The Importance of Controlled Nuclear Fission for Afghanistan

Associate Professor Mir. Azmudin Hashimi Physics Department, Education Faculty, Takhar University.

Abstract

Afghanistan is a country which possesses different metallic and nonmetallic mineral mines. Among the interesting mineral mines Uranium is one of the major mineral resources which can be found in northern Khan Nishine area in Helmand province. According to NASA (2012) preliminary estimations, the mentioned Uranium mine has 1.4 million tons reservoirs of uranium. Afghanistan needs electricity for lighting its cities and other areas; it also needs water to irrigate some lands. In addition, Afghanistan needs a number of equipped hospitals for treatment of various types of cancer by radiation and prevents from the fertilization of onions during the winter and spring by use of cobalt – 60 radiations. The main purpose of the article is to show the resources of uranium ore in Afghanistan. It also explores the creation of fast breeder nuclear reactor based on the resources of uranium ore. The author reviewed a large number of books related to resources of uranium ore in Afghanistan. The review of literature shows that Afghanistan contains more than 2 million tons of reservoirs of uranium – 235 and uranium – 238. It also demonstrates that the uranium ore in Afghanistan is enough for creating 30 nuclear reactors, which will be active for about 500 years. These reactors can generate a large amount of electricity and more than 200 types' radio isotopes.

Keywords: ***Nuclear Fission***, ***Nuclear Energy***, ***Nuclear Reactor***, ***Thermal Neutron***, ***Delayed Neutrons***, ***Thermal Energy and Self Sustaining Chain Reactions*.**

I. *INTRODUCTION*

Other type of nuclear reaction, which has performed a significant function naturally, is the splitting of nuclei. Certain amount of stable nuclei particularly after the absorbing of neutron experiences fission or splits into two parts with liberation of energy (Garg, 2011). According to Sears (2013), nuclear fission is a disintegration procedure in which during this process a nucleus absorbs a neutron and after splitting changes into two pieces of almost equivalent mass. In reality, there are two different types of fission events. The first one is called spontaneous and the second one is produced by induction (Garg, 2011). The prominent discovery, which made by four German physicists, resulted in atomic period (Cutnell and Johnson, 1992). First of all, in 1938, two physicists from Germany Otto Hahn and Fritz Strassmann made an important discovery. When they went along Fermi's theory and experiments, they comprehend that uranium after absorbing of a neutron splits into two fragments (Giancoli & Douglas, 2000). After that, they reported their outcome to Lise Meitner and Otto Frisch that they conduct research in Scandinavia. She rapidly recognized the radioactive fragments chemically created by the neutron bombardment on uranium (Ghoshal, 2012). As stated by Giancoli & Douglas (2000), the recently phenomenon was called **Nuclear fission** due to point of similarity with biological fission (cell division). Subsequently, for more clarification of the process of fission, Lise Meitner presented her famous ***Liquid-drop model***. According to this new model the reaction process may be written as the following:

$$n + {}^{235}_{92}U \rightarrow {}^{236}_{92}U \rightarrow N_1 + N_2 + neurtons. \qquad \dots(1)$$

As described by Tayal (2015), in every fission reaction which (${}^{235}_{92}U$) absorbs a neutron and splits into two fragments, very enormous amount of energies are liberated and fast neutrons are sent out. Meitner and Frisch revealed that, due to their more unusual neutrons to protons ratio, the fission parts could be unstable, experiencing a chain of (β^-) decays. For example:

$$n + {}^{235}_{92}U \rightarrow {}^{236}_{92}U \rightarrow {}^{98}_{40}Zr \rightarrow {}^{98}_{41}Nb \rightarrow {}^{98}_{42}Mo + 2\,{}^{1}_{0}n \qquad \dots(2)$$

and

$$n + {}^{235}_{92}U \rightarrow {}^{236}_{92}U \rightarrow {}^{136}_{40}Te \rightarrow {}^{98}_{41}Nb \rightarrow {}^{98}_{42}Mo + 2\,{}^{1}_{0}n \qquad \dots(2)$$

So, on the basis of binding energy curve and Coulomb law, we should calculate the released energy due to the mentioned reactions as the following:

$$E_C = \frac{Z_1 Z_2 e^2}{4\pi\varepsilon_0 d} = \frac{52 \times 40 \times (1.6023 \times 10^{-19})^2 \times 8.9876 \times 10^9}{1.5 \times 10^{-14} \times 1.6023 \times 10^{-13}}\ MeV.$$

$$\simeq 200\ MeV$$

Finally, as estimated by Sahak, Naqibullah (2012), Afghanistan contains more than 2 million metric tons of uranium metals based on which this country will be able to run out controlled chain reactions for the peaceful purposes and development of the country's economy.

II. *Methodology*

A. Identification of nuclear reactions equations for showing the energy released

The present research focuses on both releasing of energy during the nuclear fission of (${}^{235}_{92}U$) and continual producing of different fragments throughout the nuclear chain reaction. We can estimate the releasing of energy during a nuclear fission reaction by using of nuclear binding energy curve as the following:

$$n + {}^{235}_{92}U \rightarrow {}^{236}_{92}U \rightarrow {}^{141}_{56}Ba \rightarrow {}^{92}_{36}Kr + 3\,{}^{1}_{0}n \qquad \dots(3)$$

As described by Giancoli & Douglas (2000), according to equation (3) an enormous amount of energy is liberated during this reaction due to the mass of ${}^{235}_{92}U$ that is significantly larger than the entire masses of fission parts and plus the released neutrons. On the basis of binding-energy-per-nucleon curve of Fig. 1; the binding energy per nucleon for uranium is assigned about 7.6 MeV/nucleon, but for fission parts which they have middle masses, the intermediate binding energy per nucleon is around 8.5 MeV/nucleon. The distinction in mass, or energy, in the middle of main uranium nucleus and fission parts is nearly 8.5 – 7.6 = 0.9 MeV per nucleon. Since there are 236 nucleons included in a fission of an uranium atom (${}^{235}_{92}U$), the entire energy liberated per fission is

$$(0.9\ MeV/nucleon)\ (236\ nucleons)\ \approx 200\ MeV.$$

Therefore, the mentioned result shows that a very large amount of energy releases during one single nuclear fission. As described by Hecht (1998), according to Meitner estimation that used binding energy curve, a very large amount of energy is released due to a single atomic nucleus splitting (completely a million times larger energy released than to burning of one molecule of gasoline). To obtain *macroscopically* considerable amount of released power from fission, then an enormous number of nuclei have to smash into pieces (Giambattista and et al, 2004). As stated by Ghoshal (2012), that might be to earn an enormous quantity of energy because of nuclear fission of a small mass of uranium. Thus, if one g of ${}^{235}_{92}U$ is entirely broken apart, we are able to calculate the energy liberated of the process according to Q value.

For nuclear fission reaction (3) the Q value is:

$$Q = M({}^{235}_{92}U) + M_n - M\left({}^{141}Ba\right) - M\left({}^{92}Kr\right) - 3M_n$$

$$= 235.04278 + 1.00866 - 140.9129 - 91.89719 - 3 \times 1.00866$$

$$= 0.21537\ u = 200.6\ MeV.$$

As estimated by Serway (2014), if we assume that during a single nuclear reaction is released *200 MeV* energy, we can calculate the releasing of energy for one gram of ${}^{235}_{92}U$.

Thus, with regarding to mass (m) of uranium ${}^{235}_{92}U$ and the molar mass (M) of ${}^{235}U$, the number of moles of ${}^{235}U$ per kilogram is

$$n = \frac{m}{M} = \frac{1.00 \ \times 10^3 g}{235 \ g/mol} = 4.2553191 \ moles$$

Now, on the basis of the number of the mole and Avogadro's number, we obtain the number of nuclei in our sample as the following:

$$N = nN_A = (4.2553191 \ mol)(6.02 \times 10^{23} mol^{-1}) = 2.561 \times 10^{24}$$

In terms of N and Q, the energy liberated per kg of ${}^{235}U$ is

$$E = NQ = \frac{m}{M} N_A Q = \frac{1.00 \times 10^3 g}{235 \ g/mol} (6.02 \times 10^{23} mol^{-1}) \ (200 \ MeV)$$

$$= 5.123 \times 10^{26} MeV.$$

Then, the rate of liberating energy per gram of ${}^{235}U$ is:

$$E = \frac{NQ}{10^3} = \frac{5.123 \times 10^{26}}{10^3}$$

$$= 5.123 \times 10^{23} MeV$$

Hence, change this energy to kWh:

$$E = (5.123 \times 10^{23} MeV) \left(\frac{1.60 \times 10^{-13} J}{1 \ MeV}\right) \left(\frac{1 \ kWh}{3.60 \ \times 10^6 J}\right)$$

$$= 2.28 \times 10^4 kWh.$$

In terms of calculations and estimations which had been fulfilled by Ghoshal (2012), indicated the following datum:

(a) After the entirely burnt of 1 g uranium${}^{235}U$, produced energy is equivalent to:
$2.28 \times 10^4 kWh.$

(b) After the entirely burning of 1 kg coal, produced energy is equivalent to:
8.926 kWh.

Therefore, the mentioned results obviously show the strong point of using uranium as fuel for energy generation.

As stated by Walker (2008), from one side the equations of nuclear reaction show the phenomenon of fission for uranium atoms which the products of fission processes different from each other, like the following:

$$n + {}^{235}_{92}U \rightarrow {}^{236}_{92}U \rightarrow {}^{140}Xe + {}^{94}Sr + 2n. \qquad (4)$$

and

$$n + {}^{235}_{92}U \rightarrow {}^{236}_{92}U \rightarrow {}^{141}Ba + {}^{92}Kr + 3n. \qquad [Cutnell, 1992]$$

The last reaction is just one of the numerous reactions which may happen during uranium fissions (Cutnell and Johnson, 1992). That is, these nuclear reaction equations imply the continual production of radio-isotopes or radio-nuclides. According to Serway and Faughn (2006), during splitting of uranium, over 90 distinctive fragments of fission or nuclides can be created.

On the other hand, as described by Walker et al (2008), in Eq. 4, the fission parts ${}^{140}Xe$ and ${}^{94}Sr$ are both strongly radioactive, experiencing beta disintegration up to everyone arrives a nonradioactive final product. As example, for xenon, the disintegration chain is:

$$ {}^{140}Xe \rightarrow {}^{140}Cs \rightarrow {}^{140}Ba \rightarrow {}^{140}La \rightarrow {}^{140}Ce. \qquad (5)$$

On the basis of these two mentioned processes, during the controlled chain reactions there are produced many new nuclides and as stated by Sharma (2003), this area interested world-wide consideration. The new products created are varied *radio-isotopes* which are in constantly increasing requirement.

B. Modeling of some processes occurring during nuclear reactions is the best way for understanding these processes.

So far, it is around 200 years that physicists and chemists have studied atoms and established models to describe and present the consequences of the thousands of experiments they have fulfilled. With regard to our issue, our models tell us that uranium nuclei (particularly nuclei of U^{235}) are fissionable and constantly splitting and decaying and sending out neutrons (Carbon, 2006). According to Giancoli, Douglas C. (2000), Otto Frisch and Lise Meitner designed the splitting model of the U^{235} as is illustrated in Fig. 1. On the basis of the ***liquid- drop*** **model**, the new phenomenon was called ***nuclear fission*** due to its similarity to biological fission (cell division). It happens a lot more easily for ${}^{235}_{92}U$ than for the more usual isotope of ${}^{238}_{92}U$. As a result of nuclear fission process, the two nuclei are produced, N_1 and N_2 are named ***fission fragments,*** and during the occurrence of process of a number of neutrons (say, two or three) are also emitted. The reaction can be written as the following:

$$n + {}^{235}_{92}U \rightarrow {}^{236}_{92}U \rightarrow N_1 + N_2 + neutrons \qquad (6)$$

And a standard fission reaction as mentioned above is:

$$n + {}^{235}_{92}U \rightarrow {}^{236}_{92}U \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3n. \qquad (7)$$

Finally, on the order of liquid-drop model and as discussed on page (3), the releasing of energy due to splitting of one atom of uranium (${}^{235}_{92}U$) will be very enormous:

$$(0.9\, MeV/nucleon)\,(236\, nucleons) \approx 200\, MeV.$$

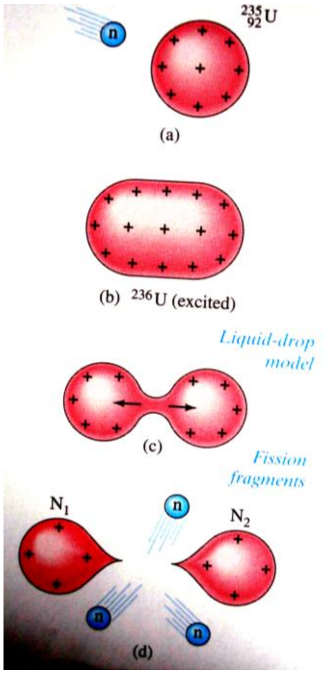

Figure 1. Fission of a U^{235} nucleus after capture of a neutron, according to the liquid-drop model (Giancoli, Douglas C. 2000).

According to Young and Freedman (2012), more than 100 distinctive nuclides, which represent over 20 distinct elements, those are found among the products of fission process. Figure 2, demonstrate the dividing up of mass numbers for division parts from the splitting of ${}^{235}_{92}U$. The majority of fission parts include mass numbers from 90 to 100 and from 135 to 145; splitting into two fission parts with about equivalent mass is implausibly.

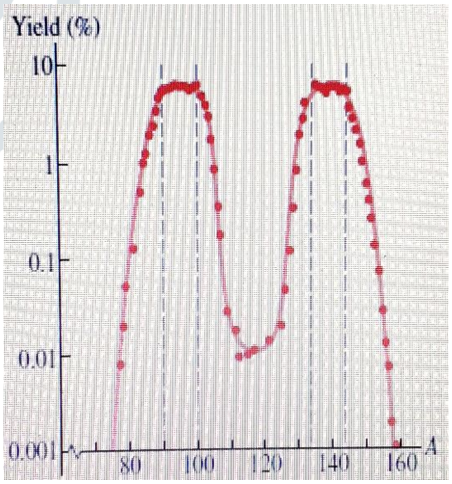

Figure 2. Mass distribution of fission fragments from the fission of uranium – 236 which is produced when uranium – 235 absorbs a neutron. The vertical scale is logarithmic (Young and Freedmman, 2012).

As stated by Serway, Raymond A. and Jerry S. Faughn (2006), when (${}^{235}_{92}U$) experienced splitting an average of around 2.5 neutrons are sent out per each process of splitting of (${}^{235}_{92}U$). The librated neutrons can be entrapped by other nuclei, which change these nuclei from stable state to unstable state. Therefore, starts additional splitting processes, which resulted in the possibility of a ***self sustaining chain reaction,*** as shown in figure 3. So, calculations have showed if the energy in 1 kg of ${}^{235}_{92}U$ were liberated, it is equivalent to the energy produced by the blowing up of around 20 000 tons of TNT.

To maintain the ***self-sustaining chain reaction*** constantly, as cleared by Krane, Kenneth S. (2012), our requirement is one neutron for every splitting process to be attainable to cause another division of (${}^{235}_{92}U$). There is a natural way to solve this challenge. Nearly 1% of the neutrons produced during the splitting process are delayed neutron, and they do not create at the moment of fission, but to a certain extent later, which comes before the radioactive disintegration of fission parts.

As figure 4 demonstrates, few of the processes which can take place in splitting event of ($^{235}_{92}U$). Therefore, a nucleus of $^{235}_{92}U$ capture a neutron and separates into two heavy parts and two swift neutrons; one of the fission parts give off a ***delayed*** neutron. The speeds of three neutrons are reduced by passing across the moderator. Due to two neutrons new fissions take place, and $^{238}_{92}U$ is captured the third one, which consequently forms split-able $^{239}_{92}Pu$, that can be obtained again from the fuel by chemical methods.

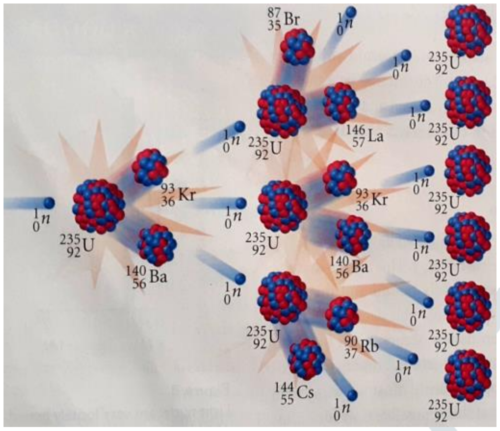

Figure 3. A nuclear chain reaction can be initiated by the capture of a neutron.

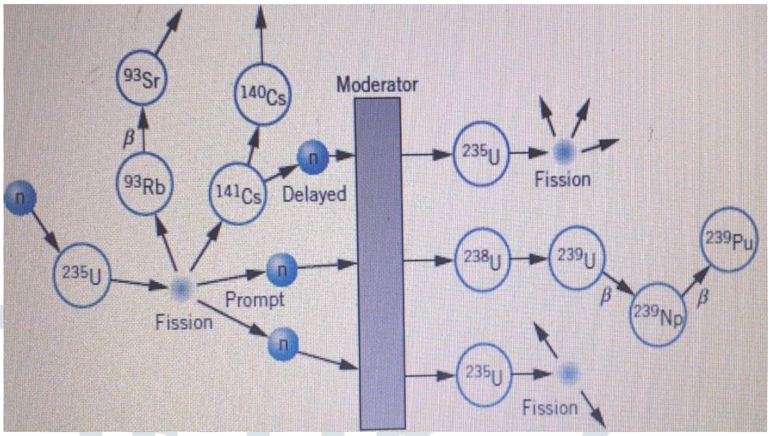

Figure 4: A typical sequences of processes in fission. A nucleus of ^{235}U absorbs a neutron and fissions; two prompt neutrons and one delayed neutron are emitted. Following moderation, two neutrons cause new fissions and the third is captured by ^{238}U, resulting finally in ^{239}Pu (Krane, Kenneth S., 2012).

III. Uranium Resources in Afghanistan

As stated by Sahak, Naqibullah (2012), Afghanistan's ore of uranium located in Surkh Parsa in Parvan province and in southern and northern Khan Neshin areas in Helmand Province. The important part of uranium mineralization is revealed in southern Khan Neshin which is located in Helmand Province. The important body of uranium ore has 300m length and from 14.2 to 58m height and the erosion process naked it up to 100m depth. The more enrichment of uranium mineralization has the metallic quantity of more than 1%. There are some kinds of uranium minerals such as: uraninite with water, uranil, phosphate and stucco which contain uranium.

According to Frozn, Sabour (2011), French geological team in 1971 fulfilled geological research about uranium ore deposit, they determined the industrial mineralization of uranium in different parts of Afghanistan such as Khan Neshin in Helmand, Khaja Rawash in Kabul, Surkh Parsa in Parvan and some areas in Panjsher, Laghman and Badakshn provinces.

As described by Peters and Tucker (2011), they discovered industrial and minable quantities of uranium and thorium in Khan Neshin. They state that "There were canary yellow minerals, speckled rocks in the ground – it was unlike anything I had ever seen. It was exhilarating to make this kind of discovery; the signs were everywhere."

On the basis of new estimation fulfilled by NASA (2010), there are 1.4 million metric tons of uranium metal and thorium metals in Khan Neshin mineralization zones.

The result had come from geological survey in 1984 which had been fulfilled by survey team under the leadership of a Soviet Union Engineer geologist had demonstrated minable quantities of uranium metal at Khwaja Rawash Mountain in Kabul Province

Figure 5. Shows the excavation processes in Khan Neshin area. This process fulfilled for purpose of determining the concentration of uranium in mother rocks. Source: Xinhua News Agency.

and Mir Daoud area in Herat Province has minable uranium as well.

IV. Calculations

As estimated by Giancoli, Douglas (2000), the minimum amount of uranium that is necessary to experience fission for the purpose to set out a $1000 - MW$ power reactor per year of self-sustaining chain reaction. In order to produce $1000 - MW$ turnout, the perfect energy generation is $3000\ MW$, of which $2000 - MW$ is reduced as "waste" heat. Therefore, the complete energy liberate in 1 year $(3 \times 10^7 s)$ from splitting of uranium is about:

$$(3 \times 10^9 J/s)(3 \times 10^7 s) \approx 10^7 J.$$

If each fission process liberates 200 MeV of power, the number of fissions demanded is

$$\frac{10^7 J}{(2 \times 10^8 eV/fission)(1.6 \times 10^{-19} J/eV)} \approx 3 \times 10^{27} fissions.$$

Thus, the mass of a single uranium atom is about $(235\ u)(1.66 \times 10^{-27} kg/u) \approx 4 \times 10^{-25} kg$. Therefore, the total mass needed is $(4 \times 10^{-25} kg)(3 \times 10^{27} fission) \approx 1000\ kg$, or nearly one ton per year. Because ${}^{235}_{92}U$ is just a small part of natural uranium and even when enriched its amount certainly not more than 10% of the total amount of uranium.

As stated by Young and et al. (2012), we can determine the right amount of uranium ${}^{235}_{92}U$ mass consuming in a nuclear reactor in the result of fission process produce 3000 MW of thermal energy. Then, fission of each nucleus of ${}^{235}_{92}U$ releases around 200 MeV per atom. We use this and the mass of ${}^{235}_{92}U$ to specify the needed amount of uranium. Therefore, for each second we need 3000 MJ or $3000 \times 10^6 J$. Every splitting reaction produces 200 MeV, or we have

$$(200\ MeV/fission)\ (1.6 \times 10^{-13}/MeV) = 3.2 \times 10^{-11} J/fission$$

The number of fissions required per each second is

$$\frac{3000 \times 10^6 J}{3.2 \times 10^{-11} J/fission} = 9.4 \times 10^{19} fissions$$

Every atom of ${}^{235}_{92}U$ contains a mass of $(200\ u)\ (1.66 \times 10^{-27}\ kg/u) = 3.9 \times 10^{-25} kg$; the mass of uranium ${}^{235}_{92}U$ that experience fission each second is:

$$(9.4 \times 10^{19})(3.9 \times 10^{-25} kg) = 3.7 \times 10^{-5} kg = 37\ \mu g$$

During a day (86 400 s), the perfect consuming of ${}^{235}_{92}U$ is:

$$(3.7 \times 10^{-5} kg/s)\ (86\ 400\ s) = 3.2\ kg.$$

For evaluation, if we compare this estimated amount of uranium with the use up of coal in 1000-MW coal-fired power plant, the second consumes or burns 10600 tons (about 10 million kg) of coal every day!

V. *Analysis*

As revealed by Giancoli and Douglas (2000), uranium mineralization in ore deposit consists of 99.3 percent ${}^{238}_{92}U$ and just 0.7 percent is fissionable ${}^{235}_{92}U$. Therefore, as estimated by Sahak, Naqibullah (2012) and NASA (2010), Afghanistan contains more than 2 million tons uranium which precisely, on the basis of future precise discoveries processes the mentioned amount will surprisingly increase. Nonetheless, according to experimental model that was developed and proposed at University of California, Berkeley, it might be possible that the heaviest famous element such as uranium ${}^{238}_{92}U$ absorbs neutron and produce "***transuranic***" elements as the reactions are shown in Fig. 6.

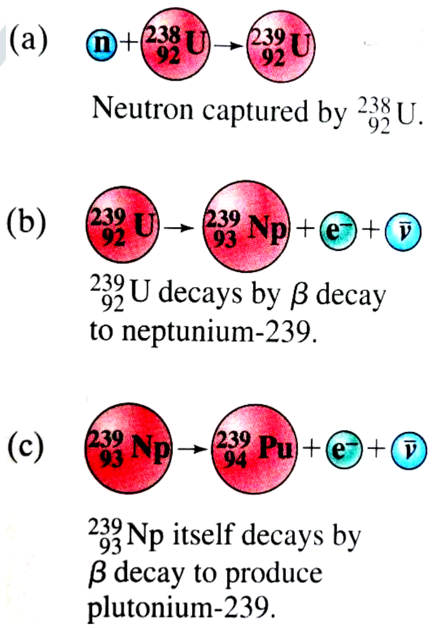

Figure 6. Neptunium and plutonium are produced in this series of reactions, after bombardment of uranium – 238 by neutrons (Giancoli, Douglas C., 2000).

Fast Breeder Reactor is able to use $^{238}_{92}U$ as fuel and change it to usable plutonium. On the other hand, according to the second phase of previous president Mohamad Daoud's strategic plan, ***Fast Breeder Test Reactor*** was planned to run out. Therefore, on the basis of two mentioned facts, it is important for the government of Afghanistan to establish ***Fast Breeder Test Reactor*** for generating electricity and compensating other demands of the country. After getting reasonable experiences, the government may work to develop the establishing of ***controlled fast breeder reactors*** according to necessity of the country and circumstances.

Finally, according to the fulfilled calculations and the mentioned reservoirs of uranium, the use of uranium as fuel will be very economic and efficient for the development of Afghanistan.

VI. Discussion

According to Garg (2011), the uranium – 235 atoms absorb neutron and experience fission which due to these processes are released tremendous amount of energy in the reaction environments. As stated by Tayal (2015), in every fission reaction which $(^{235}_{92}U)$ absorbs a neutron and splits into two parts, very enormous amount of energy are librated and fast neutrons are sent out to produce another reaction. Giancoli and Douglas (2000) revealed because of fission of one atom of $(^{235}_{92}U)$ is released about $(\approx 200\,MeV)$ energy. Therefore, as described by Giambattista and et al, (2004), for obtaining *macroscopically* considerable amount of energy for fission, then an enormous number of uranium nuclei have to split into pieces. As estimated by Serway (2014), the energy liberate per kg of ^{235}U is$(= 5.123 \times 10^{26} MeV)$. For controlling and using the released energy, we need a system called ***nuclear reactor***. Young and et al. (2012) calculated the right amount of uranium mass consuming in a nuclear reactor per day is $(= 3.2\ kg)$ which produces 3000 MW of thermal energy.

According to Sahak, Naqibullah (2012), Afghanistan uranium resources contain more than 2 million tons. As demonstrated by Giancoli and Douglas (2000), uranium resources contain 99.3% of ^{238}U, naturally. Thus, for a country such as Afghanistan with more than million tons of ^{238}U it is very important to establish ***Fast breeder Test Reactor*** on the base of the second phase of development plan of previous president Sardar Mohammad Daoud for peaceful purposes.

As considering the basic part of uranium resources located in Khan Neshin area of Helmand province, it is possible to build up the nuclear reactor near the Helmand River. Establishing of nuclear power plant on this land has many benefits for the country. From one side, this region is near to mining place of uranium which reduces the cost of transportation, and from the other side this region is located on deserts without living areas. After the operating reactor, the government will be able to conduct electricity in nearby provinces and irrigate some lands.

Because of self-sustaining chain reaction in the reactor core, there are produced more than 100 kinds of radio isotopes which are used in some areas such as medicine, agriculture and industrial sectors. In fact, the operations of fast breeder reactor will result in production of plutonium and by this way; Afghanistan will be able to run out another reactor and will receive more experiences about the management of nuclear reactors.

Finally, with regarding to this capacity of uranium and thorium in Afghanistan, this country will be able to establish around 30 breeder reactors which guarantee the development in many dimensions.

VII. Conclusion

Afghanistan is one of the countries located in the center of Asia that contains valuable and particular strategic situation and many kinds of mineral resources. Research centers of the United States of America have estimated the total price of Afghanistan's metallic and nonmetallic resources about one Trillion USD dollars and estimated the total amount of metallic uranium around two million tons. However, the ministry of mines of Afghanistan does not agree with the mentioned data and estimated the price of ores more than two Trillion dollars and the total amount of metallic uranium more than two million tons. Conducting more research and performing more discovery tasks by using new technology and modern equipment will determine the final data about Afghanistan's total resources and their prices.

As discussed before, according to the estimation by NASA (2010) the conditioning amount of uranium reservoirs just in Khan Neshin about 1.4 million tons. However, according to estimation fulfilled by Sahak, Naqibullah (2012), there are more than two million tons of uranium existed in different parts of the country. As described in calculation part, one reactor that supply 1000MW electrical energy for consumers uses 3.2 kg uranium as fuel. Therefore, the annual amount of uranium used by the mentioned reactor is: $\left(365\,day\right)\left(3.2\,Kg\right)/1\,day = 1168\,Kg = 1.168\,Tons.$ If the reactor operates for thirty years, the total amount of fuel used during these thirty years will be: $\left(30\,year\right)\left(1.168\,Ton\right)/1\,year = 35.04\,Ton$. The existed reservoirs of uranium in Afghanistan can respond to operation of many reactors during the continual years.

If we compare the capacity of Afghanistan's uranium mineralization (more than 2 million tons) with the capacity of India's uranium and thorium mineralization (60 000 tons), there is an enormous different between these two reservoirs. While India has run out 16 different types of reactors, Afghanistan did not extract their row metallic uranium so far. It is worthy to mention that building nuclear reactor is a vital process for the development of Afghanistan and defending its territory independently due to the fact that Afghanistan is surrounded by countries equipped with nuclear weapons, i.e., Iran, Pakistan and China.

REFERENCES

Carbon, Max W. (2006). *Nuclear power*. Second edition. Nuclear engineering university of Wisconsin – Madison: Pebble Beach Publishers.

Frozan, Abdulsabor. (2011). *Uranium of Afghanistan.* New Jersey State: Geological College.

Garg, Jagadish B. (2011). Nuclear *Physics Basic Concepts*. New York: Macmillan Company.

Ghoshal, S. N. (2012). *Nuclear Physics.* India: S. Chand and Company LTD.

Giambattista, Alan, Richardson, Betty, McCarthy & Richardson, Robert, C. (2004). *College Physics.* McGraw- Hill: Publishing Company.

Giancoli, Douglas, C. (2000). Physics *for Scientists & Engineers with Modern Physics.* Third edition. New Jersey: Prentice Hall Publishing, Ltd.

Halliday, David. Resnick, Robert & Walker, Jearl. (2008). *Fundamentals of Physics.* Volume 2. 8th Edition. Cleveland State University: John Wiley & Sons Publishing company, Inc.

Herbert, Sydney & Rowell, Gilbert. (1995). *General Physics.* Cambridge: University Press.

Krane, Kenneth S. (2012). *Modern Physics.* Third Edition. USA: John Wiley and Sons Publishing Company.

Martin, B. R. (2006). *Nuclear Reaction Physics*. UK: John Wiley and Sons Ltd.

Nazifi, Abdul Hay and Tanha, Mohamad Ramatullah. (2007). *Fundamentals of Applied Nucleus.* Kabul: Published by University Press.

Sahak, Naqibullah. *Science of Metallic Mines.* (2012). Nangarhar: Published by Hamdar press.

Serway, Raymond A and Jewett, John W. (2006). *Principles of Physics.* Forth Edition. USA: published by Thomson's company press.

Serway, Raymond, A & Faughn, Jerry, S. (2006). *Holt Physics.* North Carolina State University & Eastern Kentucky University. Published by: Holt, Rinehart and Winston Company.

Sethumadhavan, P., and Anila, A. K. (2010). *Complementary Course of Physics.* India: Manjusha Publication Company.

Sharma, V. K., (2006). *Nuclear Physics.* Sixth Edition. India: Para deep's publishing Company.

Tayla D. C., (2015). *Nuclear Physics*. Reprinted in India: Himalaya Publishing House.

Williams W. S. C., (2008). *Nuclear and Particle Physics.* USA: Oxford University press.

Young, Hugh, D., and Freedman, Roger A. (2012). *University Physics with Modern Physics.* Carnegie Mellon University & University of California, Santa Barbara: Pearson Education, Co.