

Re-designing the Coffee-maker SIEMENS TC 40105

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Introduction

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- Assuming the average person, older than 16 years, drinks 1 cup of coffee per day in Slovenia: 2.000.000 - 350.000 (younger than 16 years) = 1.650.000 people * 365 days = 0,6 billion coffees per year in Slovenia
- more than 400 billion cups of coffee per year around the world (Droga Portoroz, <http://www.droga.si/default.asp?id=201>)
- Types of coffees common in Slovenia:
 - filter coffee (as in Germany and USA)
 - turkish coffee (mainly Turkey, Greece, Bosnia, Montenegro)
 - espresso coffee (mainly in cafes and bars)
 - moka coffee (the modern form of coffee)
- Drinking coffee is strongly associated with personal habits, social life and national tradition.

Introduction

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Siemens produces filter coffee makers of two kinds (<http://www.siemens-hausgeraete.de>):



Type I: A filter bracket is attached to the machine skeleton and is swayed sideways when a filter is changed.



Type II: A filter bracket is not attached to the machine skeleton but is stuck upright in the machine when a filter is changed.

- Our coffee maker under study is made by Siemens and is of type 1.
- Its industrial code is TC 40105.

A filter coffee-maker

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Characteristic parts of the machine are
(<http://www.siemens-hausgeraete.de>):

- Compact structural shape with water canister
- A filter bracket
- Glass pitcher
- Electrical parts (cables, electrodes)
- Warming parts (heating pipe, heating plate)
- Button and light

A coffee maker consists of approximately **30 components**, some of which are complex and impossible to further disassemble.

Measurements of the coffee-maker

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DISSASSEMBLY OF COFFEE-MAKER

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CHARACTERISTIC PART	COMPONENT	# PRESENT	MATERIAL	TOTAL WEIGHT (g)
COMPACT STRUCTURAL SHAPE WITH WATER CAMISTER	SKELETON	1	PP - WHITE	426
	BASIC PLATE	1	PP - BLACK	104
	CABLE COIL	1	PP - BLACK	55
	LIDS	2	PP - WHITE	36
	RUBBER FEETS	3	RUBBER (GREY)	2
FILTER BRACKET	BRACKET	1	PP - WHITE	128
GLASS JUG	GLASS JUG	1	GLASS	246
	HANDLE	1	PP - BLACK	19
	LID	1	PP - BLACK	22
	FRAME	1	METAL	12
	SCREW	2	METAL	4
ELECTRICAL PARTS (CABLES, ELECTRODES)	CABLES	4	PLASTIC, METAL, ETC.	126
WARMING PARTS (HEATING PIPE, HEATING PLATE)	HEATING PIPE	1	ALUMINIUM, CERAMICS	74
	HEATING PLATE	1	ALUMINIUM	76
	RUBBER PIPES	4	RUBBER	20
	SUPPORTING WIRE	1	METAL	2
BUTTON AND LIGHT	BUTTON	1	MIXED	5
	CONNECTOR	1	MIXED	4
	CLING	1	METAL	1

DISSASSEMBLY OF COFFEE-MAKER

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MATERIAL	# COMPONENTS	TOTAL WEIGHT (g)
PP - WHITE	4	590
PP - BLACK	4	200
STEEL	5	19
ALUMINIUM	2	150
GLASS	1	246
RUBBER	7	22
MIXED	6	135
SUM	29	1.362

- 7 DIFFERENT MATERIAL COMPOSITIONS
- 29 PARTS, 6 OF THEM COMPLEX
- COMMON WEIGHT OF COFFEE MACHINE: 1,4 kg

TIME OF DISASSEMBLY: 15 MINUTES, TIME OF RE-ASSEMBLY: 20 MINUTES

RESULTS: AFTER RE-ASSEMBLY THE MACHINE STILL OPERATES

Packaging

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Packaging size (cardboard box):

$$350 \times 220 \times 260 \text{ mm} = 0.496 \text{ m}^3$$

Cardboard size & weight:

$$0.496 \text{ m}^3 \times (500 \text{ g/m}^3) = 248 \text{ g}$$

Recycling Potential

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- Short disassembly time
- Use of snaps for assembly (only 2 screws used)
- No evident hazardous materials
- Certain parts are impossible to disassemble, but there exists the possibility of thermal splitting (warming pipe, consisting of ceramics and aluminium).
- Ability to re-assemble - **a potential for re-use**

Recycling Potential

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- **PLASTICS:** Recycling of polypropylene (PP) is technically possible (http://www.visionengineer.com/env/pp_recycling.php), but the obstacles are its separation from its own variations and other plastics. Re-use of old parts to produce new ones represents an encouraging alternative.
- **METALS:** can be recycled and re-used by melting.
- **GLASS:** can be recycled by melting if small amount of ceramics is included (<http://www.gpi.org/Handling.html>).
- **RUBBER:** could be recycled and reused (www.itdg.org/docs/technical_information_service/recycling_rubber.pdf), but parts installed in coffee maker are low weighted and small.
- **CERAMICS:** could be re-used after metal removal by melting
- **Mixed-material parts:** cables could be recycled (seen in "Srebrni loti" firm), other parts are small and low-weighted.

RECYCLING POTENTIAL

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MATERIAL	TOTAL WEIGHT (g)	PERCENTAGE OF RECYCLING POTENTIAL (%)
PP - WHITE	590	100
PP - BLACK	200	100
STEEL	19	100
ALUMINIUM	150	100
GLASS	246	100 (? - IF NOT CONTAINING MUCH CERAMICS)
RUBBER	22	100 (COULD BE RE-USED)
MIXED	135	95 (CABLES ONLY)
SUM	1,362	99,3%

99,3 % OF MATERIAL COULD BE RECYCLED, WHICH EQUALS 1,353 GRAMS.

THE REMAINING 9 GRAMS WOULD BE LANDEILLED OR EVEN RE-USED.

Annual Sales & Quantities (for Siemens TC 40105 only)

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3 sources investigated:

- Slovenian statistical office (only quantities of some kitchen appliances per home) – no adequate data available
- Contact with inquiry and research firm, named GtK Gral Iteo - no response
- Contact with Siemens AG

Total sales of Siemens TC 40105 in Slovenia	138
Total sales in EU *	31000
Annual sales in EU **	10333

* Total sales in EU is based on assumption that EU has population of 450 mio compared to 2 mio in Slovenia.

** Siemens TC 40105 has been on the market for three years – annual EU sales represents approximately 1/3 of total EU sales.

Annual Sales & Quantities

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During our research we have found out that the design used in Siemens TC 40105 is sold under three different brand names:

- SIEMENS,
- BOSCH, and
- GORENJE.

For that reason we have tripled our existing sales numbers (see previous page) as follows*:

Total sales of Siemens TC 40105 and other two brand names	414
Total sales in EU	93000
Annual sales in EU	31000

* Based on assumption that all three brand names have an equal market share.

Required petroleum

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	Plastics (kg)	kg Petroleum/ kg Plastics	Total Petroleum used (kg)
Our coffee maker	0.79	2	1.58
Total sales in Slovenia	327	2	654
Total sales in EU	73470	2	146940
Annual sales in EU	24490	2	48980

Required energy for coffee-maker assembly (without packaging)

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Material	Annual quantity in EU (kg)	Total quantity in EU (kg)	Specific Energy Requirements (kJ/kg)		Total (annual) Energy Requirements (GJ)		Total Energy Requirements (GJ)	
			Primary source	Recycled source	Primary source	Recycled source	Primary source	Recycled source
Plastics	24490	73470	74300	42300	1820	1036	5459	3108
Steel	589	1767	40000	18100	24	11	71	32
Aluminium	4650	13950	279720	40320	1301	187	3902	562
Glass	7626	22878	30000	13000	229	99	686	297
Rubber	682	2046	67600	---	46	12	138	37
Mixed	4185	12555	60000	45000	251	188	753	565
Total	42222	126666			3670	1534	11010	4602

Packaging resources (paper)

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	Paper (kg)	Resource/kg paper	Total resources
		Trees	Total trees used
Single coffee-maker	0.248	0.017	0.004
Annual sales in EU	7688	0.017	131
Total sales in EU	23064	0.017	392
		Electricity (kWh)	Total electricity used (kWh)
Single coffee-maker	0.248	10.061	2,5
Annual sales in EU	7688	10.061	77349
Total sales in EU	23064	10.061	232047
		water (m³)	total water used (m³)
Single coffee-maker	0.248	0.025	0.01
Annual sales in EU	7688	0.025	192
Total sales in EU	23064	0.025	577
		oil (kg)	total oil used (kg)
Single coffee-maker	0.248	1.7136	0,4
Annual sales in EU	7688	1.7136	13174
Total sales in EU	23064	1.7136	39522

Required filter-paper for operation

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	Paper (kg) per year *	Resource/kg paper per year	Total resources per year
		Trees	Total trees used
Single coffee-maker	0.73	0.017	0.01
Annual sales in EU	22630	0.017	385
Total sales in EU	67890	0.017	1154
		Electricity (kWh)	Total electricity used (kWh)
Single coffee-maker	0.73	10.061	7.3
Annual sales in EU	22630	10.061	227680
Total sales in EU	67890	10.061	683041
		water (m ³)	total water used (m ³)
Single coffee-maker	0.73	0.025	0.02
Annual sales in EU	22630	0.025	566
Total sales in EU	67890	0.025	1697
		oil (kg)	total oil used (kg)
Single coffee-maker	0.73	1.7136	1.3
Annual sales in EU	22630	1.7136	38779
Total sales in EU	67890	1.7136	116336

* Based on assumption that each coffee-maker uses 1 filter-paper (2g) per day.

Energy required for operation

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	Electric Power (W)	Annual Electricity Consumption (kWh) *	Total Electricity Consumption in EU (kWh)	Total Electricity Consumption in EU (GJ)
Our coffee maker	750	82.1	246.4	0.89
Total sales in Slovenia	310500	34000	101999	367
Total sales in EU	69750000	7637625	22912875	82486
Annual sales in EU	23250000	2545875	7637625	27495

* Based on assumption that electric heater of single coffee-maker operates 0.3 hours per day (in average).

Energy Hierarchy

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Production

- 11010 GJ in EU (virgin materials)
- or
- 4602 GJ in EU (recycled materials)

Operation

- Electricity use for operation: 82486 GJ in EU
- Electricity use for making filter paper (per year): 2459 GJ in EU
- Electricity use for making packaging paper: 835 GJ in EU

- Electricity consumption is far most important energy related issue.
- If coffee makers are made from recycled materials instead of virgin materials, the energy consumption for production is reduced more than 50%.
- We did not find any data about energy consumption of transportation, but we assume it to be low (we have not taken it into account in our calculations)
- We did not find any data about energy consumption of assembly and disassembly, but we assume it to be low (short time of disassembly)

General assumptions for re-design

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- We assumed that the efficiency of electric heating device could not be significantly improved (mainly because of its simplicity – i.e. conversion of electrical energy into thermal energy).
- However, we established that electricity consumption could be reduced by improving thermo-isolative characteristics of coffee-maker (thermo jug).
- Packaging could not be reduced due to the safety reasons (if we use less paper then product could be easily damaged during transportation).
- The size and mass of product could not be significantly reduced otherwise it could easily lose its practicability.

Coffee-maker alternatives

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Industrial ecology paradigm	Alternative	Type	Intensity of change
AVOIDANCE/ SUBSTITUTION	Avoid drinking coffee	Social / habits change	Deep green
	Turkish or mocca coffee	Product change	Deep
	Coffee automat (service)	Product change	Deep
REDUCTION	Bigger capacities of coffee makers (use in offices)	Dematerialization	Shallow /moderate
	Use of warmth keeper (thermo jug)	Reduction of E consumption	Moderate
	Redesign of water reservoir (a hole instead of cover)	Reduction of parts number	Moderate
REUSE	Redesign cables	Dematerialization	Moderate
	Reuse of technical parts (thermostats, heating parts)	Dematerialization	Moderate
	Reuse of rubber parts (pipes, foos)	Dematerialization	Shallow / moderate
RECYCLING	Re-design a skeleton of machine (reducing No. of parts)	Design for recycling	Moderate
	No use of ceramics in glass	Design for recycling	Shallow
	Replace rubber with plastic	Design for recycling	Shallow
	Material identification	Design for recycling	Shallow

Redesigning the coffee-maker

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To further calculate material and energy savings we redesigned the coffee maker in the following way:


- Substitution of glass jug with thermos (additional 141g of plastics needed) in order to keep coffee warm and avoid a need for re-warming (we assumed electricity savings of 30%):




Coffee maker with thermos jug

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- Substitution of paper filters with permanent metal (additional 4g of metal needed) or fabric filter in order to eliminate paper consumption:



Metal filter



Cotton filter
- Redesign of power cable - enabling the cable to be separated (detached) from coffee maker and reused (126g of materials savings):



Detachable cable

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Recalculated material and energy consumption

Material	Annual quantity in EU (kg)	Total quantity in EU (kg)	Specific Energy Requirements (kJ/kg)		Total (annual) Energy Requirements (GJ)		Total Energy Requirements (GJ)	
			Primary source	Recycled source	Primary source	Recycled source	Primary source	Recycled source
Plastics	28861	86583	74300	42300	2144	1221	6433	3662
Steel	713	2139	40000	18100	29	13	86	39
Aluminum	4650	13950	279720	40320	1301	187	3902	562
Glass	7626	22878	30000	13000	229	99	686	297
Rubber	682	2046	67600	---	46	12	138	37
Mixed	4185	12555	60000	45000	251	188	753	565
Total	46717	140151			4000	1721	11999	5163

Energy required for operation

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	Electric Power (W)	Annual Electricity Consumption (kWh)	Total Electricity Consumption in EU (kWh)	Total Electricity Consumption in EU (GJ)
Our coffee maker	750	57.5	172.5	0.62
Total sales in Slovenia	310500	23800	71399	257
Total sales in EU	69750000	5346338	16039013	57740
Annual sales in EU	23250000	1782113	5346338	19247



MORE THAN 30% OF ENERGY COULD BE SAVED IF WE USE RE-DESIGNED PRODUCT AND MATERIALS RECYCLING!

Conclusions

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- Most of energy is used for operation. Redesign should be focused primarily on energy consumption required for heating, since it represents approximately 85% of all required energy in our product Life-Cycle-Assessment.
- A significant opportunity for energy savings (more than 30%!) and consequently also for pollution reduction emerges with replacement of a glass juf for a thermo jug.

Conclusions

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- Further reduction of materials (dematerialization) for product assembly is difficult to achieve – current product is already well designed (the same design is used by three different companies – brand names!)
- All of our chosen re-design steps (thermo jug, metal filter and removable cabling) are already implemented in some other Siemens's models – however, also at higher product price!