Aero Annum

Department of Aero- HiCET

2017-2018

Editor In Chief

Mr. V T Gopinathan

Staff Editor

Mr. R. Veeramanikandan

Student Editors

Hari Vignesh A (IV year)

Ganesan B (III year)

About the Institution

Hindusthan College of Engineering and Technology (HiCET) Coimbatore, established in the year 2000 by the great Industrialist and Philanthropist, Thiru.T.S.R.Khannaiyann of Hindusthan Educational Trust whose determination and dynamism made possible the realization of this institution of excellence. Surrounded with natures pristine beauty and an excellent infrastructure coupled with dedicated and experienced faculty has made the campus a much sought-after abode of learning. HiCET is one of the premier technological institutions inculcating quality and value based education through innovative teaching learning process for holistic development of the Students. The institution is recognized under Section 2(f) and 12B of University Grants Commission (UGC) and is an autonomous institution affiliated to Anna University , Chennai with permanent affiliation for most of the programmes, approved by the AICTE and the Government of India. Accredited by the National Assessment and Accreditation Council (NAAC) with 'A' grade, National Board of Accreditation (NBA).

Institute Vision

To become a premier institution by producing professionals with strong technical knowledge, innovative research skills and high ethical values.

Institute Mission

IM1:To provide academic excellence in technical education through novel teaching methods.

IM2:To empower students with creative skills and leadership qualities.

IM3: To produce dedicated professionals with social responsibility.

About the Department of

Aeronautical Engineering

The Department of Aeronautical Engineering was established in the year 2005 and now headed by Dr. N. M. Pratapraj**.** The Department also inaugurated the Aeronautical Students' Engineering Association (ASEA) in March 2008. The Department is directed by a dedicated team of teaching and non-teaching staff with a wide range of experience, and it has well-equipped laboratories and good infrastructure to support the autonomous curricular needs. Until now, the department has been in the forefront of advancing aeronautical education and indigenous research in the field of aeronautics. The department has received numerous funds under different schemes for various projects.

Department Vision

To be a global player and prepare the students with knowledge, skills, and ethics for their successful deployment in Aeronautical engineering.

Department Mission

M1:To nurture the students technically based on current trends and opportunities in the global Aerospace industry.

M2:To develop the students as innovative engineers to address the contemporary issues in the aeronautical field.

M3:To inculcate professional and social responsibility based on an innate ethical value system.

Program Educational Objectives (PEOs)

PEO 1: Graduates shall exhibit their sound theoretical, and practical knowledge with skills for successful employment, advanced education, research, and entrepreneurial endeavors.

PEO 2: Graduates shall establish deep-rooted mastering abilities, professional ethics, and communication alongside business capabilities and initiatives through lifelong learning experiences.

PEO 3: Graduates shall become leaders and innovators by devising engineering solutions for social issues in care of modern society.

Program Specific Outcomes (PSOs)

The graduates will be able to:

PSO 1: Apply the knowledge of aerodynamics, structures, propulsion, avionics, and aircraft maintenance to give solutions for complex engineering problems.

PSO 2: Use progressive methodology and tools involving design, analyze, and experiment in aircraft design.

HoD’s Message

The Department of Aeronautical Engineering, Hindusthan College of Engineering and Technology were established in the Year 2005 with a sanctioned intake of 60 students. The sanctioned intake increased to 120 from the academic year 2008-2009 onwards**.** The department endeavors to impart quality education in Aeronautical Engineering and to produce Engineers of excellence, and strive to be one of the best institutions in Aeronautical domain. We provide the best teaching faculty, high-tech labs and infrastructure. Our Students are securing ranks consistently at the University Level and the department has the excellent placement record every year. The graduated students are pursuing their higher studies at premier institutes in India and Abroad. Our Students have participated in various technical events at national and international level and won awards. I am sure in times to come many students from our department will make incredible mark nationally and internationally. We hold firm belief in our ability to succeed, practice human values, and show attitude of self-reliance, confidence and commitment. Students of our department will show a high level of professional competence in their respective areas. I wish my students all the best for all their endeavors.

HoD /AERO

Gas turbine performance prediction via machine learning

Ms. Jayameena (III AERO)

Gas turbines (GTs) have been widely used for power generation due to their high thermal efficiency and low CO_2 emissions. GT installations are steadily rising to meet the soaring electricity demand resulted from the growing populations and economies. GTs normally run in a flexible load-following manner due to the increasing penetration of renewable energy (e.g. solar energy, wind energy, and biomass energy). This operation mode requires GTs to ramp up and down frequently, and thus a precise prediction of GT performance is crucial for maintaining efficient operation. To this end, accurate and reliable GT modeling methods are necessary.

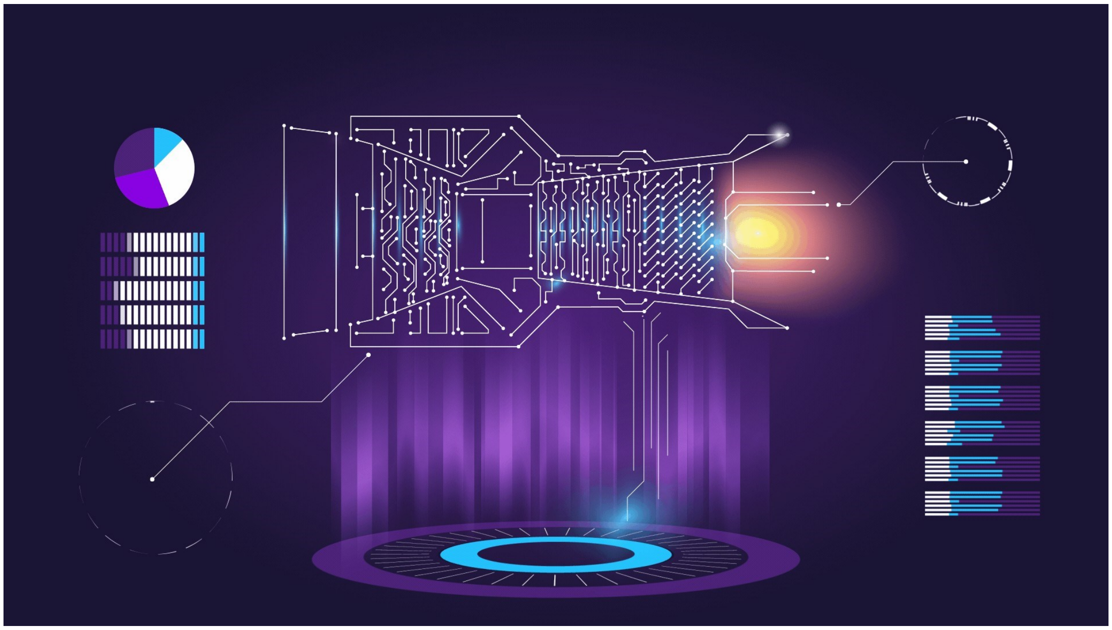
GT modeling has been studied in the literature. Al-Hamdan and Ebaid studied the modeling and simulation of a GT for power generation by superimposing a turbine map on a compressor map via suitable axis transformations. Haglind and Elmegaard proposed two models for predicting the part-load performance of aero-derivative GTs. One used actual maps for the compressor and turbine, while the other utilized a compressor map with turbine constants. Both models were found to offer good predictions of mass flow and pressure ratio profiles over 40-100% loads as well as thermal efficiencies and exhaust temperatures for part-loads above 70%. Lee developed a general simulation program for simple, recuperative, and reheat GTs. A stage-stacking method with a general stage map was used for the compressor, while a stage-by-stage model with efficiency correction was adopted for the turbine. However, their program was validated only under full-load conditions, and thus its prediction accuracy under part-load conditions was questionable. Song and team established a performance analysis model for a three-spool GT using detailed compressor and turbine maps and showed that the model offered good accuracy in predicting GT performance. Although these models can predict GT performance, they all require detailed performance maps of air compressor and turbine. In practice, real performance maps are proprietary information of engine manufacturers and often unknown even to the GT users.

Therefore, the models discussed so far are unable to provide reliable and accurate prediction, and there is a need to develop models from real operational data for predicting GT performance.

Artificial neural network (ANN) is a powerful surrogate model and has been applied to predict GT performance. Bartolini utilized ANN to describe micro GT performance, including completing the performance diagrams, assessing the influences of ambient parameters, and predicting the pollutant emissions. Nikpey presented an ANN model for a micro GT and showed that it was able to predict its normal performance with high accuracy. Later, they used ANN to evaluate the performance and emissions of a recuperative micro GT burning mixtures of natural gas and biogas. Bhowmik developed an ANN model for a diesel engine fueled with ternary blends of diesel, kerosene, and ethanol. Their model was found to be capable of mapping the ternary blends with engine performance and exhaust emissions. Fast unified two ANN models to predict the performance of an industrial GT. Their models were trained to identify if anti-icing system was in operation, and then predict GT operational and performance parameters. Their results showed good prediction accuracy with an error of less than 2.0%. Gonca [utilized ANN to analyze the effects of GT design parameters on the energetic, exergetic, and ecological performance of a GT with two intercoolers and two re-heaters.

Moreover, ANN was applied to other GT-based applications. The above ANN models can predict GT performance; however, they are unable to detect if GTs run at full-load conditions and thus cannot predict GT full-load performance. Knowing GT full-load performance, especially power generation capacity, is useful, because it helps GT users determine the operational limits of their engines. With GT power generation capacity, GT users can respond to the dynamic power demands flexibly and claim more reserve capacity to the power grid to gain more profit, if the power grid mandates such reserves. Hence, it is desirable for GT users to accurately predict GT full-load performance. Generally, compressor and turbine performance maps are needed to predict GT performance.

However, these performance maps are proprietary information of engine manufacturers and even unknown to GT users. A promising remedy is to use real operational data to predict the compressor and turbine operating characteristics (not their full performance maps) or to directly map GT performance with proper operating parameters. Machine learning methods based on surrogate models can be employed to achieve these goals.



The resulting models can then be used to predict GT part-load and full-load performances. Typically, GT full-load performance can be expressed in terms of correction curves that represent a departure of GT performance from its reference performance. Correction curves allow GT users to determine GT performance without appealing to complex numerical simulations and have been used for on-line performance monitoring [18] and diagnosis [19]. Considering GT correction curves are proprietary and may often be unknown to GT users, deriving them from GT operational data via reverse engineering can be very useful.
In this paper, a supervised machine learning-based method is developed for predicting GT performance and constructing performance correction curves. Surrogate models based on high dimensional model representation (HDMR) and artificial neural network (ANN) are developed to obtain the operating characteristics of air compressor and turbine from their real operational data. Moreover, holistic HDMR and ANN surrogate models are developed to capture GT part-load and full-load performance.

The HDMR and ANN models for air compressor and turbine are then embedded into a GT simulation program for performance prediction. All surrogate models are validated using real GT operational data. Finally, a holistic ANN model is employed to construct GT performance correction curves due to its lower complexity and higher accuracy.

What is 'Cryogenic Engine'

Ganesan B (III Year AERO)

Definition: A cryogenic engine/ cryogenic stage is the last stage of space launch vehicles which makes use of Cryogenics. Cryogenics is the study of the production and behavior of materials at extremely low temperatures (below -150 degree Centigrade) to lift and place the heavier objects in space.

Description: Cryogenic stage is technically a much more complexed system with respect to solid or liquid propellant (stored on earth) stages due to the usage of propellants at extremely low temperatures. A cryogenic engine provides more force with each kilogram of cryogenic propellant it uses compared to other propellants, such as solid and liquid propellant rocket engines and is more efficient.

Cryogenic engine makes use of Liquid Oxygen (LOX) and Liquid Hydrogen (LH2) as propellants which liquefy at -183 deg C and -253 deg C respectively. LOX and LH2 are stored in their respective tanks. From there they are pumped in to turbo pump by individual booster pumps to ensure a high flow rate of propellants inside the combustion/thrust chamber. The major components of a cryogenic rocket engine are combustion/thrust chamber, igniter, fuel injector, fuel cryo pumps, oxidizer cryo pumps, gas turbine, cryo valves, regulators, the fuel tanks and a rocket engine nozzle.

Cryogenic Injection in Rocket Engine Combustion Chambers

In the field of chemical rocket propulsion, oxygen and hydrogen are favored over other types of fuel due to the high specific impulse (Isp) that they produce. This Isp represents the ratio between the thrust (in mass equivalent units) and the fuel consumption, so that the higher the Isp, the heavier the payload can be. Oxygen and hydrogen can be easily obtained through air distillation and hydrocarbon cracking, but these components are gaseous at ordinary temperature. In order to minimize the rocket fuel tank structure, oxygen and hydrogen are liquefied at a very low temperature, hence leading to cryogenic combustion. Such extreme conditions require specifically designed test benches, such as the MASCOTTE test bench [1], in order to provide an insight into the characteristic phenomena involved in cryogenic combustion. To complement this experimental approach, numerical simulations with the CEDRE [2] code are conducted on test-case configurations, in order to develop numerical tools and models with the ultimate aim being predictable numerical simulation, which would make the designing of industrial scale rocket engines easier. This paper focuses on oxidizer dispersion through dense core destabilization, which leads to small scale structures eventually breaking into droplets or dense clusters, depending on the chamber pressure. This dispersion of oxygen greatly influences the flame shape and thus the overall combustion process, but is still difficult to represent numerically since it involves very different large scales. Subcritical regime and atomization Two-phase flows resulting from the atomization of liquid jets play a significant role in the proper functioning of cryogenic liquid-propellant rocket engines under subcritical operating conditions [3]. As depicted in figure 1, the great velocity difference between the two phases (liquid Ox and Gaseous H_2) at the exit of a coaxial cryogenic injector generates fluctuating accelerations. Due to these fluctuations, Rayleigh-Taylor instabilities destabilize the liquid to create ligaments. These instabilities then grow and eventually cause the peeling of the main LOx jet, which is referred to as "primary atomization". Large random-shaped liquid structures are thereby ejected towards the gas flow, subsequently undergoing "secondary break-up" when inertia forces exceed the liquid surface tension. This results in a spray of small LOx droplets, mainly spherical, which are dispersed by the turbulent gas flow and finally vaporized to feed the combustion with hydrogen. Such a configuration therefore exhibits a two-phase flow where the liquid phase is only composed of LOx, whereas the gas phase is made up of hydrogen H_2 , vaporized oxygen O_2 and combustion products. Eventually, the resulting high-enthalpy combustion products exhaust through a nozzle at supersonic speed, thereby providing the required thrust.