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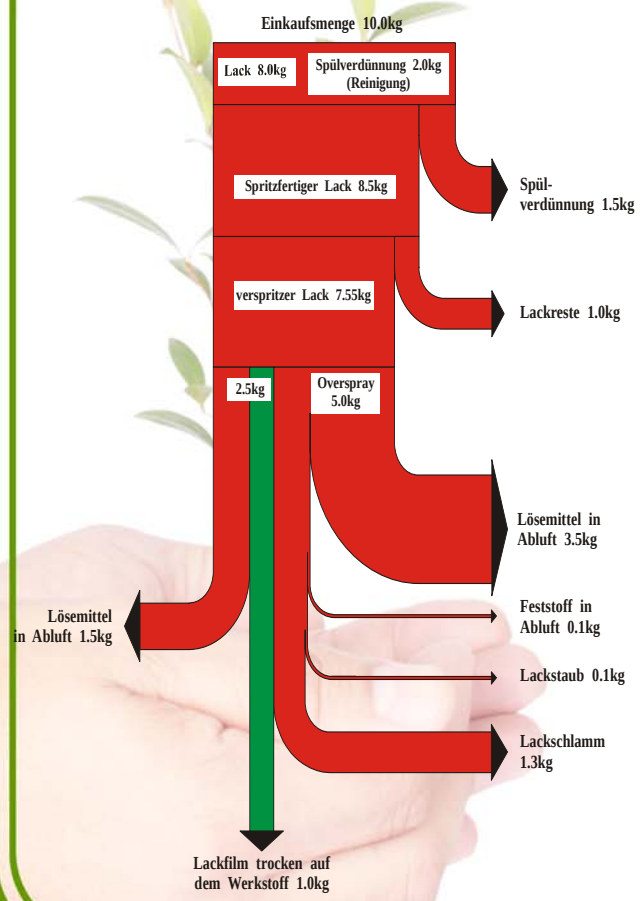
MATERIAL FLOW ANALYSIS



STENUM Ltd.

www.stenum.com

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How does a balance work?

input mass =

output mass

+ storage

(no chemical reaction present)

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Goals of a material flow analysis:

- to observe raw materials through the company
  to demonstrate linkages in the process
- to trace waste and emissions back to the place where they were produced
- to demonstrate weak points (inefficiencies)
- to elaborate the basis of evaluation
- to present data in view of decision making
- to give priority to sensible measures for waste and emission minimization

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What are Materials?

- goods/material (e.g.wood, gravel, PVC)
- elements (e.g. carbon, cadmium)
- compounds (e.g. benzene, methane)

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Selection criteria

- Quantity:
  - Mass
  - Cost
- Quality:
  - Toxic properties
  - Legal requirement
  - Storage restrictions, etc.

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How do we make a material flow analysis?

1. Definition of goals and considered parameters
2. Limitation of the balance-space
3. Limitation of the balance-period
4. Recording and Defining the production steps
5. Drafting the flow sheet: material flows - in quality
6. Balances: material flows - in quantity
7. Interpretation and conclusions

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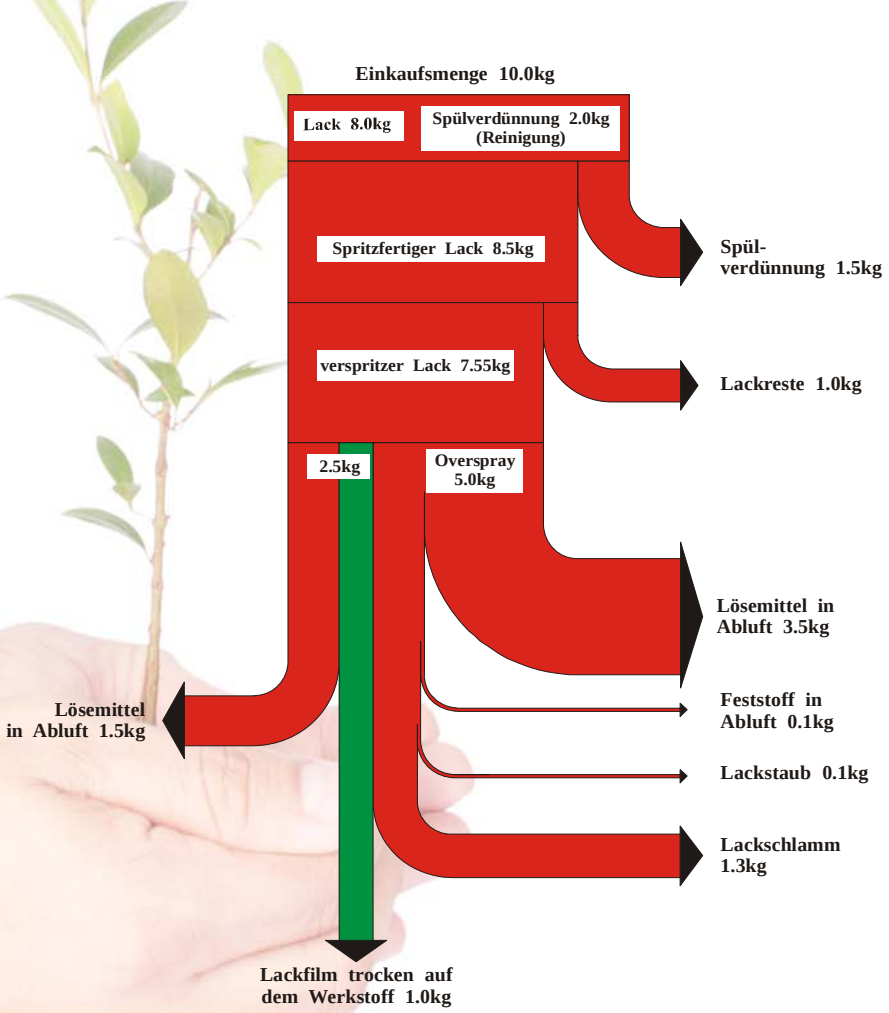
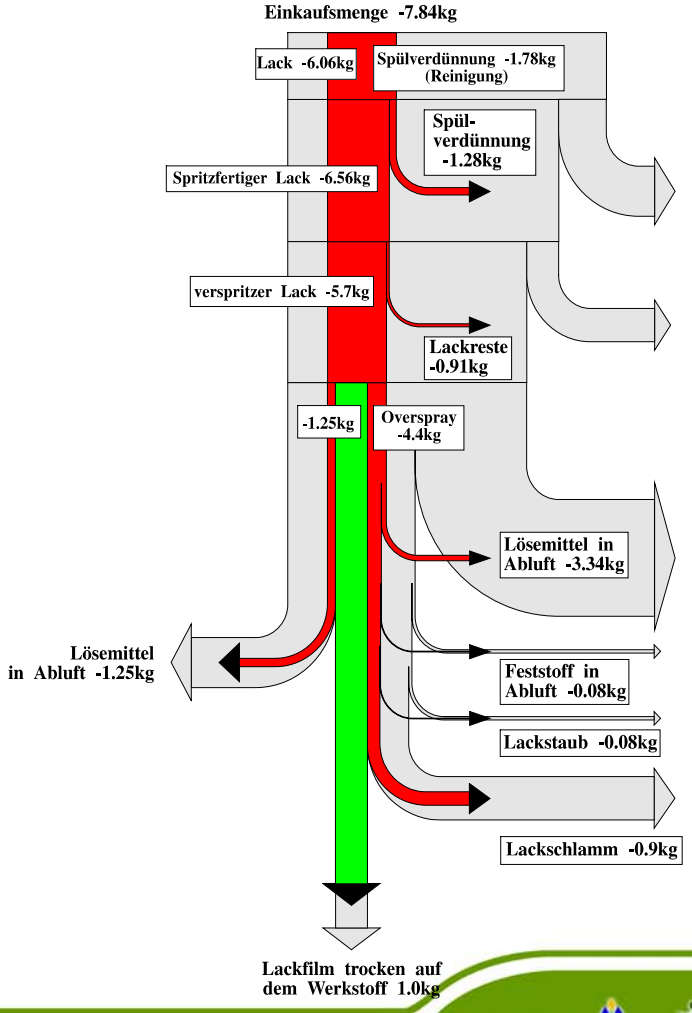
Material flows in a car repair workshop





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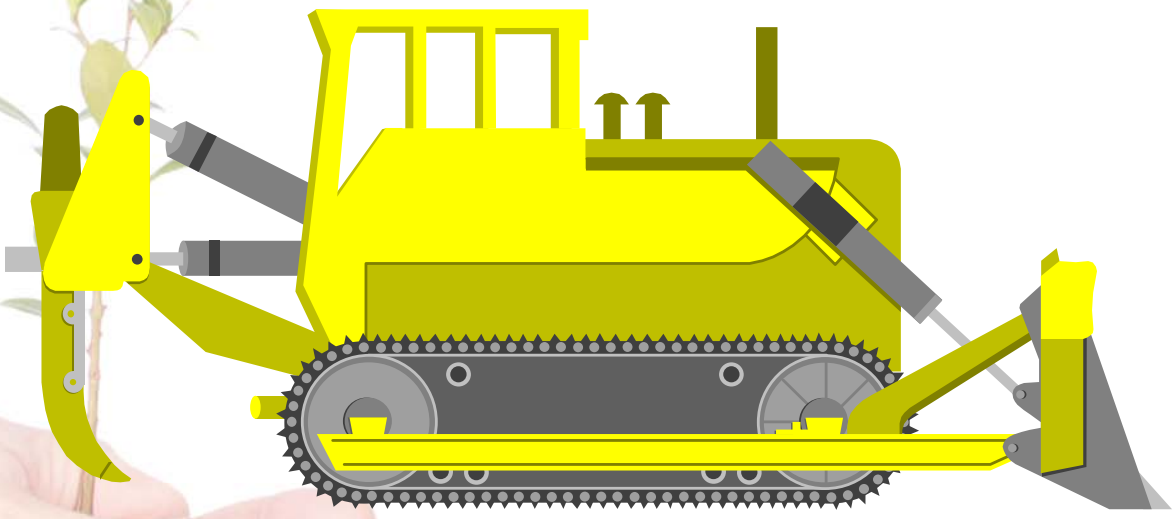
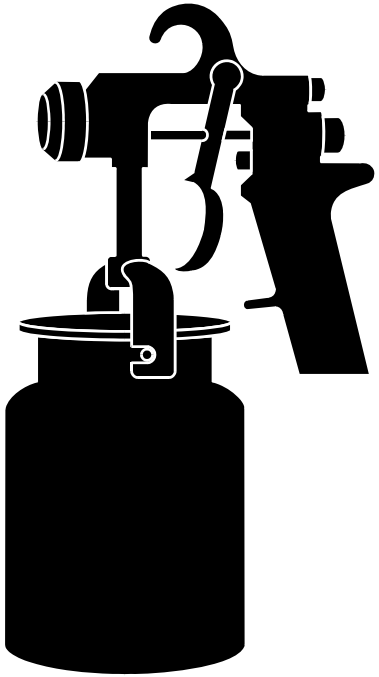
Material flow analysis of machine painting





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Step 1: considered parameters

paints, solvents, (all process materials)

Step 2: balance-space

painting chamber and drying

Step 3: balance-period

1 year

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Step 4: Operating steps within machine painting

Operating steps:

- pre-treatment
- priming, painting
- drying

additional equipment:

- steam generator
- exhaust air filter
- spraygun- and container cleaning

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Step 5: Flowsheet

- Representing process steps with rectangles
- Representing process steps with arrows

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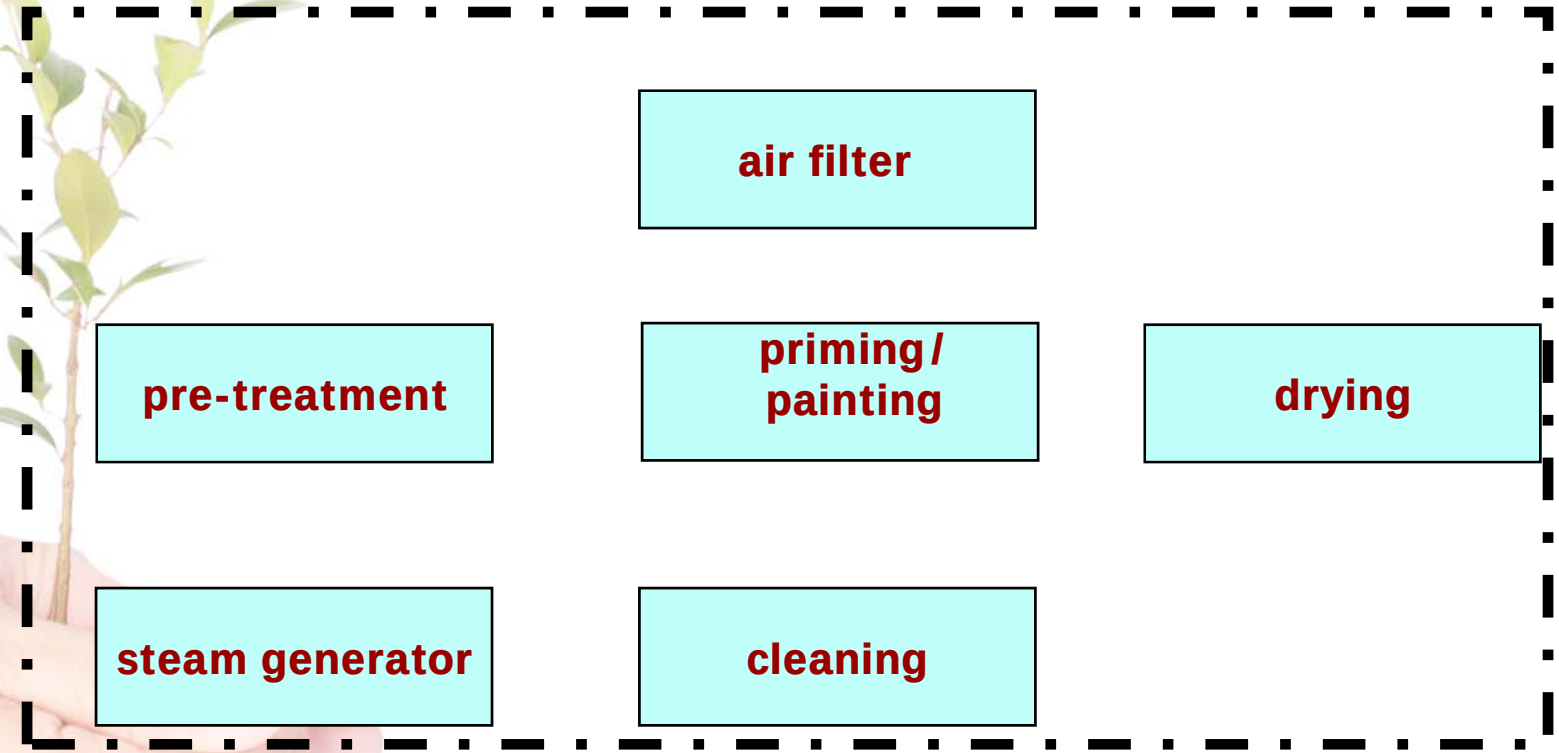
Step 5: Flowsheet



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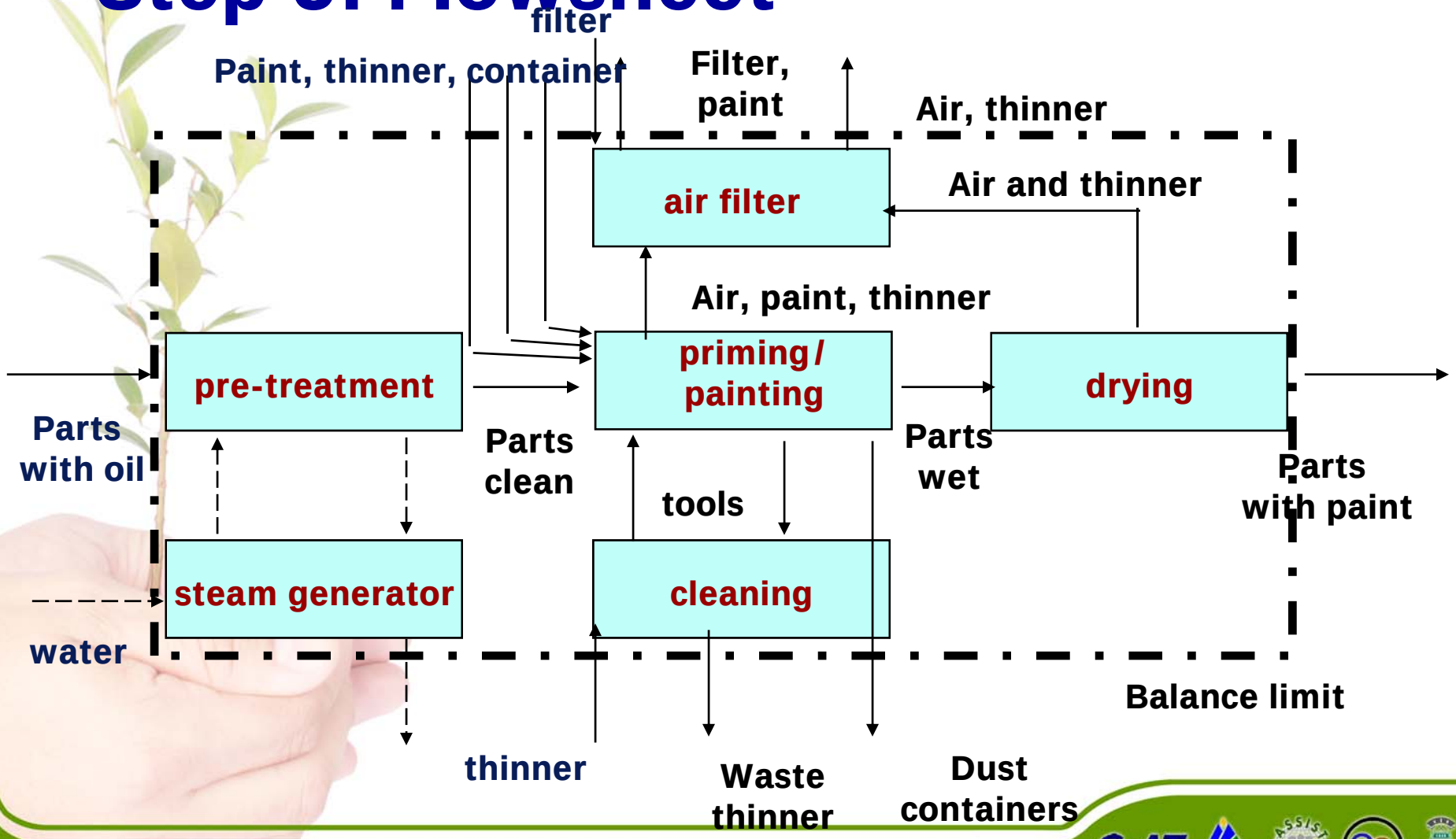
Step 5: Flowsheet



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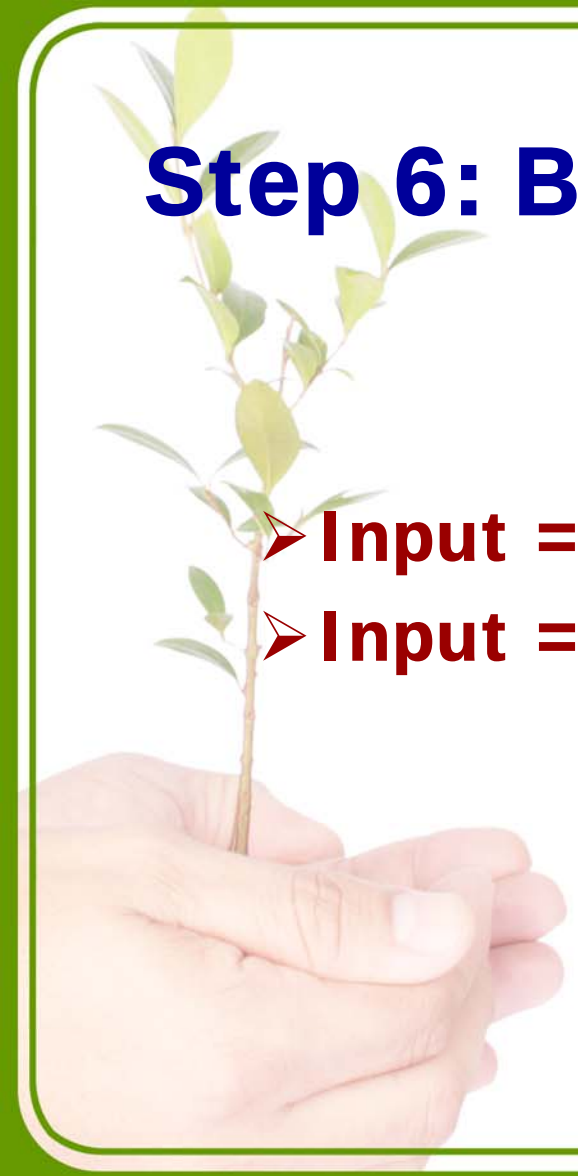
Step 6: Balances



- Input = Output for the whole system
- Input = Output for the single steps

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Quantitative material flow analysis

Material flow analysis – flow data

Stream		Quantity	Unit	Stream		Quantity	Unit
E1	Oily workpiece	20400	kg	A1	Workpiece With paint	20000 800	Kg Kg
E2	Steam, water	9500	M^3	A2	Waste water With oil, sludge	50000 400	Kg Kg
E3	Detergent	60	L	A3	Air solvent	101 mi. 3600	M^3 Kg
E4	Filler	120	Kg	A4	Dust	100	Kg
E5	Hardening agent	24	Kg	A5	Container	n. q.	
E6	Films	150	M^2	A6	Spent solvent	1400	kg
E7	Tape	450	Roll	A7	Spent filter	2700	kg
E8	Pressurized air	39000	M^3	A8	Sludge	393	Kg
E9	Air	59 million	M^3	A9	Covering material	n. q.	
E10	Paint Solvent	4000 2000	Kg kg				
E11	Solvent	3000	Kg				
E12	Air	42 million	M^3				
E13	Filter	100	kg				

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Quantitative material flow analysis

Balance for solvents

Input			
E10	Solvent in paint	2000	Kg
E11	Solvent	3000	Kg
Total		5000	kg

Output			
A2	Solvent in exhaust air	2700	Kg ???
A6	Spent cleaning solvent	1400	Kg
A8	Paint sludge	393	kg
	Losses	*507*	*kg ???*
Total		5000	kg

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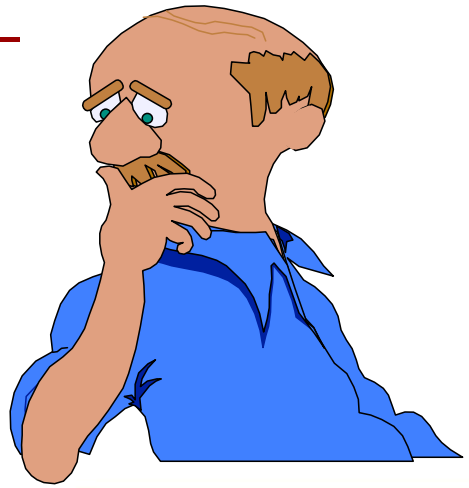
Step 7: Interpretation

e.g. through parameter identification

Calculation of the so called „Application efficiency":

$$\text{efficiency} = \frac{\text{dry surface film mass}}{\text{solid state mass}}$$



in the concrete case for small pieces < 10%

in the concrete case on average < 20%

State of the art?

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Typical efficiencies (application efficiency, expressed as % solids):

Conventional	35-50%
HVLP	50 – 70%
Airless	40-75%
Electrostatic	50-85%
Rotating disc	75-90%
Dipping	90%
Pouring	95%
Rolling	98%

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Typical resource consumption data

in European breweries

Country	Water *(hl/hl)*	Heat *(MJ/hl)*	Electricity *(kWh/hl)*
Spain	5.3 - 11.9	114 - 262	9.2 - 19.7
Germany	6.6 - 8.6	153 - 244	11.0 - 16.0
United Kingdom	5.9 - 11.1	155	12.5
Norway	7.4 - 10.6	209 - 232	19.2
Denmark	4.1 - 8.7	120 - 228	6.6 - 16.9

Note 1 litre of oil equals 39.6 MJ

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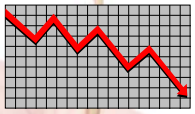
Evaluation of material flow analysis

Flowsheets — **to illustrate material flows and processes,**

Pie charts and histograms — **to illustrate distributions and compositions,**



X-Y-graphics — **for chronological illustrations**

Sankeydiagramme — **to visualize material flows true to scale**

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Evaluation of material flow analysis - 2

Indicators:

e.g.:

Efficiency factors (ratio between use and expenditure)

Quality factors (ratio between real efficiency factor and the theoretically possible one)

Linkage

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Data sources

- Book-keeping
- Storage keeping
- Collection of process data
- Operational accounting
- personal information (e.g. methods engineer)
- Estimation
- Measurements
- Original documents
- own measurements
- ...

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Data collection: the „waste box“

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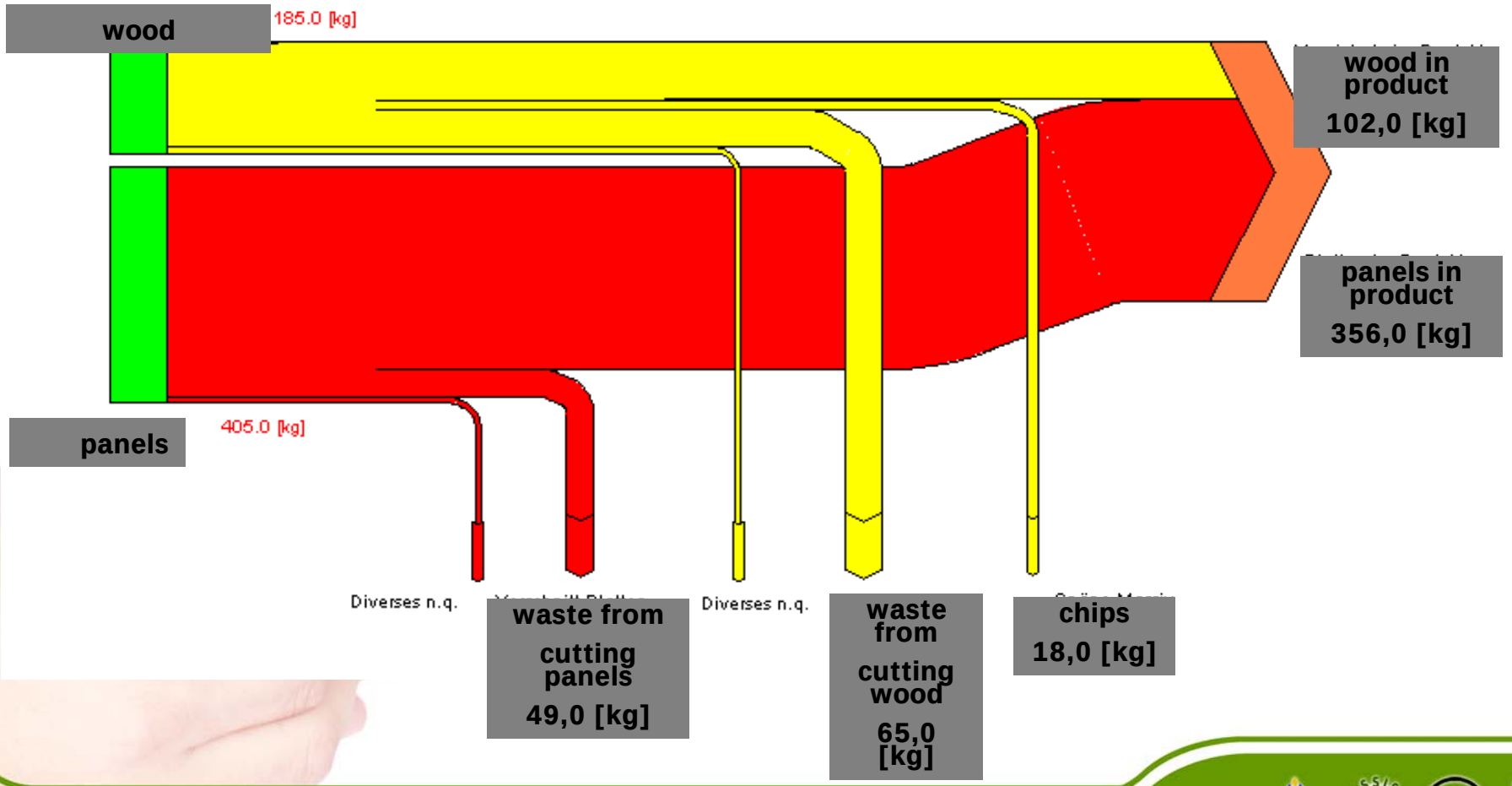
Evaluation of the „waste box“:



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Material flows in a car repair workshop