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Civil and Military Uses of Nuclear Technology

Sumayyah 'Aqilah Antar[1]

[1*] Independent Research Scholar

[*]*Corresponding Author:* e-mail: *Summaia66955@protonmail.com*

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Abstract— The vast majority of natural phenomena common to Earth involve only gravity and electromagnetism, not nuclear interactions. This is because atomic nuclei generally remain separate because they contain positive electrical charges and therefore repel each other. In 1896, Henri Becquerel researched and studied the phosphorylation of uranium salts when he discovered a new phenomenon that came to be called [[radioactive decay]]. He, Pierre Curie and Marie Curie began investigating this phenomenon. In the process, they isolated the element radium, which is highly radioactive. They discovered that radioactive materials produce intense, penetrating rays of three different types, which they called alpha, beta and gamma as the first three Greek letters. Some of these types of radiation can pass through ordinary matter, and they can all be harmful in large amounts. All the early researchers had many radiation burns, which were like sunburns, and they didn't think much about it. The new phenomenon of radioactivity has been seized upon by manufacturers of quack medicine (as had been done with the earlier discoveries of electricity and magnetism), and a number of drugs and treatments have been released from patent medicine involving radioactivity..

Keywords— Natural Phenomena – Nuclear Technology – Nuclear Weapons – Nuclear - Radioactive Decay

I. INTRODUCTION

Gradually it was realized that the radiation from radioactive decay was ionizing radiation, and that even very small amounts of incineration could pose a severe long-term danger. Many scientists working in radioactivity died of cancer as a result of exposure to it. Radioactive drugs have mostly disappeared, but other applications of radioactive materials have persisted, such as using radium salts to produce glowing discs over the meters.

As the structure of the atom was better understood, the nature of radioactivity became more clear. Some large atomic nuclei are unstable, and thus [[radioactive decay] (release of matter or energy) after a random period. The three forms of radiation discovered by Becquerel and Curie

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are also well understood. Alpha decay occurs when the nucleus releases an alpha particle, two protons and two neutrons, the equivalent of a helium nucleus. Beta decay is the release of a beta particle which is a high energy electron. Gamma decay releases gamma rays, which unlike alpha and beta radiation is an insignificant but very high frequency electromagnetic radiation, and therefore energy. This type of radiation is the most dangerous and the most difficult to prevent. The three types of radiation occur naturally in certain elements.

It has also become apparent that the ultimate source of most of Earth's energy is the nuclear source, either through radiation from the Sun from stellar thermonuclear reactions or via the radioactive decay of uranium within the Earth, the main source [[geothermal energy]].

II. NUCLEAR FISSION

In natural nuclear radiation, the byproducts are very small compared to the nucleus from which they originate. Nuclear fission is the process of splitting the nucleus into roughly equal parts, releasing energy and neutrons in the process. If these neutrons are captured by another unstable nucleus, they can also fission, resulting in a chain reaction. The average number of neutrons released per nucleus that continues to fission another nucleus is referred to as k. Values of k greater than 1 mean that the fission reaction releases more neutrons than it absorbs, and is thus referred to as a self-sustaining chain reaction. A mass of fissile material large enough (and in an appropriate composition) to induce a self-sustaining chain reaction is called the critical mass.

When a neutron is captured by a suitable nucleus, fission may occur immediately, or the nucleus may remain in an unstable state for a short time. If there is enough instantaneous decomposition to continue the chain reaction, the mass is said to be instant critical, and the release of energy will grow rapidly and uncontrollably, usually resulting in an explosion.

When it was discovered on the eve of World War II, this idea led many countries to start programs to investigate the possibility of building an atomic bomb - a weapon that uses fission reactions to generate much more energy than can be created with chemical explosives. The Manhattan Project, operated by the United States with assistance from the United Kingdom and Canada, developed multiple fission weapons that were used against Japan in 1945 in Hiroshima and Nagasaki. During the project, the first fission reactors were also developed, although they were primarily for weapons manufacture and did not generate electricity.

In 1951, the first fissionable nuclear power plant was the first to produce electricity at Experimental Generation Reactor 1 (EBR-1), in Arco, Idaho, ushering in the "atomic age" of intense human energy use.

However, if the mass is only critical when the delayed neutrons are included, the reaction can be controlled, for example by inserting or removing a neutron absorber. This is what allows building nuclear reactors. Fast neutrons are not easily captured by nuclei; They must be slowed down (slow neutrons), generally by hitting a neutron-moderating

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nucleus, before they can be easily captured. Today, this type of fission is commonly used to generate electricity.

If the nuclei are forced to collide, they can undergo nuclear fusion. This process may release or absorb energy. When the resulting core is lighter than the iron core, energy is released naturally; when the core is heavier than the iron core, the energy is generally absorbed. This fusion process occurs in stars, which derive their energy from hydrogen and helium. It forms, through stellar fusion reactions, light elements (lithium to calcium) as well as some heavy elements (beyond iron and nickel, via the slow neutron capture process). The remaining abundance of heavy elements, from nickel to uranium and beyond, are due to nucleosynthesis in a supernova, the fast neutron capture process supernova.

Of course, these natural astrophysical processes are not examples of nuclear "technology". Due to the strong repulsion of the nuclei, fusion is difficult to achieve in a controlled manner. Hydrogen bombs get their immense destructive power from fusion, but their energy is uncontrollable. Controlled fusion is achieved in a particle accelerator; this is the number of synthetic elements that are produced. A fusor can also produce controlled fusion and is a useful neutron source. However, both devices operate at a net power loss. Controlled, viable fusion energy proved elusive, despite the occasional ploy. Technical and theoretical difficulties have hampered the development of a working civilian fusion technology, although research continues to this day worldwide.

Nuclear fusion was initially pursued only in theoretical stages during World War II, when scientists at the Manhattan Project (led by Edward Teller) investigated it as a way to build a bomb. The project abandoned fusion after concluding that it would require a fission reaction to explode. It took until 1952 for the first complete hydrogen bomb to be detonated, so called because it used reactions between deuterium and tritium. Fusion reactions are more active per unit mass of fuel than fission reactions, but the initiation of a fusion chain reaction is more difficult.

III. NUCLEAR WEAPONS

A nuclear weapon is an explosive device that derives its destructive power from a nuclear reaction, either fission or a combination of fission and fusion. Both reactions release huge amounts of energy from relatively small amounts of matter. Even small nuclear devices can destroy a city by explosion, fire and radiation. Nuclear weapons are weapons of mass destruction, and their use and control have been a major aspect of international politics since their first appearance.

The design of a nuclear weapon is more complex than it might seem. Such a weapon must have one or more subcritical fission masses that are stable to deploy, and then induce criticality (creation of a critical mass) to detonate. It is also very difficult to ensure that such a chain reaction consumes a large portion of the fuel before the device flies away. Purchasing nuclear fuel is also more difficult than it may seem, given that materials not stable enough for this process do not currently occur naturally on Earth in adequate quantities.

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One of the isotopes of uranium, uranium-235, is naturally occurring and unstable enough, but is almost always found mixed with the more stable isotope uranium-238. The latter accounts for more than 99% of the weight of natural uranium. Therefore, some isotope separation methods must be performed on the basis of the weight of three neutrons in order to enrich (separate) uranium-235.

Instead, plutonium has an isotope that is not stable enough for this process to be usable. Earth's plutonium is not currently found naturally in sufficient quantities for such use, so it must be manufactured in a nuclear reactor.

In the end, the Manhattan Project created nuclear weapons based on each of these elements. They detonated their first nuclear weapon in a test codenamed "Trinity", near Alamogordo, New Mexico, on July 16, 1945. The test was conducted to ensure that the implosion method would work, which was done by the uranium bomb, Little Boy, which was dropped on Japan in Hiroshima on August 6, 1945, followed three days later by the plutonium-based Fat Man in Hiroshima-Nagasaki. In the wake of unprecedented destruction and casualties from a single weapon, the Japanese government quickly surrendered, ending World War II.

Since these bombings, no offensive nuclear weapons have been deployed. However, they have prompted an arms race to develop increasingly destructive bombs to provide a nuclear deterrent. A little four years later, on August 29, 1949, the Soviet Union detonated its first fission weapon. The United Kingdom followed suit on 2 October 1952; France, on February 13, 1960, and China built a nuclear weapon. About half of the deaths from Hiroshima and Nagasaki died after two to five years of radiation exposure.

Radiological weapons are a type of nuclear weapon designed to distribute dangerous nuclear materials into enemy areas. Such a weapon would not have the explosive power of a fission or fusion bomb, but it could kill many people and contaminate a large area. A radioactive weapon has not been deployed. While such a weapon is considered useless by the conventional military, such a weapon raises concerns about nuclear terrorism.

More than 2,000 nuclear tests have been conducted since 1945. In 1963, all nuclear and many non-nuclear states signed the Limited Test Ban Treaty, pledging to refrain from testing nuclear weapons in the atmosphere, underwater, or in outer space. The treaty allowed underground nuclear testing. France continued atmospheric tests until 1974, while China continued until 1980. The last underground tests were conducted by the United States in 1992, the Soviet Union in 1990, and the United Kingdom in 1991, and both France and China continued testing until 1996 After signing the Comprehensive Nuclear-Test-Ban Treaty in 1996 (which has not entered into force as of 2011), all of these countries pledged to stop all nuclear testing. The non-signatories India and Pakistan tested nuclear weapons in 1998.

Nuclear weapons are the most destructive weapon known - the archetype of weapons of mass destruction. Throughout the Cold War, opposing powers possessed nuclear arsenals huge enough to kill hundreds of millions of people. Generations of people have grown up under nuclear

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devastation, as portrayed in films such as Doctor Strangelove and The Atomic Café.

However, the enormous energy released in the detonation of a nuclear weapon also indicates the possibility of a new source of energy.

IV. CIVILIAN USES OF NUCLEAR ENERGY

Nuclear Energy

Nuclear power is a type of nuclear technology that involves the controlled use of nuclear fission to release energy for work including propulsion, heat and electricity generation. Nuclear energy is produced through a controlled nuclear chain reaction that produces heat - which is used to boil water, produce steam, and drive steam turbines. The turbine is used to generate electricity and/or to perform mechanical work.

Nuclear power currently provides approximately 15.7% of the world's electricity (in 2004) and is used to propel aircraft carriers, icebreakers, and submarines (so far, economics and concerns in some ports have prevented the use of nuclear power in transport ships). All nuclear power plants use fission. But no man-made fusion reaction has produced a feasible source of electricity.

Medical applications

Imaging - The largest use of ionizing radiation in medicine is in medical radiography to make images of the inside of the human body using X-rays. This is the largest artificial source of human exposure to radiation. Medical x-ray machines use cobalt-60 or other x-ray sources. A number of radiopharmaceuticals, sometimes bound to organic molecules, are used to act as radiotracers or contrast agents in the human body. Positron nucleotides are used for high-resolution, short-time-lapse imaging in applications known as positron emission tomography.

Industrial applications

Because some ionizing radiation can penetrate the material, it is used in a variety of measurement methods. X-rays and gamma rays are used in industrial radiography to make images of the interior of solid products, as a means of non-destructive testing and inspection. The object to be x-rayed is placed between the source and photographic film in a cassette. After a certain exposure period, the film is developed and any internal defects in the material are revealed.

Metrics - Metrics use the exponential absorption law of gamma rays

Level Indicators: The source and detector are placed on both sides of the container, indicating the presence or absence of material in the horizontal radiation path. Beta or gamma sources are used, depending on the thickness and density of the material to be measured. The method is used in containers of liquids or granular materials

Thickness Gauges: If the material has a constant density, the signal measured by the radiation detector depends on the thickness of the material. This is useful for continuous production, such as paper, rubber, etc.

Electrostatic Control - To avoid build-up of static electricity in the production of paper, plastics, synthetic textiles, etc., a

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tape-shaped source of the Alpha 241Am emitter is near the material at the end of the production line. The source ionizes the air to remove electrical charges on the material.

Radioactive tracers - Because radioactive isotopes behave chemically, often like an inactive element, the behavior of a particular chemical can follow the radioactivity. Examples include:

Adding a gamma ray tracer to a gas or liquid in a closed system allows a hole to be created in the tube.

Adding a tracer to the surface of an engine component allows wear measurement by measuring the activity of the lubricant.

Oil and Gas Exploration - Nuclear well logging is used to help predict the commercial viability of new or existing wells. The technique involves using a neutron or gamma ray source and a radiation detector lowered into wells to determine the properties of surrounding rocks such as porosity and lithography.

Road Construction - Moisture/Nuclear Density Meters are used to determine the density of soil, asphalt and concrete. The cesium-137 source is usually used.

Commercial applications

Radio luminescence

Tritium illumination: Tritium and phosphorous are used in a riflescope to increase the accuracy of shooting at night. Some runway signs and building exit signs use the same technology to remain lit during a power outage.

Petavoltaic device.

Smoke detector: An ionized smoke detector includes a small mass of radioactive americium-241, a source of alpha radiation. Two ionization chambers are placed next to each other. Both have a small source of 241Am which results in a small constant current. One is closed and operated for comparison, and the other is open to ambient air; It contains a mesh pole. When smoke enters the open chamber, the current is interrupted as the smoke particles adhere to the charged ions and return them to the electrically neutral state. This reduces the current in the open chamber. When the current drops below a certain threshold, the alarm is triggered.

Food processing and agriculture

In biology and agriculture, radiation is used to induce mutations to produce new or improved species, such as in atomic horticulture. Another use is in insect control in the sterile insect technique, in which male insects are sterilized by radiation and released, so that they do not have offspring, to reduce the population.

In industrial and food applications, radiation is used to sterilize tools and equipment. An advantage is that the body can be closed with plastic before sterilization. An emerging use in food production is food sterilization using food irradiation.

Food irradiation is the process of exposing food to ionizing radiation in order to destroy microorganisms, germs, viruses, or insects that may be present in the food. Radiation sources used include isotope gamma ray sources, X-ray generators, and electron accelerators. Other applications include inhibiting shoots, delaying ripening, increasing juice yield, and improving re-hydration. Radiation exposure is a general term for the intentional exposure of a material

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to radiation to achieve a technical objective (in this context, "ionizing radiation"). As such, it is also used in non-food items, such as medical devices, plastics, gas line pipes, floor heating hoses, shrink film for food packaging, auto parts, wire and cable (insulation), tires, and even gemstones. Compared to the amount of radioactive food, the volume of these daily applications is huge but the consumer has not noticed. The real effect of food processing with ionizing radiation is related to damage to DNA, the genetic information essential for life. Microorganisms are no longer able to reproduce and continue their insidious or pathogenic activities. The spoilage microorganisms cannot continue their activities. Insects do not survive or become infertile. Plants cannot continue their normal process of maturation or aging. All of these effects benefit the consumer and the food industry as well. The specialty of processing food by ionizing radiation is the fact that the energy density of each atomic transfer is very high, and it can cleave molecules and induce ionization (hence the name) that cannot be achieved by mere heating. This is the reason for the new beneficial effects, but at the same time, for new concerns. Processing of solid food by ionizing radiation can provide an effect similar to thermal pasteurization of liquids, such as milk. However, the use of the term cold pasteurization to describe irradiated foods is controversial, because pasteurization and irradiation are fundamentally different processes, although the intended end results can be similar in some cases.

Critics of food irradiation have expressed concerns about the health risks of induced radioactivity.[citation needed] A report by the American Council on Science and Health industrial advocacy group "Irradiated Foods" states that: "The types of radiation sources approved for processing foods have much lower certain energy levels." Of those that would make any ingredient in food radioactive. Food that is subjected to radiation does not become more radioactive than luggage that passes through an airport x-ray scanner or x-rayed teeth."

Food irradiation is currently permitted in more than 40 countries, and the volume is estimated to exceed 500,000 metric tons (490,000 long tons; 550,000 small tons) annually worldwide.

Food irradiation is essentially a non-nuclear technology; It relies on the use of ionizing radiation from electron accelerators and converting it to sunlight, but it may also use gamma rays from nuclear decay. There is a global industry for ionizing radiation treatment, the majority in number and processing power using accelerators. Food irradiation is a specialized application only compared to medical supplies, plastic materials, raw materials, gems, cables, wires, etc.

V. Conclusion

As we have noted, there are many beneficial uses of nuclear energy that can contribute to the development and progress of mankind, and which can contribute to a global renaissance. What is important in this regard is to ensure the safety and security of this energy.

Authors Profile

[1] Independent Research Scholar.