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Examination of the processing of end of life railway towing vehicles

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Recy & DepoTech

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FACULTY OF EARTH SCIENCE & ENGINEERING

Institutes:

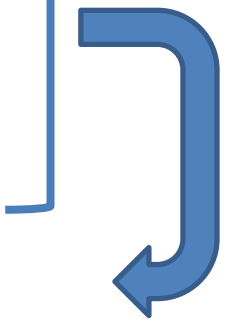
- **Institute of Raw Material Preparation and Environmental Process Engineering (Established in 1923 as *Department of Ore and Coal Preparation*)**
- Institute of Minerology and Geology
- Institute of Mining and Geothechnical Engineering
- Institute of Geography
- Institute of Geophysics and Spatial Informatics
- Institute of Environmental Management
- Institute of Petroleum and Natural Gas Engineering

Introduction

- Circular Economy: waste processing and recovery of the generated waste plays a key role
- Many rail vehicle are purchased and planned in Hungary in the near future
- Developments on the rail network in Hungary

  (e.g.: electrification on Budapest – Serbia, on Nord-Balaton)

Locomotive scrapping



- Two investigated Locs: one diesel-hydraulic and one electric locomotive (MÁV)
- The demolition began with dangerous units/parts, followed by the frame structure, the units of the interior, and the demolition of the chassis and the bogies.
- The theoretical maximum value of the locomotives was estimated (London Metal Exchange) for year 2019 and 2022.

Literature overview

- Number of literature on the dismantling of railway vehicles is low.
- Recycling rate of materials from railway vehicles that have reached the end of their life is very high, approx. 90%
- Railway vehicle: 45.4% magnetic, 32.5% non-ferrous metals, rest the non-metallic fraction aprox. 22%.

	Railway Vehicle [%]	Personal vehicle [%]	Buses [%]
Ferrous metals	45,4	64	35
Non-ferrous metals	32,5	9	6
Plastics	2,6	8,5	14
Ruber	3,1	7,5	15
Glass	2	3,5	12
Liquid	1,8	2,5	2,5
Electronic.	1,20	0,1	1
Other	11,4	4,9	14,5
∑	100,0	100,0	100,0

Composition of railway vehicles, examples (Delogu et al, 2016)

OPTISOL Project (Alcufer Ltd., UM, other partners)

End of Life Commercial Vehicles

- Dismantling is not regulated in EU
- Ratio of electronic parts increasing
  Processing technology is necessary!
- Composite fractions (plastic covering, seats, etc.)
  Processing technology is necessary!

Main group		Ikarus 395		Ikarus 260		Ikarus c56	
		Mass [kg]	Mass. [%]	Mass [kg]	Massr. [%]	Mass [kg]	Massr. [%]
External Components	headlamps, direction indicators, taillights	1,3	0,01	n.a.	0,00	3	0,03
Internal Components	Electronic components (e.g.: connectors, electrical wiring, speakers, lighting fixtures, printed circuits)	191,2	1,76	108,1	1,00	270	2,48
	Relay boxes	n.a.	0,00	n.a.	0,00	41	0,38
	Air conditioner	162	1,49	0,0	0,00	n.a.	0,0
	Other: (Battery)	111	1,02	n.a.	0,00	118	1,08
Total		465,5	4,28	108,1	1,00	432	3,97

Locomotive types involved in research 1.

- **MÁV 438** series of the Hungarian State Railways: medium-duty diesel-hydraulic locomotive for non-electrified tracks
- Drive: diesel-hydraulic, power transmission via cardan shafts.
- Original number at HSR: 168,
- current number at HSR: 8.
- Production: 1974-1979.

Locomotive types involved in research 2.

- **MÁV 431** series with silicon rectifiers is the largest series of electric locomotives ever delivered to HSR
- Production: about 400 units between 1963 and 1982;
- Current number: 258 units.
- Producer: GANZ-Mávag (Ungarn)

Demolition process, analysis 1.

- Demolition place: **Alcufer Ltd. (Partner of UM)** site in Szolnok, under the direction of the Ltd.
- First removed: Windshields and other glasses from the towing vehicles, and the superstructure was lifted from the chassis.
- After unpacking the larger units, they were grouped according to different material categories, and the sub-units were further broken down.

Demolition process, analysis 2.

- After each piece was unpacked, disassembled and analyzed for metal composition, chassis was cut and lifted from the rail, and the axles were also cut out from under the bogies („Reuse”: e.g. rectifier, axles).
- In the last phase, the metal composition of the units was analyzed and weighed. (Olympus Vanta portable, hand-held XRF alloy and precious metal analyzer). Simplyfied method.
- In the case of bogies or axles, 1 each was weighed.
- Estimation of composition, based on results.

Results 1.

- Romanian Type MÁV 438 locomotive nearly complete (93%), the incoming weight was 42.64 t (service weight: 46.00 t). Long storage before dismantling.
- Hungarian Type MÁV 431 incoming mass 70.86 t (with other transformer) (service weight: 80.00 t) (89%)
- There are units that can be found in both types of locomotives, e.g.: the frame structure, air system.

	Series 438		Series 431	
Main Units	**Mass [kg]**	**Composition [%]**	**Mass [kg]**	**Composition [%]**
Frame structure	14706	99,23 (Fe), 0,77 (Glass)	14685	99,08 (Fe), 0,92 (Glass)
Bogie	12840	100 (Fe)	28120	100 (Fe)
Air system	963	98,86 (Fe), 1,14 (Plast.)	93	88,17 (Fe), 12,83 (Plast)
Other electrical eq., electronic	600	49,17 (Fe), 35,83 (Cu), 15 (Plast.)	141	46,81 (Cu), 31,21 (Fe), 20,57 (Al), 1,41 (Plast.)
Other eq.	650	98,46 (Fe), 1,54 (Al)	1888	75,95 (Fe), 4,05 (Al)
Engine and its eq.	6700	97,01 (Fe), 2,99 (Al)		
Diesel eng. And its eq.	5680	96,30 (Fe), 3,70 (Al)		
Main circuit electrical eq.			25365	87,99 (Fe), 11,80 (Cu), 0,12 (Plast.), 0,05 (Wood), 0,02 (Al), 0,02 (Cer.)
Auxiliary electrical eq.			272	97,79 (Fe), 0,37 (Cu), 1,84 (Egyéb)
Other electrical eq.			295	54,24 (Fe), 33,22 (Al), 5,08 (Wood), 4,07 (Cu), 2,37 (Plas.), 1,02 (Cer.)
Other fractions	281	67,97 (Wo.), 14,23(Plas), 13,17 (Oth,), 2,63 (Al)		

Results 2.

- Engine of the 438 series locomotive contains almost only (more than 96%) iron.
- Type 431 locomotive contains a significant amount of copper concentrated in electric traction motors.
- No significant difference in composition between the diesel engine and its service equipment, as well as the auxiliary electrical equipment of the electric locomotive

Results 3.

- For both types, 35-46% of the ***additional electrical equipment*** and other fraction is copper (mainly cables).
- In the case of ***other equipment***, metallic components are still present in a large percentage.
- The ***other factions***, and ***other electrical equipment***, plastic, wood, porcelain appear.

Material composition and theoretical value estimation 1.

- During the estimations demolition and other costs (e.g.: further processing or landfilling of non-metallic materials) were not considered.
- The two types of towing vehicles that were dismantled, the electric locomotive represents a larger value, more than twice as much.
- The copper content of an electric locomotive can be even higher if we are talking about a locomotive that is more complete than the tested

		Series 438 diesel-hydraulic locomotive			Series 431 silicon rectifier electric locomotive		
Compound	**Specific value [USD/t]**	**Weight [t]**	**Weight [%]**	**Value [USD]**	**Weight [t]**	**Weight [%]**	**Value [USD]**
Iron	320	41,297	97,35	13215	66,975	94,52	21432
Aluminum	1700	0,433	1,02	736	0,56	0,79	952
Copper	6000	0,215	0,51	1290	3,073	4,33	18434
Plastic		0,141	0,33	-	0,034	0,05	-
Wood		0,191	0,45	-	0,077	0,11	-
Glass		0,106	0,25	-	0,135	0,19	-
Lining		0,037	0,09	-	0,005	0,01	-
∑27.10.2019		**42,42**	**100**	**15241**	**70,895**	**100**	**40727**
∑27.10.2022				**28997**			**67785**

Material composition and theoretical value estimation 2.

- In 438 series locomotive, the value is given by the iron content above 97%,
- In 431, the theoretical maximum value of the large amount of copper is slightly less than the value of the also respectable amount of iron content,
- The value of the locomotives almost duplicated during the pandemic and the Russian-Ukrainian conflict.

Future

Pesa SM42 6Dn

Stadler

RCH - CRRC Zhuzhou Locomotive Co. Ltd

Summary

- 438 series diesel locomotive contains more than 97% iron, approximately 1% aluminium and 0.5% copper.
- Theoretical maximum value of the locomotive today is 28.997 USD (Series 438).
- Series 431 electric locomotive: over 94 % iron with approximately 0.8% aluminium and over 4% copper was found.
- Theoretical maximum value of it is 67.785 USD.
- Future trends: significant increase of EEE parts in Locomotives: computers, sensors, regulators, accumulators. Waste categories appearing in more waste streams.
- Disappearing of diesel locomotives (HU, EU).
- Estimation process was developed for other type Locomotives (MÁV 418) according to length, number of axes, number of engine cylinder, with good results, for further first estimation.

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Thank You for Your Attention!

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