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DESIGN OF A NEW OIL SHALE SURFACE MINE*

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The paper discusses designing of oil shale surface mines covered with relatively thin overburden – thickness less than 10 meters. The main issues to pay attention to at the designing procedure are presented.

Introduction

There are some unmined reserves near the outcrop line of Estonia oil shale deposit. The amount of reserves is not worth of mentioning, and the shale quality is not the best either, but the location has a logistic value. Kunda cement plant (10 km from Ubja field), Kiviõli shale oil plant (1 km from Põhja-Kiviõli field), and Ahtme power plant (5 km from Tammiku-Kose field) would be the possible users of the reserves mentioned above, and also owners of surface mines. These enterprises consume relatively small amounts of oil shale. For example, Kunda cement plant needs 200,000 tons oil shale annually. Putting their own surface mine into operation would mean that small enterprises are capable for mining activity as well. Design of *Ubja* oil shale surface mine for Kunda cement plant was started in 2000. Mining operations will be started during next two years.

Mining conditions in surface mines near the outcrop line are less or more similar to the conditions in the operating surface mine at Kohtla-Vanaküla. They would differ in the usage of modern machines suitable for various operations enabling to design a modern, environment-friendly surface mine.

Designing and Environment

All through designing process environmental impact of every operation must be considered carefully. For example when designing *Ubja* surface mine several environmental aspects have been taken into consideration (Figure):

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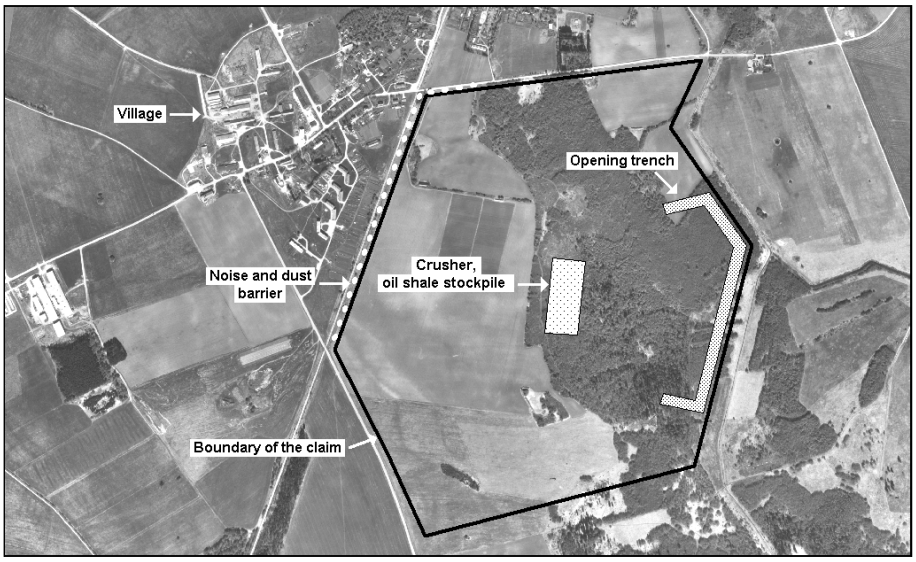
- Additional environmental investigations were made to prove local people the tolerable impact of mining.
- Surface mine will be opened as far as possible from the village.
- Blasting operations were abandoned because of the near-situated village.
- Mining operations must not open certain aquifers to avoid groundwater contamination.
- Oil shale stockpile, crushing and loading unit will be located in forest to reduce noise and dust spreading.
- A noise and dust barrier will also be established between the village and the surface mine. For that purpose trees will be planted.



Areal photo of the claim of *Ubja* surface mine

After mining the land has to remain in conditions similar to those before mining operations. Land reclamation is an expensive procedure but some mining technologies can make it easier. For instance, when using a bulldozer for overburden removing, levelling of spoils after mining is not necessary.

Designing Principle

Designing of oil shale surface mine is like solving a function with a given answer. Designing must find the formula, i.e. mining technology to reach the answer. The latter consists of a group of certain requirements for the surface mine output: oil shale heating value, fraction size and quantity. Of course, it is impossible to solve this function without geological data.

In other words: the requirements for the output, and geological data are the starting-points for designing a surface mine.

Fulfilling these requirements depends directly on the mining technology. Technologies are based on two mining methods: non-selective mining and selective mining.

The principle of non-selective mining is that the whole productive seam with limestone interlayers is mined. The result is oil shale with lower heating value. Today this method is used in *Aidu* surface mine. Usually oil shale mined by the non-selective method needs processing, but in some cases, as Ubja project, oil shale will not be processed.

The whole productive seam can be broken using drilling-blasting operations, front shovel or excavator. Drilling-blasting operations and front shovels have been used in Estonian oil shale surface mines for a long time. Excavator for the seam breaking has been tested recently.

Selective mining is based on the oil shale seam property to comprise various layers of different heating value, and therefore the layers are mined separately. The output is oil shale with higher heating value without processing.

Layers can be mined separately using bulldozer with ripper, excavator with ripper or surface miner. Bulldozers with ripper have been used in *Eesti Põlevkivi AS* (*Estonian Oil Shale* Ltd.) surface mines for quite many years. Excavator with ripper has been tested recently. Surface miner has been tested only in limestone quarries. Surface miners enable high selective mining due to precisely adjustable horizontally rotating cutting tool.

Selection of Mining Technology

The main factors mining technology depends on are requirements for output, overburden thickness, rock hardness and surface mine location.

If the required heating value is not high, as the case of Ubja project (8.3 MJ/kg), or concentration plant is available, the technology based on non-selective mining can be applied. When oil shale with higher heating value is needed, the technology based on selective mining should be used.

Displacing overburden by bulldozer, excavator or surface miner is rational if overburden thickness is less than 10 meters.

Overburden thickness and rock hardness are usually related – rocks with greater hardness lie under thicker overburden. Rock hardness determines the power and weight of machines.

Surface mine location is important when drilling-blasting operations are considered to be used.

As this paper focuses on designing relatively small surface mines, it is important to consider the use of different machines as less as possible. Therefore it would be excellent if one machine could break and displace overburden and also break and load oil shale.

Bulldozer with ripper can do all mentioned operations except loading oil shale. Excavator with ripper and surface miner can do all operations, but the

latter is not suitable for displacing soft overburden. Front shovel is basically capable of all operations but, comparing with other machines, its working range is limited.

Another important issue at selecting machines is their weight and power which are determined by rock hardness. Harder rock needs powerful machine. The latter must be heavy enough to have sufficient contact with the rock. For oil shale surface mining a machine must weight at least 100 tons to break oil shale and limestone efficiently. These machines have quite high productivity, and in a small surface mine like *Ubja*, the annual output 200,000 tonnes would be mined approximately in 60 days. Roughly 120 days would be needed for overburden removal. That means that the machine is needed only for a certain period in a year. It must be decided whether to own the machine or buy the service (i.e. rent the machine).

Conclusions

The main issues to pay attention to during the designing process of oil shale surface mine are as follows:

- How to minimise environmental impact of mining?
- Is it possible to use non-selective or selective mining method?
- Which mining technology guarantees determined requirements for the output?
- How to reduce the usage of different machines?
- Own or rent machines?

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