A NOVEL METHOD FOR USE OF CREOSOTE PRETREATED WOOD IN POWER PRODUCTION

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Objectives

- The aim of the EU Directive 2001/77/EU is to reduce the share of fossil fuel in production of electric power and, along with that, to restrict effluents into the atmosphere.
- Among the most popular uniform waste timber materials are railway sleepers, regularly replaced by the end of the service process, which enables the forecast of their amount with a sufficient precision.
- 1.5 - 2.0 million pieces of railway sleepers are built on the main railway lines and sidings in Latvia. Urgent is the utilisation of 20-30 year-old used-up sleepers, for whose treatment creosote with the benzo(a)pyrene content up to 1000 mg/kg.
- 100,000 railway sleepers (about 9500 solid m^3) are replaced annually.
- Railway sleepers are made exclusively from pinewood, and mainly the sapwood portion is soaked (impregnated) with creosote without previous treatment with other preservatives.
- It is not advisable to use creosote-impregnated used-up pinewood sleepers for production of firewood.

Railway sleepers waste- hazardous or not?

- In accordance with the Latvian environmental legislation, the waste containing the wood preservative – creosote is hazardous.
- In the case of the absence of laboratory data on combustion with non-hazardous emissions, the process is considered potentially dangerous.
- Because the aim is to prevent, as far as practicable, negative effects on the environment and the resulting risk to human health – permission for combustion or co-combustion of waste is not given.

Attention ! Creosote !!!

- Producing pine sleepers, their sapwood part is impregnated with the coal carbonisation tar distillate fraction (b.p. 270-370^{o}C), including creosote. Creosote consists of 85% of polyaromatic hydrocarbon, 10% of phenol and 5% of heterocyclic compounds. Creosote contains also carcinogenic **benzo(a)pyrene.**

- In compliance with the data of the **EU Toxicity, Ecotoxicity and Environment Scientific Committee,** the carcinogenic action of benzo(a)pyrene in a creosote mixture increases, and the currently set **permissible level of benzo(a)pyrene in creosote (50 mg/kg) is actually too high.**

- This excludes the applicability of used-up sleepers as firewood in household and complicates essentially the industrial-scale utilisation, because it is difficult to ensure sanitary standards when crushing and grinding them before burning in modern furnaces.

Creosote content in sleepers

Our studies testify that :

- the creosote content in the used-up sleeper sapwood portion makes up 11-30% from oven dry mass, but on the average, 5-13% from oven dry mass in sleepers;

- in the course of service, 40-75% from the initially impregnated creosote is lost by leaching in the railway embankment, the losses depend on the service duration, the operation intensity and the environment.

Proximate and ultimate analysis of the samples of railway sleepers

(wt % on the oven-dry mass basis)

Characteristics	Railway sleepers	Pinewood
Volatile matter	76.2	77.8
Fixed carbon	23.1	22.0
Ash	0.65	0.20
C	47.51	46.79
H	6.07	5.99
O	46.42	47.22
S	0.059	0.015

Sulphur content is 0.05% for the average sample of the sleeper wood. Non-impregnated pinewood contains about 0.015% of sulphur. Sleeper wood has an increased content of ashes, namely, 0.65% from oven dry mass, on the average, which is three times higher than in non-impregnated wood (0.20% from oven dry mass).

The higher heat of combustion and sulphur content of tars

Sample	Higher heat of combustion, MJ/kg	Sulphur content, % on the o.d. mass basis
Supernatant tar : max temperature 400°C	36.84	0.59
max temperature 600°C	33.76	0.55
Settled tar (average wood sample)	23.43	0.27

If wood moisture is 10% in terms of 1 kg of oven dry sleeper mass, then 0.8 kg of the vapour-gas mixture with the average highest combustion heat 11.6 MJ/kg is released from the retort to the furnace, which, when burning, forms 4.3 Nm^3 flue gases, whose temperature, retaining in the furnace, is about 1000°C. The high value of combustion heat is explained by the fact that, on the average, 33% of the dry vapour-gas mass is composed from the tar and creosote vapour mixture with the highest combustion heat 23.4-36.8 MJ/kg.

Carbonisation

Type	Originator	Temperature, °C	Yield, %
Batch	LSIWC, Latvia	500 - 600	29-32
Continuous	Terra Humana, Hungary	450 - 560	23-29

Both batch installations, which process bulk wood and continuous action apparatus for woodchip or hogged chips are suitable for carbonisation. Depending on the technology and the final temperature of the process, the yield is 29-32% or 23-29% from the oven dry mass of sleepers.

Charcoal properties and characteristics of creosote-treated railway sleepers

Raw material		Creosote-treated railway sleeper average wood chips (heartwood + sapwood)		
Process characteristics				
Wood moisture content	% wet basis	10.4	10.4	10.4
Maximum temperature	^{o}C	400	500	600
Mean heating rate	$^{o}C\ min^{-1}$	12.7	8.7	18.0
Charcoal yield	% on the o.d. wood	28.3	23.3	20.1
Charcoal characteristics:				
Ash content	% on the o.d. mass	1.8	1.5	2.4
Volatiles	% on the o.d. mass	27.9	19.1	13.9
Fixed carbon	% on the o.d. mass	70.3	79.4	84.5
Sulphur content	% on the o.d. mass	0.035	0.035	0.048
Combustion heat	MJ/kg	29.209	29.858	33.695

Content of heavy metals in creosote-treated wood charcoal ash (mg/kg)

Metals	Creosote-treated sleeper wood (average)	Pinewood (control)
Arsenic	53	37
Chromium	483	52.1
Copper	357	373
Zinc	588	2 990
Lead	13.6	31.9
Cobalt	7.19	4.51
Iron	49 129	1 452
Cadmium	4.79	5.56
Mercury	< 0.2	< 0.2

- In sanitary terms, charcoal is applicable also in household (except grilling), because the content of the non-degraded benzo(a)pyrene in it does not exceed 4 mg/kg.
- From the ecological point of view, attention should be focused on the elevated content of different metals in charcoal ashes. The use of ashes in composts would not be permissible.

Conclusion

- The sulphur content in charcoal is only 0.03-0.05% from the oven dry mass of charcoal (for comparison, in compliance with DIN 5173 and DIN Plus, the permissible sulphur content in wood pellets is 0.08% and 0.04%, respectively).
- The study of the charcoal formation mechanism indicates that the presence of creosote in wood favours the formation of a more homogeneous condensed carbon plane structures.
- Such a turbostratic charcoal structure is capable of graphitising and has well-organised polyaromatic carbon layers. At high temperatures, such structures actively react with oxygen in burning chain reactions.
- Pretreatment of railway sleepers by carbonisation not only detoxifies creosote-treated wood, but makes it a more homogenous, handy and high-caloricity fuel.
- The considered process is appropriate for small-scale power plants, because railway sleepers are not fit for long distance transportation.

Acknowledgements

The work has been carried out in the framework of the EU FP5 contract NNE 5/363/2001
Multi Fuel Operated Integrated Clean Energy Process:
Thermal Desorption
Recycle-reduce-reuse Technology
http/www.terrenum.net/cleancoal

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