SUSTAINABLE UTILIZATION OF OIL SHALE AS AN ALTERNATIVE ENERGY SOURCE

**Zoran Markovic, Zoran Stirbanovic,
Jovica Sokolovic, Pantovic Radoje, Luka Markovic**

Abstract: *Oil shale presents an energy resource for the future. There are many known occurrences of oil shale in the world such as in USA, Estonia, Jordan, Morocco, Australia, China, Argentina, Canada etc. All of those are of great economic importance in terms of alternative energy sources. Also, there is one great oil shale deposits in the Republic of Serbia near the town Aleksinac. The oil shale is occurs in the Aleksinac coal mine basin, following the coal seams and spreads on 40 km^2. the known reserves of oil shale in this deposit are estimated on 3.935.522.000 t with average oil contents from 9,5 to 12,5%. In this paper will be presented results on utilization of oil shale in cement industry directly and indirectly, after burning them and after retorting them, i.e. in form of ash and in form of petrol coke.*

Applying od oil shale in cement industry has very important sustainable and environmental aspect, because after burning them the residue ash remain in the cement as a component of it. On this way it is possible to utilizes all oil shale material, both energetic and ash parts, with any residuals which means that the sustainability and environmental protection will satisfy on the high level.

Keywords: *Oil Shale, Alternative Energy Source, Cement Production*

Introduction

Oil extraction

Oil shale is an inorganic, non-porous rock that contains some organic material in the form of kerogen. In some respects, oil shale is similar to the source rock that produced petroleum. One important difference between oil shale and oil source rock is that the former contains greater amounts of kerogen (as much as 40%) than the latter, which usually contains about 1%. A second major difference is that oil shale has never been exposed to sufficiently high temperatures to convert the kerogen to oil. In a sense, one can think of oil shale as being a 'hybrid' of oil and coal. Oil shale contains more kerogen than oil source rock, but less than coal. The composition of the oil derived from oil shale is much more similar to the composition of petroleum than to coal. Some oil shale can be ignited, like coal, and they burn with a very sooty, smoky flame much like a coal of very high volatile matter

content. However, oil shale are of no interest as solid fuels. Their principal interest is in the possibility of conversion to liquid fuels.
Lean shale contains about 4% kerogen. When heated to 350-400 °C, it yields about 6 gallons of oil per ton of shale. Rich shale may contain up to 40% kerogen and typically yields about 50 gallons of oil per ton. Two thirds of the world's oil shale reserves are located in the United States. The largest known reserves of hydrocarbons of any kind are the Green River shale deposits in Wyoming, Colorado and Utah. These reserves are estimated to be 270 billion tons. At 20 gallons per ton of shale, this translates into 130 billion barrels of oil. This is five times as much as the proven reserves of petroleum in the U.S. However, no commercial production of fuels from oil shale exists today, so their economic recoverability is not well known. It is probably safe to say, however, that oil from shale is not economically competitive with petroleum at current world petroleum prices.

The recovery of oil shale uses mining techniques similar to the methods used in coal mining. The room-and-pillar method is one such approach. Oil is then recovered from the shale by *retorting* the shale. Retorting involves heating the shale in the absence of air to temperatures of 500 °C or more. Typically, 75-80% of the kerogen is converted to oil. An alternative to mining is *in situ retorting*. In this process, holes are bored into the shale deposit underground. By injecting hot gases and air into the shale, the shale can become hot enough for the kerogen to turn into oil underground. *In situ* retorting eliminates the mining cost, many of the costs for above-ground retorts and liquid handling equipment, and addresses the problem of disposing of the shale after the oil has been 'cooked' out of it. In this case, since the shale has never been removed from the ground, there is, in a sense, no disposal problem at all [1, 2].

Cement production

Oil shale is a major natural resource of Estonia. The power plants use oil shale as a fuel despite its very low calorific value of 8-14 MJ/kg. Oil shale consists approximately of 55-65 % of inorganic matter. Since 1960, the finest fraction burnt at >1300 ^{o}C and collected by electric precipitators has been used as the main constituent of cement. Burnt oil shale has been used as the main constituent of Portland cement to enhance the quality of Portland cement, at the same time economizing natural resources and using wastes of power plants.

Portland cement with the second main constituent has specific properties. Differences in the properties are in direct dependence of the type and content of the second main constituent.

Fly ash as the by-product of the power plants has wide scale variations in its properties. The type of combustion and dust collection equipment has direct impact on the mineralogical composition, structure and shape of fly ash particles. As a result, Portland cement is provided specific properties, the characteristics of the main constituent used [3].

Oil shale from aleksinac deposit

Oil shale reserves

Aleksinac's deposit of oil shale is situated near town Aleksinac in the central Serbia, and such as presents largest one in the Serbia and in the South Europe. The total estimated reserves of oil shale from this deposit are 1,8 x 10^9 t. On the figure 1, is presented outcrop of the oil shale layer and on the figure 2. is presented sample of oil shale.

Figure 1. Outcrop of the oil shale layer

Figure 2. Lump of oil shale

Technical assay of oil shale

There are a lot of technical assays on great number of oil shale samples and average results are presented in Table 1. [4].

Table 1. Technical assay of oil shale

Items	Span
Organic substance contents	16,6 – 21,0 %
Ash contents	72,0 – 73,0 %
Sulfur contents	2,23 – 3,85 %
Gross caloric value	6.050 – 7.000 kJ/kg
Crude oil contents	9,5 – 12,5 %
Density	1.850 – 1.960 kg/m^3

The residue after oil shale burning is ash. The ash composition is given in Table 2.

Table 2. Chemical assay of spent ash

Item	Contents (span), %
SiO2	42,57 – 59,87
Fe2O3	9,50 – 14,21
Al2O3	5,69 – 7,27
CaO	8,04 – 24,03
MgO	2,30 – 9,20
CO3	0,38 – 5,45
P2O5	0,31 – 0,52
TiO2	0,62 – 1,06
Na2O	0,80 – 3,00
K2O	0,50 – 2,20

After retorting of oil shale, extraction of oil by pyrolysis, the residue material has specific composition and looks like semi burned shale. That residue contains, among others, and semi coke which is suitable for further burning. The Fisher analyze of oil shale sample is given in table 3, and analyze of semi coke is given in table 4.

Table 3. Fisher analyze of oil shale samples in average

Item	Average contents in %
Crude oil	12,6
Water	7,6
Semi coke	75,3
Gas and losses	4,5

Table 4. Analyze of semi coke on residue from Fisher retort

Item	Average contents in %
Ash	81,0
Sulfur	2,63
Inorganic CO2	12,47
C-fix	6,70
Volatiles	5,64
Gross caloric value	2.735 kJ/kg
Net caloric value	2.383 kJ/kg

Discusion of results and conclusion

Regarding to presented results one can see three opportunities for utilization oil shale without any residue.

1. Burning the oil shale material in order to obtain energy. The residue from this process the large amounts of ash are produced. That ash may be used as a raw materials for cement production, mixing with feeds, because it has similar chemical composition like other primary raw materials in cement production. Doing like that the sustainability and environment protection will be completely satisfy.
2. Extracting crude oil by pyrolysis (retorting) process, we can obtain crude oil and semi coke. the semi coke may be used in cement industry like minor energy carrier and mineral residue which is similar to primary material feed. Doing like that the sustainability and environment protection will be completely satisfy, too.
3. Applying of oil shale raw material together with other materials as a primary feed, we can utilize energy and mineral residue. That energy has important significance in energy efficiency of cement

production process, but the other compounds from oil shale will be utilized as raw material in cement production process. Doing like that the sustainability and environment protection will be completely satisfy and energy efficiency (energy saving) in the whole process.

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Notes on the authors

ZORAN MARKOVIC, ZORAN STIRBANOVIC, JOVICA SOKOLOVIC, PANTOVIC RADOJE

University of Belgrade – Technical Faculty Bor, Serbia

LUKA MARKOVIC - University of Belgrade – Mining and Geology Faculty Belgrade, Djusina 7, 11000 Belgrade, Serbia (student);