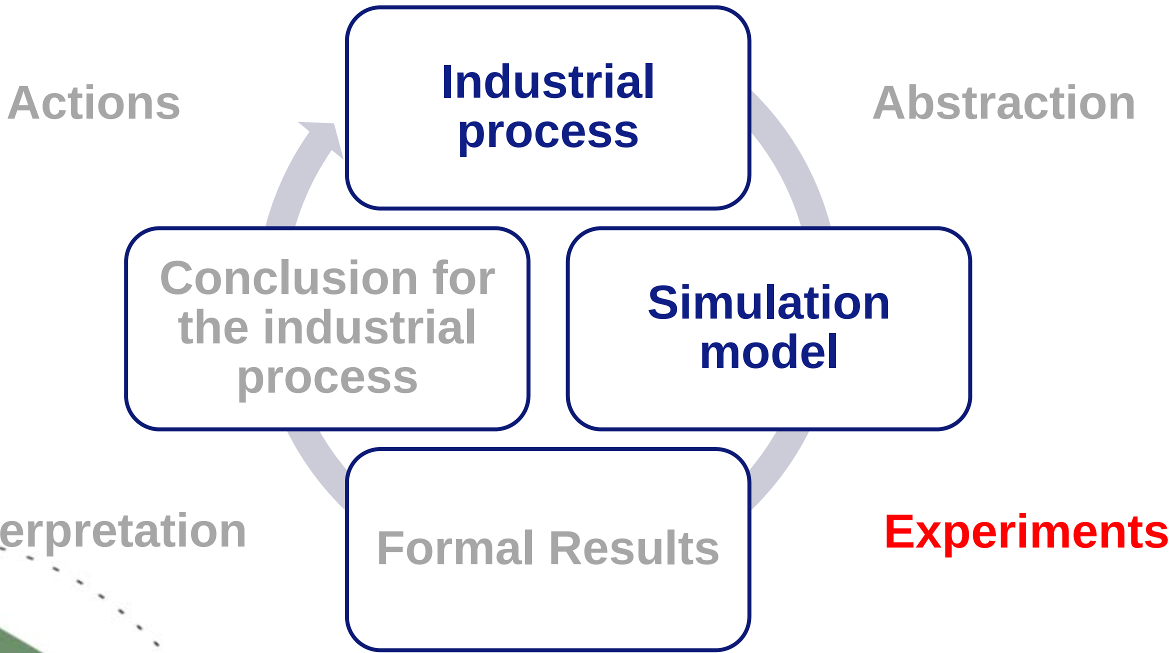
2	Manual inputs				
3					
4			Input Material properties	Output Material Properties	
5	Parameter	Unit	Stage 1	Accepts	Rejects
6	volumetric flow rate	l/min	25000,00	32676,73	823,27
7	consistency	%	0,77	0,56	1,06
8	mass flow rate	kg/min	192,50	183,75	8,75
9					
10					
11	Haindl-McNett				
12	long fibres (sieve 30)	%	16,68	15,02	51,46
13	long fibres (sieve 30)	kg/min	32,11	27,60	4,50
14	short fibres (sieves 50+100)	%	28,02	27,91	30,35
15	short fibres (sieves 50+100)	kg/min	53,94	51,28	2,66
16	fines (sieve 200+P200)	%	55,30	57,07	18,18
17	P200	kg/min	106,45	104,86	1,59
18	Ash				
19	525°C	%	32,71	33,76	10,76
20		kg/min	62,97	62,03	0,94
21					
22	Stickies				
23	total	mm2/kg	426,48	19,86	8738,23
24	small	mm2/kg	38,80	10,31	636,80
25	medium	mm2/kg	55,42	8,07	1049,41
26	large	mm2/kg	332,26	0,00	7307,23
27					
28	Optical charactistics				
29	specific dirt spec area >100 µm	mm2/m2	1574,40	730,76	19073,95
30		mm2/min	7114366,20	3184336,08	3919105,50

Fine Screening | MIX | S1A | S1B | RT1 | S2 | RT2 | S3

Design of the models

	A	B	C	D	E	F	G	H	I	J
34										
35	Separation device specific data									
36		Unit	Stage 1 A	Stage 1 B	Stage 2	Stage 3				
37	Mass reject rate	%	0,34	0,34	0,26	0,29				
38	Spec. Screening Index Long Fibres		0,62	0,62	0,79	0,85				
39	Spec. Screening Index Short Fibres		0,78	0,78	1,33	0,81				
40										
41										
42	Resource consumption calculation data									
43	**Energy**	Unit	Stage 1 A	Stage 1 B	Stage 2	Stage 3	Reject chest 1	Reject chest 2	Mixing point 1	Total
44	feed pump	kW	39,22	39,55	37,01	10,67				126,438181
45	screen rotor	kW	58	58	26	6				148
46	agitator	kW					N.A.	N.A.		0
47										**274,438181**
48	**Water**									
49	Fresh water consumption	l/min	8	8	8	8				32
50	Process water consumption	l/min					2000	1000	4300	7300
51										**7332**
52										

The Process of Modelling



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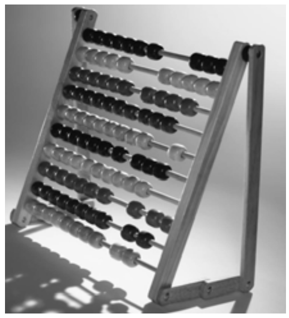
Workflow



Sampling

Laboratory tests

Calculation and modeling

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Calculation of quality parameters and resource consumption

$$SR = f(long\ fibre\ content\ \%, short\ fibre\ content\ \%, fines\ content\ \%)$$

$$WRV = f(long\ fibre\ content\ \%, short\ fibre\ content\ \%, fines\ content\ \%)$$

$$ERIC, R457, Y = f(RR_m, RR_V)$$

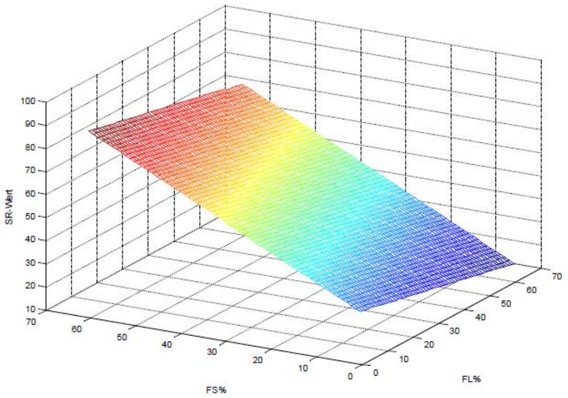
$$Energy\ consumption = f(\Delta p, \dot{V})$$

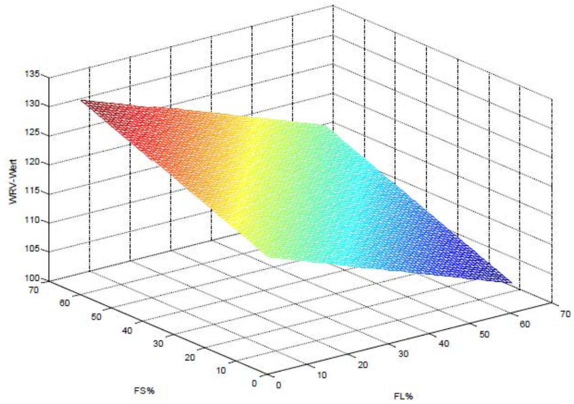
$$Water\ consumption = f(c, \dot{V})$$

Calculation of Schopper-Riegler Value and Water Retention Value

SR(LF, SF, FS)=
-0,0019*LF+0,2511*SF+1,215*FS

WRV(LF, SF, FS)=
0,9515*LF+1,2006*SF+1,4206*FS





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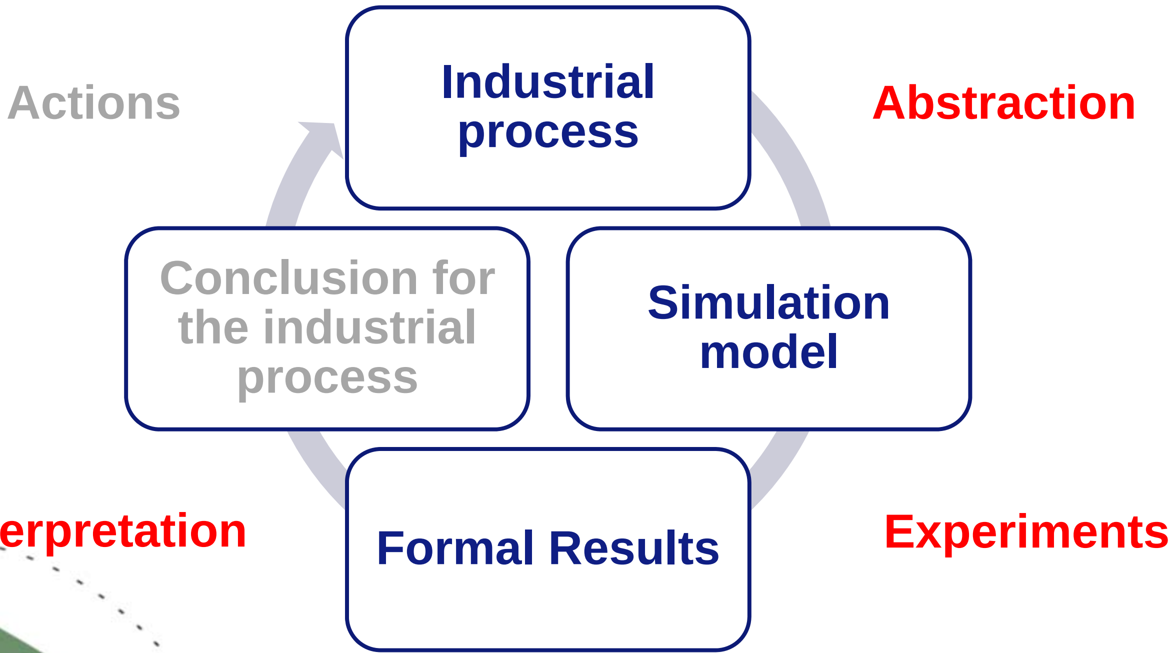


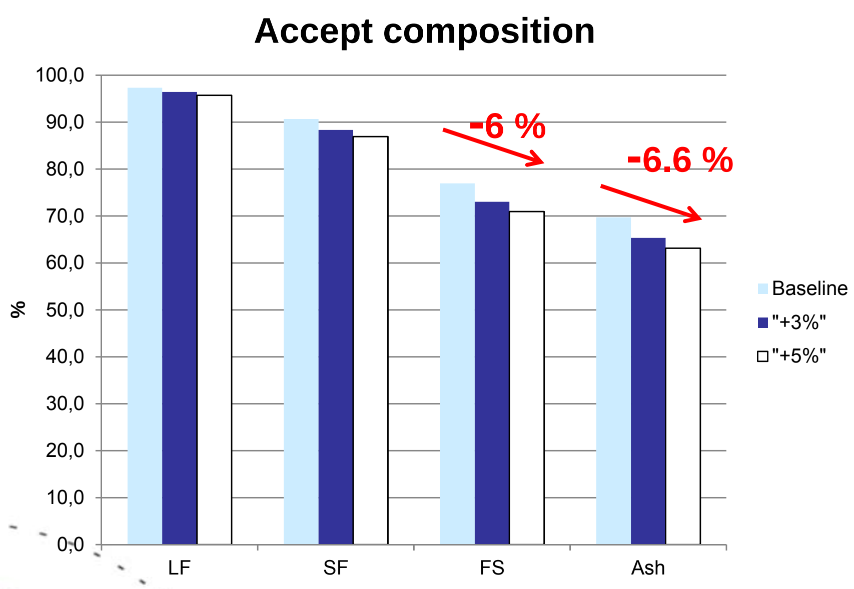
Case Study - Increased rejects in flotation deinking (1)

- Increasing the amount of rejects in flotation deinking results in
  - Higher brightness levels due to ink removal,
  - Reduction of both organic and inorganic fines.
- Also valuable material such as fibres are lost.

- Therefore, a precise forecast of yield and the resulting product qualities becomes necessary.

- As deinking rejects can be used for side stream applications the composition of the rejects becomes more important like before.

Case Study - Increased rejects in flotation deinking (2)



- An increase of the total amount of rejects does not affect the long fibre content in the accepts but reduces the amount of organic and inorganic fines significantly!

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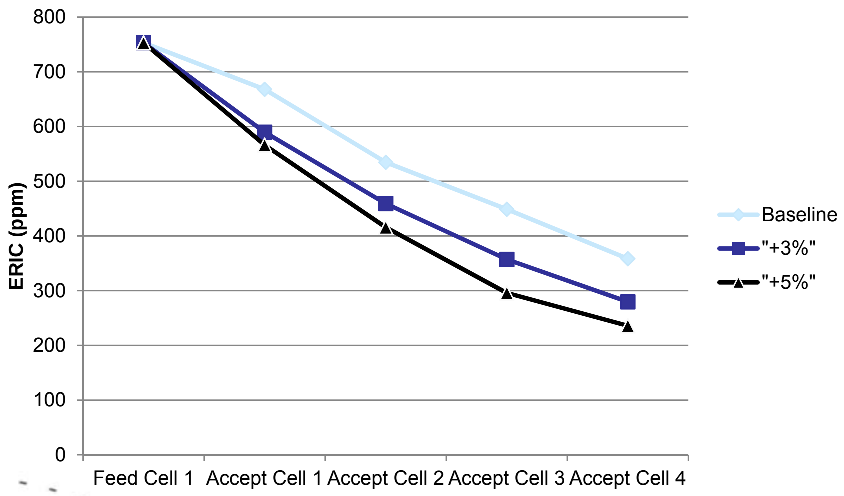
Case Study - Increased rejects in flotation deinking (3)



- An increase in the total amount of rejects of 5 % leads to a decrease of the ERIC value.

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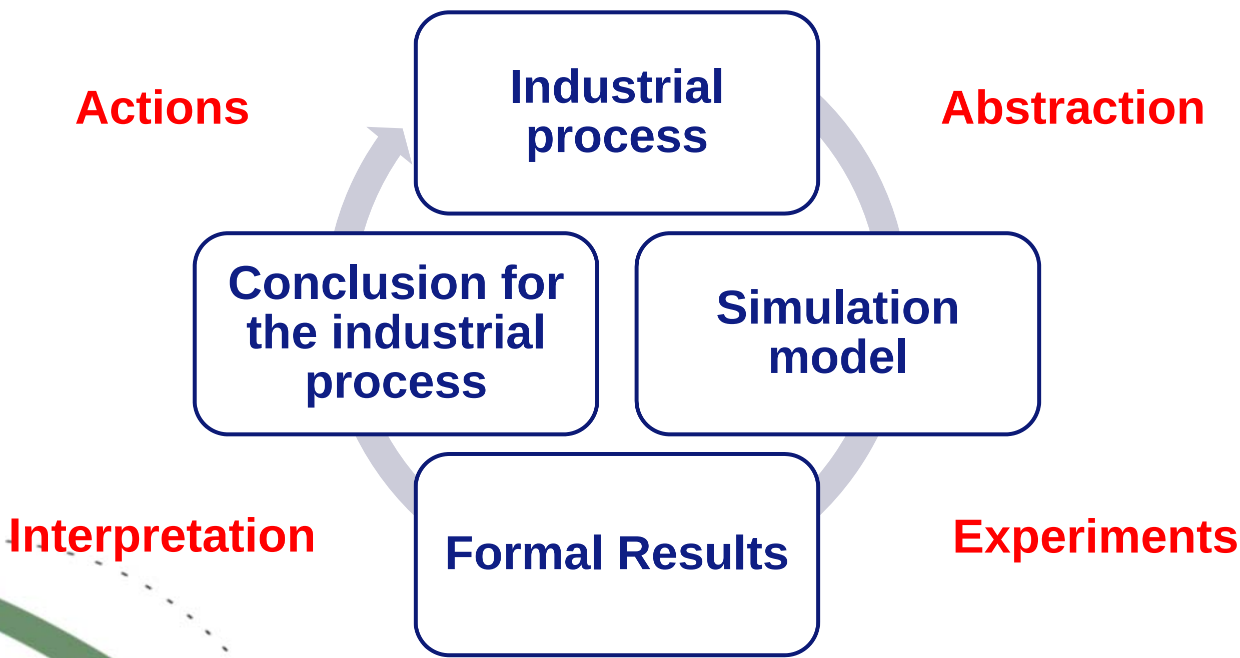
The Process of Modelling



Use of process modelling tools

- Forecast on:
  - Changes in composition of feed material,
  - Changes in reject rates,
  - Changes in the interconnection of process elements,
  - Changes in the resource consumption of different processes.

Conclusions

- There is a need to have an easy tool for companies to skip the time lag in the process chains.

- REFFIBRE project is helping by
  - Modelling the fiber flows within paper mills and predicting pulp properties,
  - Reducing the time lag between the implementation of a change within the process chain and the prediction of the outcome pulp properties,
  - Integrating the modelling in a common tool.

Acknowledgement

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