Editorial

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Editorial on the need and advantages of SBES approach of 21st century over the approximate methods of 20th century

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Editorial

Fluids carry the energy in the form of heat which can be converted to mechanical energy. In 1883 de Laval from Sweden achieved a practical device "Converging Diverging Nozzle" through which an Impulse Turbine, a rotating machine was devised, a dream come true after a long wait over 2000 years since Hero's aelopile was demonstrated in the school of Alexandria. This is the first rotating machine having crossed the first critical speed beyond the so-called instability threshold speed by one of the greatest scientists Rankine in 1869. This has revolutionized the world and it has seen developments all the way in different fields of 20th and 21st centuries.

We owe a lot to the Scientific Revolution since 1697 ever since Newton invented Calculus of Variations ushering a new era in the history of thinking in this world. This resulted in basic sciences that have evolved and remained unchallenged. Basically Physics ruled with the invention of Calculus, a new Mathematics, through which Mass conservation, Momentum, Energy were expressed as governing equations that control the behavior of fluids. They are Euler equations becoming later into Navier-Stokes equations that included the turbulence aspects. Similarly Solids behavior is evolved on the displacements, strains, stresses were expressed, called as Theory of Elasticity through a set of coupled partial differential equations. Stress remains the main governing factor that controls all designs ever since 1883. The stress is essentially due to the fluids carrying the energy and imparting the loads for deformation of solid enclosures of the fluid path.

Another significant development in the Science Revolution period is Electromagnetism. Faraday argued if electricity could produce magnetism as shown by Oersted in 1820, why not magnetism produces electricity? He found electricity could be produced through magnetism by motion in 1831. He discovered that when a magnet was moved inside a coil of copper wire, a tiny electric current flows through the wire. Edison made it practical by making a practical Dynamo in 1882. Driven first by an IC engine and later by steam turbine a power plant that distributed to forty households in Manhattan area was born in 1882. This has revolutionized the way man lives and a new Engineering era was borne, where Fluids play the main role.

Actually it is James Watt who has ushered the Industrial Revolution after the Science Revolution and his reciprocating steam engine has brought in immense prosperity to mankind through land and ocean transportation. This is an important application of steam (fluid) carrying energy and converting to useful energy in transportation. However it is too slow, very heavy inducing lot of shaking forces and making it unwieldy. It has ruled 19th and 20th centuries and is now almost a museum piece ever since converging-diverging nozzle appeared.

Science of Fluid Mechanics played an important role in the airborne vehicles since Wright brothers test flight of early 20th century. Steam engines had no possibility to be used as the prime movers for propulsion. Piston engines were employed instead. Von Ohain and Frank Whittle during the II World War developed a gas turbine for aviation instead of an unwieldy steam turbine and soon after air transportation has become a standard mode for travel. Fluid mechanics or Aerodynamics plays a significant role in providing the lifting surface as well as propulsion for the airborne system through the gas turbines.

The aircraft itself gets its lift by aerodynamics from the moving body. The flight and atmosphere are never steady but are subject to transient conditions. The aerodynamics provides the lift while deflecting the structural surfaces and the deflections in turn alters the aerodynamics characteristics. For certain angles of attack and speeds, this fluid-structure interaction produces instability called flutter and can prove to be disastrous to the vehicle. This phenomenon is known with galloping of transmission lines in northern climates and Tacoma bridge failure. Thus multi-physics is borne where solids and fluids sciences get coupled together. An interesting feature during the II World War is the deployment of rockets and later torpedoes which used the converging-diverging nozzle of de Laval. These rockets led to space travel. Another interesting feature is the development of cryogenic engines using liquid Hydrogen and Oxygen for space vehicles and interplanetary travel. These cryogenic engines are used in Space Shuttle and Geostationary Launch Vehicles.

The above developments from 1883 necessitated the beginnings of Engineering in academic schools. American Universities such as Stanford began instruction in the field of engineering instead of science alone taught in the universities to enable design of engineering structures, rotating machines. The approximate engineering was developed as there were no digital computers at that period. Science itself was exact but proved to be unwieldy in dealing with coupled partial differential equations in absence of advanced digital computers. Approximate designs with simplifications along with experimentation and applying factors of safety were norm of that day but became obsolete with the development of digital computers.

This was changed with ENIAC developed during the II World War in Philadelphia. Logarithmic tables and slide rules gradually gave way to calculators, main frame computers, and then desktops leading to high speed computation of multi-physics problems.

Initially in the second half of last century, main frames in the Research laboratories and advanced educational institutions are used in developing computer programs which are author-centric in nature. Commerce and Business led to individual dedicated commercial codes development and availability to industries and other institutions. They are obviously most commonly applicable ones and when an end-to-end design is sought which involves multi-physics commercial codes are developed to link different physics codes with any special codes developed for specific individual applications. Thus Basic Sciences bounced back in lieu of approximate engineering. The designs avoided testing during design by adopting virtual testing and the new adaptations were much faster using high performance computing.

Hitherto unknown technologies were developed with the new-found computation and handling of geometries, flow paths, optimization and lifing under repeated loads and multi-physics amongst others. A specific example is in bringing back stars to the earth and produce abundant sustainable energy in place of fossil fuels amongst other means available that have been stored over millions of years and getting depleted with the usage time. This is Fusion of light atoms; hitherto unknown temperatures of million degrees centigrade of Plasma under enormous pressures and superconducting magnetic fields of several Tesla under molecular level vacuums are deployed in the designs of Thermo nuclear reactors. What was once thought analytical in coupling of electromagnetic fields with the flow (magneto hydrodynamics) has now become a reality. Lighthill and Ffowcs-Williams Wave propagation and noise from vortices in a flow controlled by Navier-Stokes equations is a typical multi-physics problem that can be easily addressed by today's high performance computing. We can also provide shape optimization of enclosures using topology optimization to keep noise under control using basic sciences borne in 17^{th} century. Another application can be the energy transferred to Earth from Gravitational waves that might be causing Continental drift and Tectonic plate movements over the Earth's mantle.

Fluids, Electromagnetism and Solids Sciences couple together in governing the design of modern equipment in different fields of Energy, Land transportation, Ocean transportation, Air transportation and Space transportation.

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Conflicts of interest

The author declares there is no conflicts of interest.