ISSN 1691-5402
Environment. Technology. Resources
Proceedings of the 9th International Scientific and Practical Conference. Volume 1

Reduction of Oil Shale Losses

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***Abstract*. Oil shale utilisation losses reach 70% in some cases. These are closely related to legislation, backfilling and waste rock usage. Much smaller sections include production of oil, electricity and chemicals in which most of the research and development is performed today. Current urgent topics for investigating, testing and developing of oil shale mining related questions are backfilling, mechanical extracting of shale, fine separation, selective separation and optimised drilling and blasting. Reducing oil shale losses will be more actual in the future, because the depth of mining increases and the taxes for resource and pollutants are increasing as well.**

***Keywords* – oil shale, losses, mining, extraction.**

I INTRODUCTION

Oil shale utilisation losses reach 70% in some cases. These are closely related to legislation, backfilling and waste rock usage [9]. Much smaller sections include production of oil, electricity and chemicals in which most of the research and development is performed today. Current urgent topics for investigating, testing and developing of oil shale mining related questions are backfilling, mechanical extracting of shale, fine separation, selective separation and optimised drilling and blasting [43].

Mining related waste is mainly solid waste from separation and processing, operating solid waste from overburden removal and drifting, liquid waste from dewatering, processing and washing processes [13]. Mining losses include tonnage, mining waste water, mining influenced water, surface water, soil water, groundwater and mining water, mining influenced land and ground layers [17]. Origin of mining waste is separation waste form Heavy Media Separation (HMS), processing waste, crushing and screening waste [15].

The main usage of solid mining waste is filling material, construction material and cementing material [44][45]. Liquid waste can be used as heat carrier or as source for kinetic energy of water or for industrial usage. Waste as used land is used mainly as space for depositing, construction and recreation [27][28]. The principal direction of developing mining technology is filling the mined area. This provides control over majority of environmental effects [16]. Filling the workings decreases the loss of resources and land subsidence, and at the same time provides usage for stockpiling. Filling the spoils of surface mine decreases dewatering; harmless waste can be used for filling surface mines and in this manner offer new building land [48]. The methods are: mapping the modelling criteria, indicators and processes of the mined areas; experimenting the possibilities of application, compatibility and results of mining software; applying laboratory experiments and fieldwork in modelling; creating models for blanket deposits; applying seismological methods for developing theory for collapse risk [10]. The key question of current study is related to resource wastage, if it is possible to decrease resource wastage or has it reached its limits.

II Methods

Series of analytical and testing methods have been applied in current study **Error! Reference source not found.**.

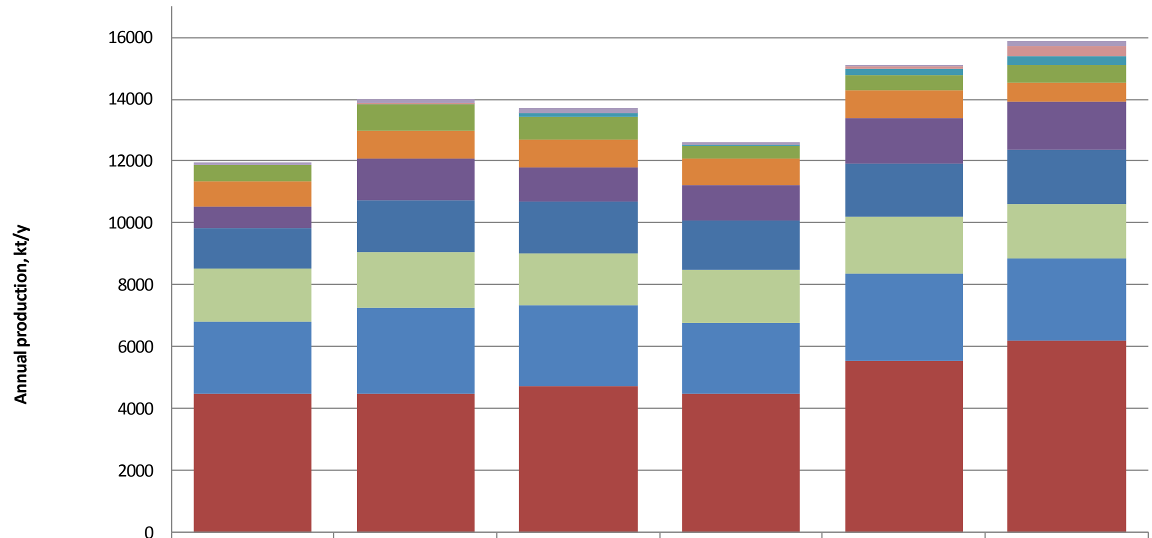
Beginning from resource analyses and followed by tests of extracting processes have been performed [20][31]: selective oil shale seam blasting, longwall mining, high selective surface mining, selective extraction by mechanical shovel, bulldozer ripper and hydraulic excavator ripping in several oil shale mining fields [18]. Separating tests included fine separation, dry separation and jigging.

Resource analyses and availability of resources are crucial part of the study influencing the base of the industry [22].

Although based on quality parameters oil shale resource could be evaluated as economically mineable resource [21], some resource is lost by geological dislocations and nature protection zones [14]. According to the Estonian Nature Protection Law it is prohibited to mine oil shale on nature protection zones. It is not specified how deep in the ground the law applies [23]. For example south-western part resources of Estonia oil shale mine may be estimated as not mineable resources because of Selisoo mire above the mine.

There is not enough adequate information about oil shale processing or extracting losses available. Official data from mining companies are kept in secret and will not be public. Only overall losses and changes of the mineral reserves of the deposits can be seen in official balance of mineral recourses in the Environmental Register. The authorized processors of the Environmental Register are the Ministry of the Environment and Estonian Land Board. This part of the register consists of mineral reserves of the deposit, mined amounts of the mineral reserves and changes of the mineral reserves of the deposits [26].

Overall losses are higher in underground mines because of roof supporting pillars and it grows with depth increase [29][30]. Deepest oil shale mine Estonia has up to 30% overall losses (Fig. 1, Fig. 2, Fig. 3). At the same time largest losses are in the largest mine. In the future this trend continues [11][12]. Mining depth and amount of losses is related to the stability of the overburden rocks [5][6][7]. Losses and stability are influencing each other if backfilling is not used [19]. At the same time monitoring systems have developed rapidly [24][25].



	2006	2007	2008	2009	2010	2011
Ubja open cast	101	109	162	58	59	146
Sompa mine		33	1	31	77	315
Ojamaa mine		26	96	12	204	288
Vanaküla open cast	516	832	761	410	481	575
Põhja-Kiviõli open cast	818	896	908	868	885	637
Narva open cast	727	1375	1090	1147	1493	1539
Aidu open cast	1286	1682	1664	1582	1724	1770
Viru mine	1706	1761	1699	1740	1836	1730
Sirgala open cast	2345	2779	2587	2261	2813	2677
Estonia mine	4478	4499	4738	4500	5537	6188

Fig. 1 Annual oil shale production in Estonia, thousand tonnes per year

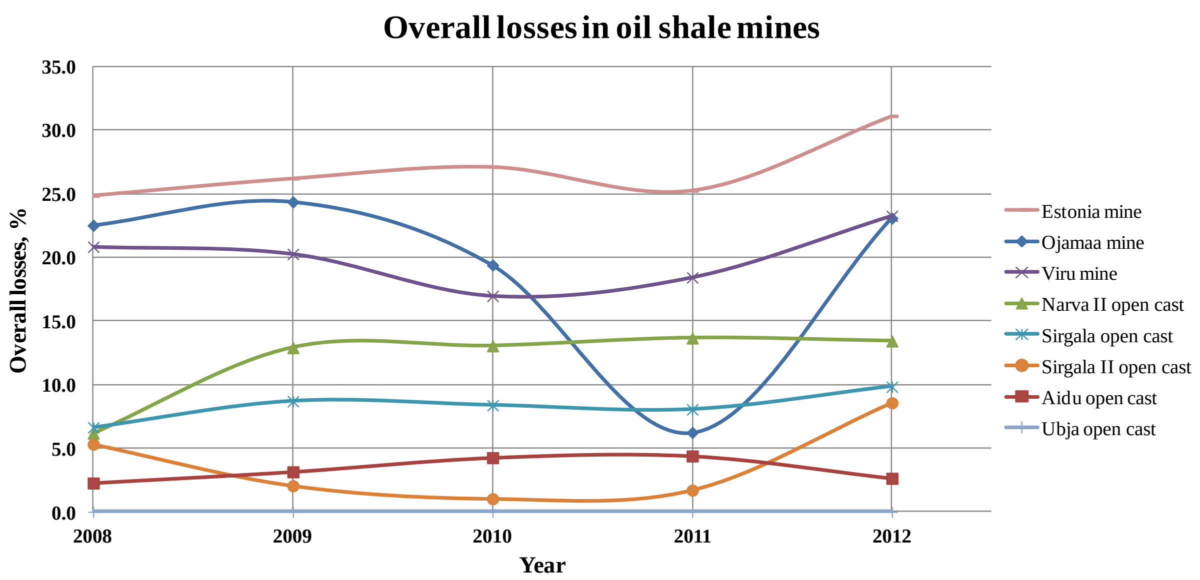


Fig. 2 Overall losses in oil shale mines during last five years [Environmental Register]

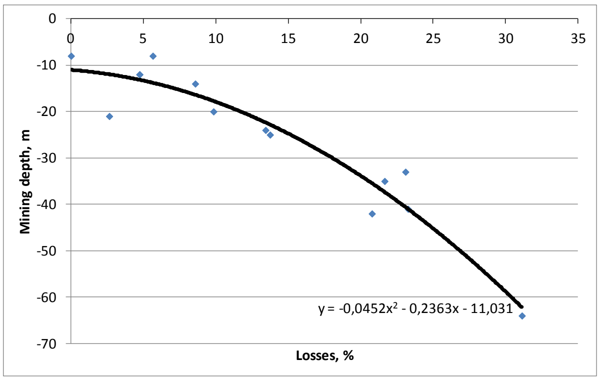


Fig. 3 Amount of losses depending on mining depth

A. Processes

The main processes affecting resource usage are resource management, extracting, crushing, separating and processing.

B. Extracting

Several extraction technologies have been used for mining oil shale during last 96 years [42]. In first years high selective hand mining was used due to absence of machines. The main problem related to losses and dilution was the rock that contained both oil shale and limestone what could not be separated by hand [3].

Later, when drilling and blasting was applied, only sorting or selective blasting influenced losses and dilution. Both full seam and selective seam blasting was used. In case of underground mining full seam and partial seam blasting was used. In years 1970 to 2000 partial seam longwall mining was used [32][33][34][35].

Due to weak limestone layers on top of underground room and pillar mining sections in Estonia mine, dilution is high and not only full seam, but in some cases 1.3 times higher seam is extracted [35].

Also surface miners have been used for selective mining of the oil shale [46][47]. For analysing possibilities of selective mining, range of tests and theoretical studies have been carried out during last decades [2]. Tests of high selective mining have been carried out in Estonia in limestone, dolostone and oil shale mining areas [42]. As well selective extraction has been performed by mechanical shovel, bulldozer ripper and hydraulic excavator ripping in several oil shale mining fields [38][39].

Several separation technologies have been used for processing the run of mine [40][41]. Due to the complex chain of mining processes optimisation is performed in some cases for finding optimal solution between losses, dilution, yield and other factors [4]. At the same time extraction technology has not been well analysed [36][37].

Surface miners productivity result show great variation in different oil shale layers and in other minerals layers. Surface miner Vermeer T1255 studies in 2012 show that surface miner productivity in F3 layer is 736 t/h and in C/D interlayer 591 t/h. The cutting speed in F3 layer is 0,12 m/s and in C/D interlayer 0,05 m/s.

Surface miner Wirtgen 2500SM studies in 2009 show that surface miner productivity in limestone interlayer H/J layer is 594 t/h and cutting speed is 0,06 m/s. Initial studies show that 80% of material pass through 25mm mesh and 30% through 3mm mesh (Fig. 4). Larger pieces are required for vertical oil generators. Solid heat carrier could use such material more easily.

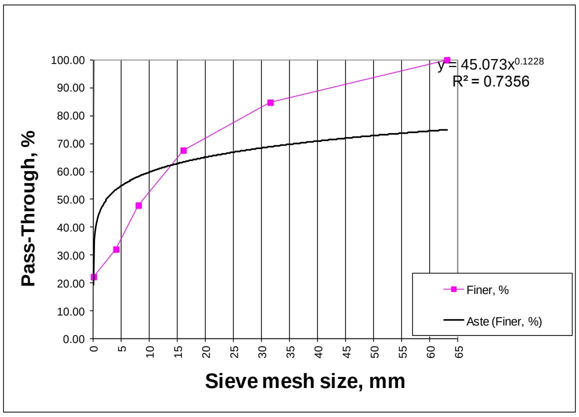


Fig. 4 Mechanical sieving analyses

C. Crushing

Initial tests with bucket crushers have been performed, showing promising dry separation results.

D. Separating

Fine separation machine, with the aim to separate fines from the separation pulp before it goes to sedimentation pond (Fig. 5).

Fig. 5 Fine separation cyclones

The fine separation machine is a hydro cyclone, what could process 50 m^3 in hour. The testing was done in two ways, first was with coagulant and the second one without it. Coagulant is additive what combines fine particles together and it should increase the amount of material. Fine particles were divided into the size 0-8 mm and 0-5 mm.

Fine particles with size 0-8 mm productivity were 162 kg/h and 0-5 mm 29 kg/h. Hydro cyclone productivity was 191 kg/h. Also was tested separated fine particles moisture, calorific value, ash value and were done mechanical sieving (Fig. 4). Initial tests showed that it is not possible to concentrate higher calorific value with coagulant.

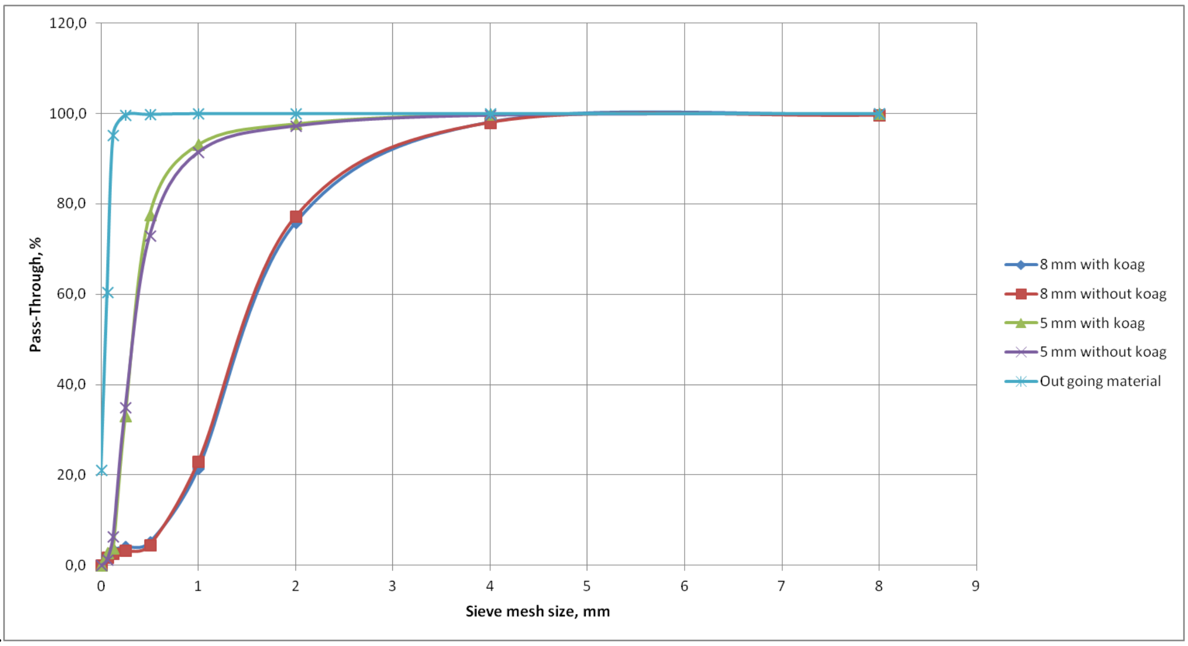


Fig. 6 Mechanical sieving results

III Conclusion

Reducing oil shale losses will be more actual in the future, because the depth of mining increases and the taxes for resource and pollutants are increasing as well. In several cases selectivity is the key solution for extraction, separation or processing. Fine separations has not shown good results for oil shale, but limestone fine separation, granulating or jigging should still be analysed with more options. In addition dry separation with sizers, drum crushers and roll-crusher sieves should be considered.

IV Acknowledgments

This research is related to the project MIN-NOVATION – http://www.min-novation.eu; ETF8123 "Backfilling and waste management in Estonian oil shale industry" – http://mi.ttu.ee/ETF8123; Energy Technology Program Sustainable and environmentally acceptable Oil shale mining No. 3.2.0501.11-0025 - mi.ttu.ee/etp and Doctoral School of Energy and Geotechnology II, interdisciplinary research group "Sustainable mining" DAR8130/1.2.0401.09-0082 – mi.ttu.ee/doktorikool

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