PLENARY LECTURE: ENERGY FOR TOMORROW

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Abstract

Respected colleagues! We are again at DAAAM symposium, again are intending to share our thoughts about technology perfection. We are doing that because we are interested in engineering activity – very special kind of people occupation. Albert Einstein gave an interesting definition what tells engineers from scientists: “*Scientists investigate that which already is; Engineers create that which has never been”*. (A. Einstein).

Keywords: Knowledge; Power; Energy; Electricity

1. Introduction

What is in common for these two categories of creators? Both are continuously looking for new knowledge. Both are continuously thinking how to perform better this search. Ability to think makes life interesting. Fortunately, the space for thoughts is boundless. Now the number of people on our planet is very great and there are plenty of problems which must be solved to preserve mankind. These problems concern food production, drinking water supply, restraint of diseases, energy supply. Many others.

Our symposium is organized in cooperation with -.the organization which coaching new generations of creators of future sciences and future technologies. I want to call your attention only to one problem which must be solved during the active life of today’s students. I mean energy supply. More precisely - electricity generation

Fig. 1. Power lines

2. Types of power plants

Today more than 85% of electricity are being produced by three types of power plants.

2.1 Thermal power plants.
They are producing around 65% of electricity. These plants are using fossil fuels. Reserves of these fuels are limited. According expert's data explored reserved of oil will be exhausted in 40-45 years; of gas in 50 years; of coal in 110 years

Fig. 2. Thermal Power Plants

2.2 Nuclear power plants.
They are producing around 10% of electricity. These plants are using uranium. Explored reserves of uranium will be exhausted in around 80 years.

Fig. 3. Thermal Power Plants

2.3 Hydroelectric power stations.
The stations are producing around 16,6% of electricity. Hydroelectric stations are using today globally around 20% of the falling water energy. At the first glance it seems that here are great reserves. But there is a great obstacle on this way. Building of many dams would require resettlement of huge number of people.

Fig. 4. Thermal Power Plants

3. Alternatives

Looking at this we should conclude that during the next 50 years people must find new sources of energy. And not only find new sources, but also must create new power plants able to generate energy using those sources. In this situation many scientists and engineers believe that the next step of development will be made into the direction of nuclear fusion technology. On their opinion future of energy will be connected with fusion thermonuclear plants.

Today isotopes of helium-3 and deuterium are being considered as fuels for future plants. At fusion of these components a great amount of energy will be generated.

$$^{3}He + {}^{2}D \quad {}^{4}He + {}^{1}p + \text{energy / 3 gramsv} = 493\ \text{MWh} \tag{1}$$

At the consumption of 3 grams of helium -3, 493 megawatthours of energy may be received. This amount will be enough to supply with electricity 100 families during one year. Only one teaspoon of helium -3!

Now this technology is under development. Optimists believe that it will be created in 20 years; less optimistic people – in 50.

The problem of fuel for those plants is seen already now.on the Earth amount of Helium – 3 is very small. Significant quantity of this isotope is on the Moon. Scientists believe that total reserve there would be enough to satisfy people needs during thousands of years. Today there are people in the USA, in Russia, in China, who propose to arrange extraction helium-3 from the moon surface and its transportation to the Earth. Let's look how much work should be done to realize this proposal.

Let's assume that there is a decision to start this process in 2050 and at the beginning to satisfy 10% of global electricity demand with fusion technology. There is a prognosis that global demand for electricity that year will be 38 billion of megawatthours. !0% of this amount will be 3.8 megawatthours. Let's assume further that fusion power plants will use helium – 3 with effectiveness 50%. It is a very high effectiveness. At this effectiveness power plants will need 46,2 tons of helium – 3 per year.

On the Moon Helium-3 is accumulated in the upper layer of soil – regolith. Research data show that the average concentration of it is approximately 1 gram of Helium – 3 in one hundred tons of regolith. To get the needed quantity of Helium - 3, 4,6 billion tons of Regolith should be processed. And this is true if 100% of Helium – 3 will be extracted from regolith. It doesn't look verisimilar.

Let's make an assumption that an ideal production process will be developed and such results will be realistic. Let' divide the year volume of regolith by number of hours within one year. We shall see that during each hour 210.240 tons of regolith should be processed. Is this figure impressive? 10.000 of loaded trucks per hour!

Today experts believe that the process of Helium-3 extraction will be organized according the following scheme.

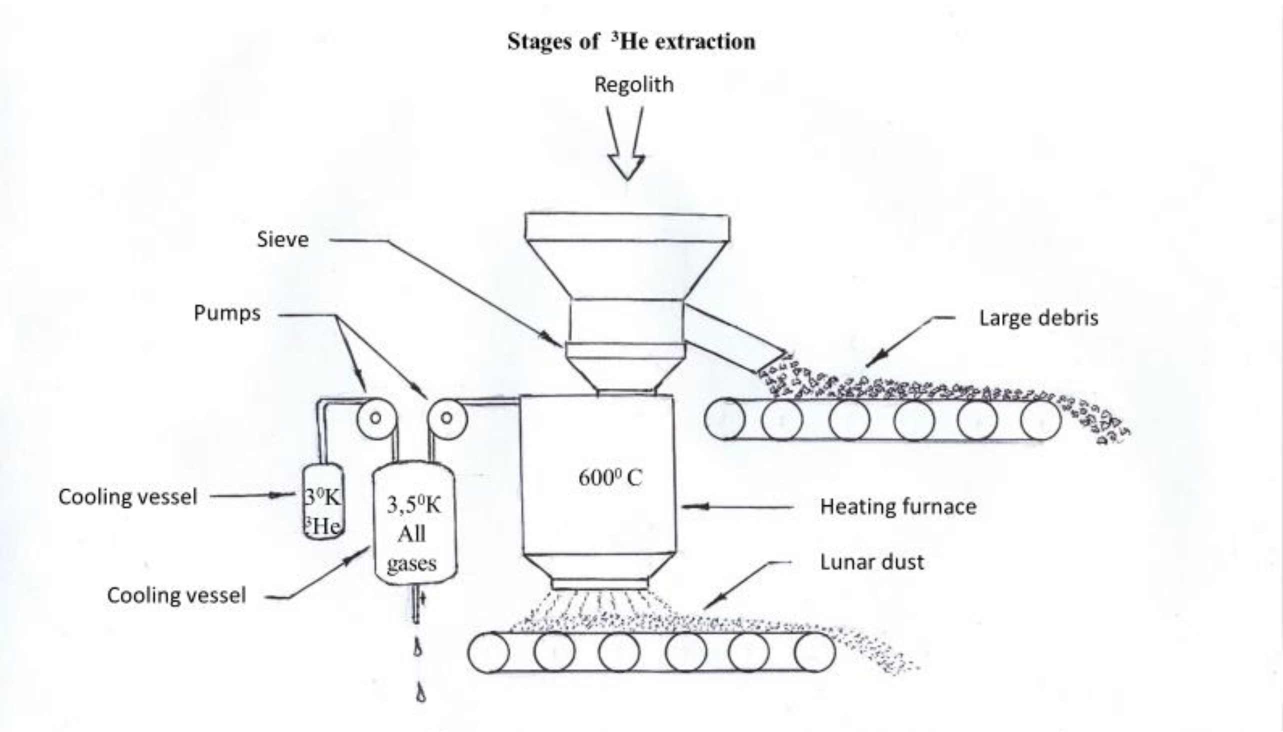

Fig. 5. Helium 3 Extraction

Regolith will be taken from the Moon surface at a depth from zero to three meters. It will be screened. Only fine regolith with particle size less than 1 mm will go for processing. The screened regolith will go to a heating furnace. This furnace will be sealed and then regolith will be warming up to 600-700 degrees centigrade. During this warming process regolith will emit different gases, including Helium – 3. According to scientists the lowest boiling temperature will belong to Helium – 3. It is 3,19K. From the heating furnace gas will go through a filter to the first cooling chamber. In this chamber Helium – 3 will be cleaned up from other gases. For this purpose gas mixture will be cooled down to 3,5 K. By this temperature all gases, with the exception of Helium - 3, will be converted into liquid. Helium – 3 will be pumped over to the second cooling chamber. There it will be also converted into liquid and poured into a thermos for further sending to the Earth.

Each hour 210.240 tons of regolith should go along this chain of operations, It seems evident that such task cannot be solved with one production line. The number of lines will depend on the equipment. Let’s assume that heating furnace has capacity 105 tons, can warm up regolith during half an hour and can be loaded and unloaded instantly.

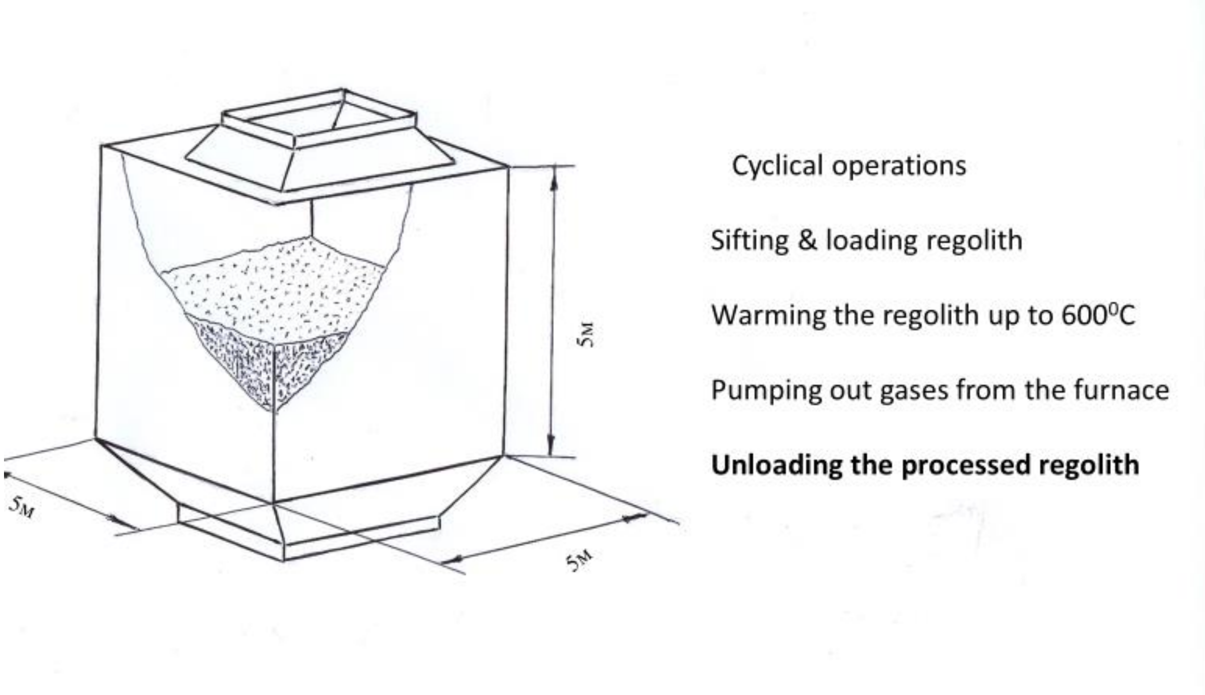

Fig. 6. Heating furnace for 105 tons of regolith

In this case 1000 furnaces will be needed. Actually more than that, since the processes of sifting, loading and unloading will take time. Thus,, more than 1000 production lines will be needed. Can you imagine such scale of industry on the Moon?

There is another great problem. Functioning of the equipment on the Moon will require huge amount of energy. People life support, regolith excavation, regolith transportation and processing, lighting of the Moon during the night time, rocket launches from the Moon – all this will require electricity. To get an idea about the quantity of the needed energy let’s make an approximate calculation related to only one operation – regolith warming. Amount of regolith, which should be warmed up during one hour is 530 million kilograms. Range of heating: from 300K up to 900K (from zero Celsius up to 600 Celsius). Average regolith heat capacity in that range of temperature is approximately 950 J/kg.K. To warm the said amount of regolith 83,4 MWh will be needed. If heating process consumes 10% from total energy consumption, lunar power plant should have capacity around 1 gigawatt. It is a big plant.

So, to get helium-3 from the Moon people have to create a large industrial base there. It is evident that building of plants and arrangement of all technological processes will require participation of many people directly on the Moon. Beside the production lines, it will be necessary to create a habitable complex. Rocket launch complex and rockets themselves will be also needed on the Moon for product transportation and people evacuation. All this is a super complicated task. Now it seems unrealistic. On the other hand, our generation has created first space rockets and first space vehicles. We may hope that the next generation will go much farther.

4. Future

There is another idea concerning energy generation. Also on the border between reality and fantasy. The idea is: to build on the geosynchronous orbit a solar space station and to transmit wirelessly energy from that station to the Earth. Solar generators are already spread widely around the globe and are functioning reliably.

But they supply minor consumers. Their main drawback is that they are generating electricity only during the day time. And the second drawback – they require large space for each kilowatt of energy.

If a solar panel is placed on geosynchronous orbit, it will be lighted by the Sun 99% of time. Besides, panel doesn't take any room on the Earth. There are two main problems on this way. One is bound up with panel size. To generate significant amount of energy on a world scale, generator will need a very large solar panel. Let's suppose that people decided to generate 10% of globally needed energy using solar space station already in 2050. Let's assume also that transmission of the energy from the space station to the Earth will go without losses. In this case the panel should have size 640 square kilometres. Exactly equal to the area, occupied by the Zagreb city. How to make such panel? How to deliver it to the orbit? How to assemble the panel from its fragments there?

And the second problem – energy transmission. Power of the beam should be 640 gigawatts. Today there is a positive experience to transmit a few kilowatts on the distance tens of metres.

Going to the end of my irresponsible speculations, I want to say a few words about the third idea. It seems to me the most logical - to use energy which is under out feet - Geothermal energy.

Fig. 7. Geothermal energy

5. Conclusion

People are already using this source, but a little. One of the reasons is that this source is not enough studied. Well drilling is expensive. And there is no technology, which would enable us to judge how much heat magma is able to deliver to the area where the well has bottom. Development of such technologies would cost much money. But it is quite possible that the expenses will be comparable with those related to the helium – 3 acquisition or creation of solar space station.

It is not clear which sources will be used for electricity generation by the end of this century. Preparatory works are running on different directions. And everywhere there are many problems. There are many incentives to think, many considerations for discussion, many reasons for meetings like this one. I wish every participant to get some new knowledge in the course of this conference. Thank you very much!

Advanced knowledge is the basis for the best solutions!