How The Development of Accelerators Has Shaped The Engineering and Science Around Us

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Electrical Engineering

Electrical engineering has been developed to support science and a continuous progress of technology.

The effective Use of Particle Accelerators in the medical field has revolutionized procedures such as imaging and therapy in various ways, resulting in noticeably more concise diagnosis and research of improved treatments. Medical physicists continue to present ideas in particle physics into medicine, opening doors to new paths of research in most disorders that occur to the human body.

Magnetic Resonance Imaging (MRI) is a type of particle accelerator that has been a crucial instrument for scanning the anatomy and physiology of the human body without physical contact. It creates magnetic fields targeting the behavior of Hydrogen nuclei such that it aligns the nuclear spin of the protons. Abnormal behavior of the nuclei is mathematically translated to visualize images leading to the diagnosis and prognosis of disorders within concern. MRI is considered to be one of the most impressive advances in the application of particle accelerators.

Cancer Treatment is one of the most important applications of particle accelerators. Using techniques of radiotherapy, such that the cancer is targeted and destroyed through energy deposited by radiation. Those therapies fall into different categories:

- Tomotherapy consists of firing electrons in form of radiation at the DNA of the cancer cells, killing the cells.
- Electron Beam Therapy uses a similar technique to X-ray except it fires the electrons directly at the tumors without the use of producing targets (such as tungsten).
- Hadron Beam Therapy introduces particle therapy made of quarks, and subcategories into proton, neutron, and ion therapy.

Biomedical Engineering

Biomedical engineering is centered on the development of biological components and their application in medicine.

Chemical Engineering

Chemical Engineering is the branch of engineering that deals with manipulating the production and the manufacture of products through chemical processes. A lot of consideration is taken into account regarding the design of equipment, and the design of systems and the processing chemicals to make valuable products.

Chemical engineering has had a profound contribution on the development of the new technologies for construction and operation of present-day accelerators and detectors. In this way, we can mention a range of cutting-edge technologies that developed from the particle accelerators.

Nuclear energy

- Particle accelerators are used as a source of high-energy protons.
- Spallation is a nuclear reaction in which high-energy light particles produce many neutrons that are emitted from a nucleus.
- Accelerated Device System accelerates neutrons at the speed of light, causing the heavy nuclei to collide with protons.
- The nucleus then ejects a large number of neutrons proportional to the energy of the original proton.
- Benefits of this approach for an effective transmutation depends on the cross section of the waste elements.
- This causes radionuclides to emit several particles that will decay at a slower rate and will be less hazardous for the environment, proposing less health risks.

Cryogenics

- Extreme cold temperatures
- Cooling to cryogenic facilities
- Reducing the cost
- Simplifying the cryostat
- Minimizing the heat leaks
- Applications in superconductivity at low temperatures, Electric power transmission, Frozen food

Materials

Hardening surfaces
- Ion implantation (metals, ceramics and biomaterials)
- Electron Beam Heat Treating

Hardening Materials
- Electron Beam Material Irradiation - Cross-linking polymers
- Welding and Cutting Materials
- Electron Beam Welding (EBW)
- Electron Beam Machining (EBM)

Characterization
- Ion Beam Analysis
- Using Synchrotron Light Accelerator Mass Spectrometry (AMS)

References


Chemical Engineering and Mechanical Engineering

The particle accelerator is one of the most versatile instruments designed by physicists. The construction of the machine is mostly done by mechanical engineers, but the infrastructure that surrounds the particle accelerator is all done by civil engineers. Before the particle accelerator was built, certain standards have to be fulfilled to insure adequate results. It is vitally important to have a designated underground facility for arrangements of complexity to take place, in which this case had to help accommodate the needs of such a large particle accelerator like the LHC. Reasons being:

- Protecting the environment from the radiation produced by the machine
- A more stable underground

- Temperature consistency
- Helps in keeping precision machinery positioned over a few parts per billion
- Cherenkov shielding from any stray particles that come from the Sun, space, and activities on Earth.

The LHC did not only break history in the branch of physics, but in the field of civil engineering, as well. Significant achievements were accomplished, because of the work done by civil engineers, to house the LHC machine. Some examples are:

- A large circular tunnel with a circumference of 17 miles, buried in the ground under an average of 328 ft. of dirt and rock
- Taking two years to burrow a cavern large enough to hold a 12-story building for the installation of detectors
- Atlas and CMS installations, required the excavation of huge caverns up to 1148ft wide, 1380ft high and 268ft long. These caverns are of up to twice the size of any existing underground structures at CERN.
- Particle accelerators, as stated in the chemical engineering side, can change one element into another. This is called particle transmutation, allowing us to create strong/hotter/more stable materials for every-day construction and civil engineering projects. For example, they could create heavier and denser material than anything found in nature.

References


