International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Performance Characteristics and Efficiency of Steam and Gas Turbine Plant

B. Karthikeya, [2]A. Laxmana Prasad, [3]A. Lakshumu Naidu

[1,2,3] Department of Mechanical Engg, GMR Institute of Technology, Rajam. AP- 532127
*Email Id: badijanakarthik@gmail.com

ABSTRACT:

This paper is concerned with the improvement of the performance of steam and gas turbines discussing various efficiency improvement cycles. Also, the arrangements of different auxiliary equipment of the power plant system are discussed. Improvement of the performance due to varying the different parameters (temperature, pressure, enthalpy, entropy, etc.,) are discussed. The detailed analysis of inlet pressure, exhaust pressure with percentage of change in output according to change in input quantities are discussed. Effect of heat in turbine is also discussed with heat losses.

Keywords: Performance, efficiency, turbine, temperature, pressure, enthalpy, entropy, emissions, power generation

INTRODUCTION:

Electricity which is very much required for the sustainability of the world, has few sources and one among those few sources is power plants. With the continuous rapid increase in population around the world demands for more production of electricity. According to global statistics, energy supply has grown when compared to the past but the energy supply is not meeting the demands. As a reason, there is the need for the establishment of new and advanced power plants and at the same time, the older plants need to be improved in terms of performance and productivity.

The steam turbine is one of the important essential components of the power plant which converts the thermal energy of pressurized steam into mechanical work by rotating shaft. It is essential to improve the performance of steam turbines to increase the overall output from a particular input that will be given to the turbine. The losses inside the turbine should be as minimized as possible to increase the output. The performance depends on many factors viz., arrangement of the components in the power plant, arrangements of the auxiliaries like feed water heaters, feed pumps, etc. also using multi-stage turbines. The performance of steam turbines largely depends on the blades of the turbine (shape, size, weight, etc.) also inlet temperature, pressure, and velocity of jet impacted. Proper selection of the blade material is very important in the reliability of the machine parts. This saves on the maintenance cost of the plant. Due to the high cost of setting up a steam power generation plant, it is important to have an optimal design to maintain good returns on capital investments.

Provide an overview of the significance of optimizing power plant efficiency and reducing energy consumption. Present the examination papers and their commitments to this field. Steam and gas turbines resemble the motors in power establishes that transform energy into power.

Steam turbines use steam to make power, and gas turbines consume fuel to do similar work. Making these turbines work better means we can deliver greater power utilizing less fuel, which is perfect for saving assets and being kinder to the climate. Researchers and specialists are continuously trying novel thoughts like utilizing better cooling frameworks or smart PC stunts. to make these turbines work far and away superior. By working on their productivity, we can make greater power while utilizing fewer assets, which is uplifting news for everybody.

1. CYCLES OF STEAM TURBINE:

1.1: IDEAL CYCLE OF STEAM TURBINE PLANT: RANKINE CYCLE

This cycle consists of a boiler where the steam is produced, a turbine where the steam is expanded to produce work, a condenser where the steam in a gaseous state converts into a liquid state by rejection of heat, and a pump which increases the pressure of the liquid which is being sent into the boiler. The actual cycle of the power plant differs from this ideal cycle with the addition of some accessories and components. The path of the fluid also varies for the improvement of performance.

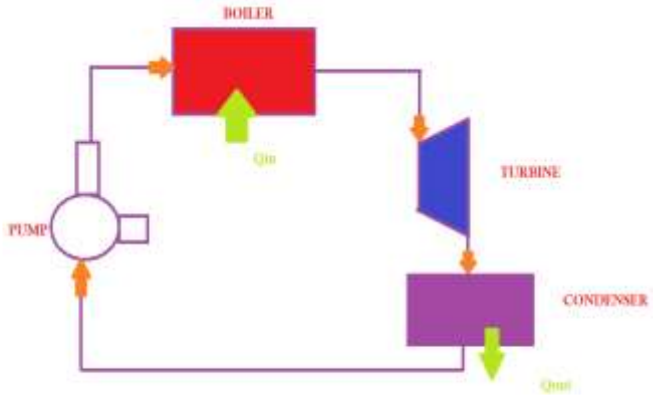
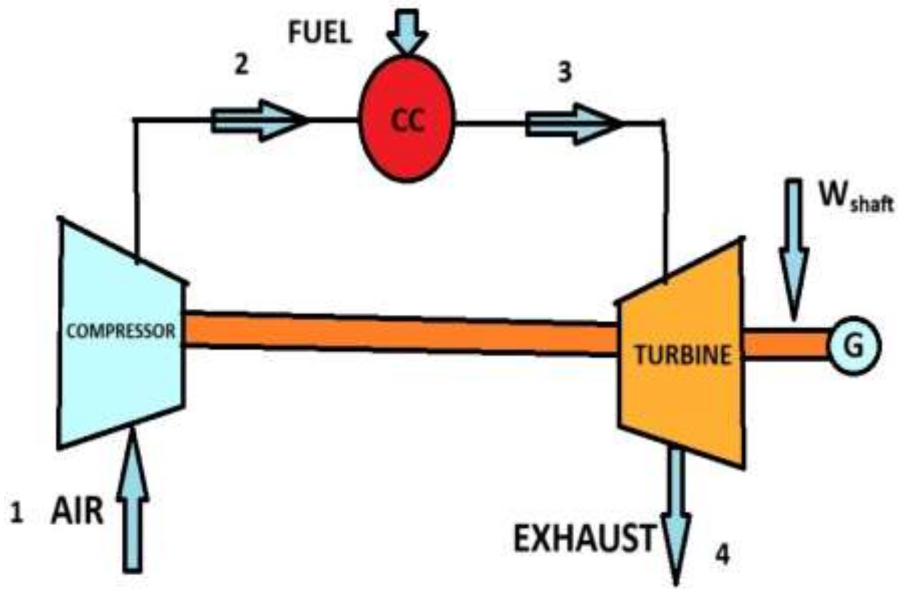


Fig 1: Ideal cycle (Rankine cycle) for steam power generation

LAYOUT-OF-BASIC-GASTURBINE-CYCLE:



The air is compressed in the compressor and then passed into the combustion chamber, the compressed gas is combusted inside the combustion chamber and later expanded through the blades of the turbine which rotates the shaft.

1.2: METHODS TO IMPROVE STEAM TURBINE EFFICIENCY

1.2.1: REHEAT CYCLE

In this method, the steam is reheated (heated twice) before entering into the turbine for power generation. This makes much dry steam to get enter the inlet of the turbine reducing the wear and tear of the components inside the turbine. It has some advantages by improving the efficiency of the turbine, increasing the work done through the turbine, and reducing erosion and Internal loss of the turbine by increasing in dryness fraction of steam at exhaust.

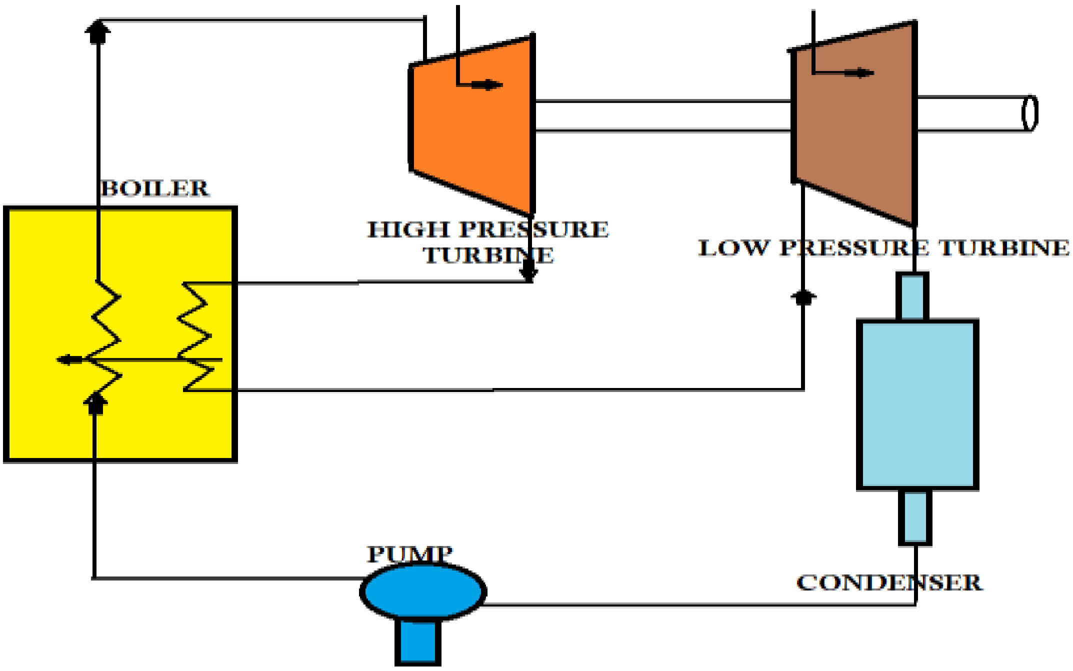
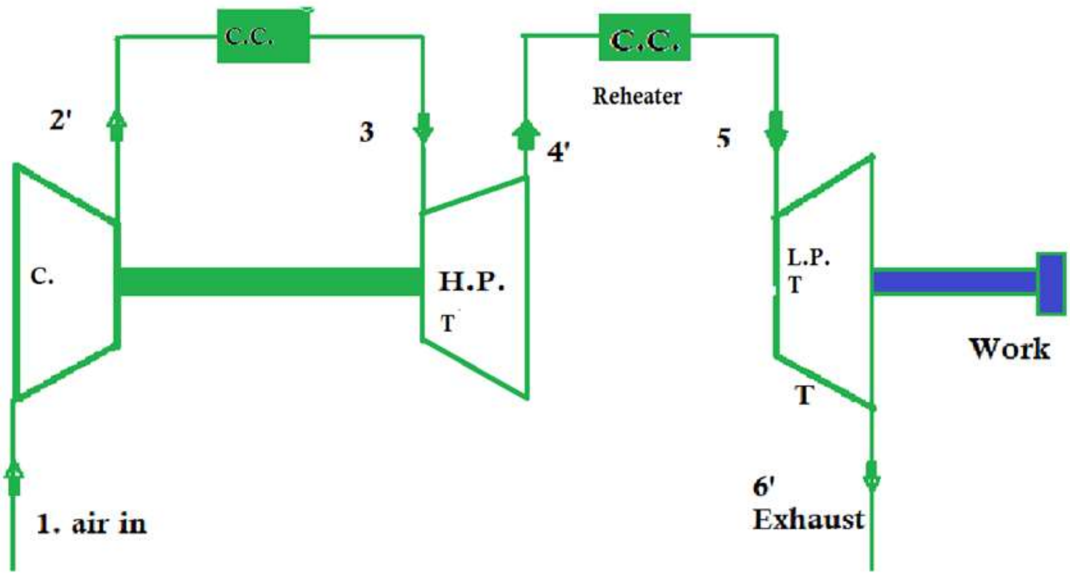


Fig 2: reheat steam turbine cycle

REHEATING GAS TURBINE CYCLE:



The reheating cycle is different from the basic cycle as there are two turbines in the reheating cycle, the efficiency achieved is superior to the basic cycle.

1.2.2: REGENRATION CYCLE

In this method, the dry saturated steam which is coming from the boiler enters into the turbine at a higher temperature. In the turbine it expands isentropically to a lower temperature now the steam is coming from the turbine and condensed in the condenser. So, a large amount of heat is rejected from the condenser. This heat is now pumped back and circulated around the turbine casing in the opposite direction to the steam flow in the turbine. The hot steam re-enters into the boiler. This type of steam heating is called Regenerative Heating.

In regenerative heating, some steam is carried out from the turbine at certain points during its expansion. This steam is fed into the feed water heater increasing its temperature and then supplied to the boiler, and is known as bleeding. Using this process, there is a slight increase in efficiency but there is also a decrease in the horsepower developed.

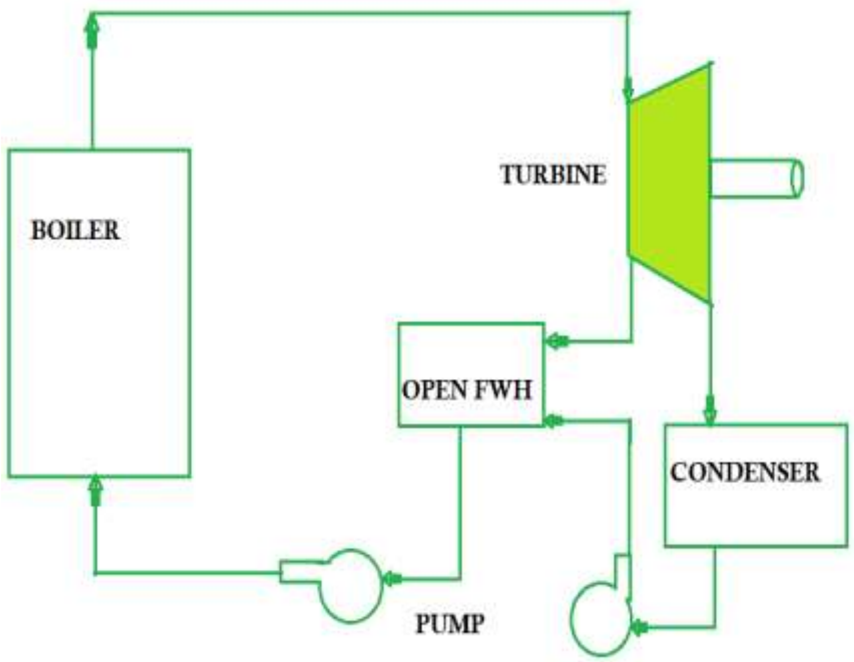
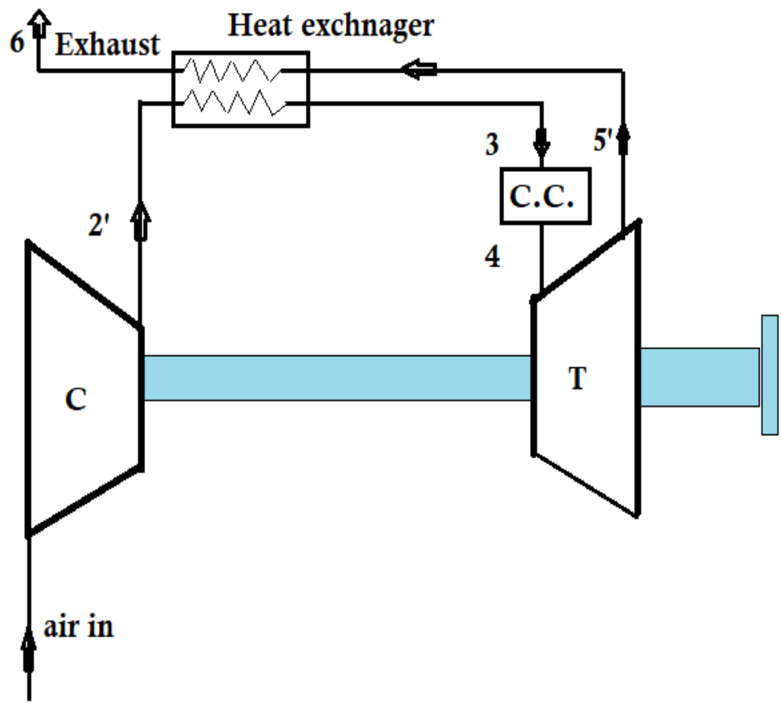


Fig 3: Regeneration steam turbine cycle

REGENERATIVE GAS TURBINE CYCLE



The regenerative gas turbine cycle has a regenerator through which the hot exhaust gas and cooler air coming from the compressor flow in opposite directions. The heat is transferred in the heat exchanger making the efficiency higher.

1.2.3: BINARY VAPOUR CYCLE

Mercury is used to increase the temperature of the plant without increasing its pressure. Liquid mercury is coming from a heater to a boiler, where it is evaporated. After that, it flows and expands in the mercury turbine at a low-pressure limit. Now Mercury exhausts to the Mercury condenser steam boiler where its latent heat is given to the hot feed water. The Mercury is then returned to the mercury liquid heater and completes the cycle.

1.2.4: COMBINED GAS STEAM TURBINE CYCLE

Combined cycle power plant uses gas turbine as well as steam turbine cycles to get better optimum performance from the input fuel. The gas taken from the atmosphere is compressed in the compressor later the gas is ignited in the combustion chamber and expanded in the gas turbine thus completing the gas cycle and exhaust gas from the gas turbine is sent into the boiler for the production of steam which reduces the energy required to heat the water. The steam is expanded in the turbine later condensed back to liquid state in the condenser and recirculated into the boiler, thus completing the cycle.

High input temperatures and low output temperatures can be achieved by these combined cycles. The emissions can also be reduced along with reducing cost and improving efficiency.

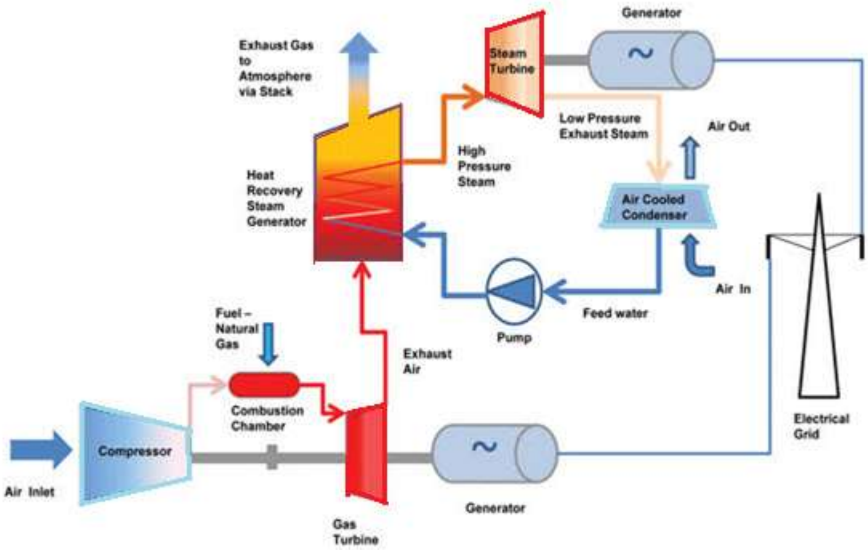


FIG 4: COMBINED CYCLE GAS-STEAM POWER PLANT

2. EFFECT OF DIFFERENT PARAMETERS ON THE PERFORMANCE OF STEAM TURBINE

2.1: EFFECT OF PRESSURE

Steam turbine inlet pressure has a major impact on the turbine performance to retain efficiency the inlet pressure should be lowered which not only increases efficiency but also increases the steam consumption.

2.1.1: EFFECT OF INLET PRESSURE

With the increase in inlet pressure work output from the turbine will be increased. This is because the pressure difference across the blades of the turbine will be increased with increased inlet pressure. Results show that a 10% increase in inlet pressure can increase 6% turbine power output.

2.1.2: EFFECT OF EXHAUST PRESSURE

With the decrease in exhaust pressure, the work from the turbine increases. The exhaust pressure creates a pressure difference across the blades of the turbine making them to rotate faster. 10% decrease in exhaust pressure can result in 4% increase in power output.

2.2: EFFECT OF TEMPERATURE

Turbine inlet temperature also impacts on the performance. Reducing the temperature reduces the heat generation from the turbine and also increases the life span of the turbine parts. The level of the steam temperature reaches 600 ◦C, the reheat steam enters the intermediate turbine part at even higher temperature level of 620 ◦C. Some more advanced projects assume the live and reheat steam at respectively 700 and 720 ◦C. Results show that 10% increase in steam inlet temperature cause 8% increase in power output.

Heat losses from the turbine also impact the performance of the turbine. These losses decrease the thermal efficiency of the turbine. With including a proper cooling system, heat losses can be minimized.

2.3: EFFECT OF ENTHALPY

The specific enthalpy difference in the turbine has to be increased to as much as possible which will improve efficiency. The enthalpy difference in the boiler should be decreasing which complements to the increment of efficiency.

2.4: EFFECT OF ENTROPY

The power plant cycle is assumed to work at constant entropy due to friction, but in the actual cycle, the entropy will change from the ideal case. So the entropy should be maintained near to the ideal value.

3. Augmentation of Gas Turbine Performance Using Air Coolers:

3.1: Air Cooler Technology and Implementation:

Air cooler innovation is utilized in gas turbines to improve their presentation and effectiveness. These frameworks work by cooling the air that enters the gas turbine before it goes through ignition. The cooler air entering the turbine takes into consideration more effective burning and, subsequently, expanded power age. Execution includes introducing these cooling frameworks in the gas turbine arrangement, guaranteeing that the approaching air is adequately cooled to enhance turbine activity and power creation. Eventually, air cooler innovation assumes a crucial part in working on the general effectiveness and result of gas turbines in the power age.

3.2: Performance Enhancement and Efficiency Gains:

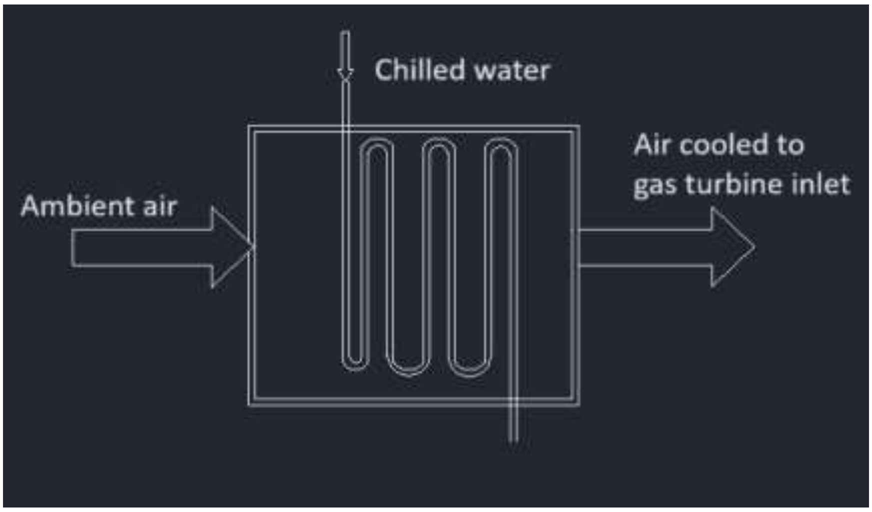
Performance Enhancement: This implies tracking down ways of making turbines capable all the more. It could include working on their plan, changing how they work, or utilizing innovations to produce more power.

Efficiency Enhancement: This alludes to utilizing less fuel or energy to create a similar measure of power or considerably more. It includes limiting energy squandering and boosting the result of turbines.

3.3: Limitations and Future Directions:

Limitations are the things that can prevent turbines from functioning. It very well may be things like how hot or how much strain they can deal with, the materials they're made of, or even innovation issues that make them not fill in as impeccably as possible.

Future directions mean where turbines can go straightaway. For instance, tracking down better materials, making new advancements, or evaluating novel plans to fix issues and make turbines work far and away superior later on.



CONCLUSION:

- The performance can be improved by changing the path of steam in reheating, and regeneration and also by the binary vapor cycle by including various feed water heaters and heat exchangers.
- By utilizing imaginative advances like hereditary calculations, air coolers, layer refining, evaporative cooling frameworks, and media evaporative coolers, these explorations try to exhibit unmistakable upgrades in turbine execution.
- The effect of different parameters viz., temperature, pressure, enthalpy, and entropy show that the temperatures and pressure are to be reduced by installing proper cooling methods, the enthalpy difference has to be increased and the entropy should be maintained close to the ideal value.
- Inlet pressure has to be increased to increase work output at the same time exhaust pressure has to be decreased.

REFERENCES:

1. Sinan Karakurt*1, Ümit Güneş1, "Performance analysis of a steam turbine power plant at part load conditions", Journal of Thermal Engineering, Vol. 3, No. 2, pp. 1121-1128, April, 2017
2. Abolaji Joseph Omosanya1*, Esther Titilayo Akinlabi1,2 and Joshua Olusegun Okeniyi1,2, "Overview for Improving Steam Turbine Power Generation Efficiency", *et al* 2019 *J. Phys.: Conf. Ser.* 1378 032040
3. P. I. Onwuamaeze (2018), "IMPROVING STEAM TURBINE EFFICIENCY: AN APPRAISAL",*Research Journal of Mechanical Operations,* 1 (1): 24-30
4. *Sorina* Anutoiu1, *Ion* Dosa1* and *Dan Codrut* Petrilean1, "Steam turbine efficiency assessment, first step towards sustainable electricity production", 1University of Petrosani, Department of Mechanical, Industrial and Transport Engineering, 20 Universitatii, Petrosani, Romania, https://doi.org/10.1051/matecconf/202134204007
5. Ambra Giovannelli, Luca Tamasi, Coriolano Salvini, «Performance analysis of industrial steam turbines used as air expander in Compressed Air Energy Storage (CAES) systems", Energy Reports 6 (2020) 341–346
6. *S.O. Oyedepo, O. Kilanko and M.A. Waheed "* Dataset on thermodynamics performance analysis and optimization of a reheat –regenerative steam turbine power plant with feed water heaters " *et al. / Data in Brief 32 (2020) 106086*
7. J.B.W. Kok and E.A. Haselhof "Thermodynamic analysis of the thermal and exergetic performance of a mixed gas-steam aero derivative gas turbine engine for power generation " University of Twente, Laboratory of Thermal Engineering, PO Box 217, 7500AE, Enschede, the Netherlands.
8. Santarao, K., and J. Sai Kumar Varma1 CLVRSV Prasad. "Preparation, Stability and Characterization of Nano fluids: A Review." International Journal of Mechanical Engineering 6: 3081-3095.
9. Kona, Srinivas, et al. "Evaluation of Compressive Strength of Thermoplastic Materials Prepared Using 3D Printer with Different in-Fill Structures." Advanced Manufacturing Systems and Innovative Product Design: Select Proceedings of IPDIMS 2020. Singapore: Springer Singapore, 2021. 209-215.
10. Naidu, A. Lakshumu, and PSV Ramana Rao. "Compatibility Study of Bamboo/Jute Fiber and Epoxy Reinforced Composite materials for Application of Industrial Helmet." Solid State Technology 63.6 (2020): 4704-4712.
11. Naidu, A. Lakshumu, and PSV Ramana Rao. "EXPLICIT DYNAMIC ANALYSIS OF HYBRID REINFORCED COMPOSITE FOR INDUSTRIAL SAFETY HELMET." Strain 10: 100.
12. Babu, V. Ram, M. Jaya Krishna, and A. Lakshumu Naidu. "Tribological Behaviour of Biodiesel and Metal Oxide Nanoparticles as Alternative Lubricant: A Pin-on-Disc Tribometer and Wear Study." Journal of Positive School Psychology (2022): 2066-2074.
13. Lakshumu Naidu, A., and Srinivas Kona. "Experimental study of the mechanical properties of banana fiber and groundnut shell ash reinforced epoxy hybrid composite." International Journal of Engineering 31.4 (2018): 659-665.
14. Kumar, D. Srinivas, and A. Lakshumu Naidu. "The Business Philosophies For Extended Enterprise In Manufacturing Automobile Sectors." International Journal Of Mechanical And Production Engineering Research And Development (Ijmperd) 8 (2018): 715-730.
15. Rambabu, V., et al. "Mechanical properties of okra and jute fibers filled with groundnut shell ash reinforced composites with epoxy (LY556) and epoxy (XIN 100 IN) resin matrices." Journal of Materials and Environmental Sciences 9.7 (2018): 2169-2173.
16. Naveen, P., and A. Lakshumu Naidu. "A study on chemical treatments of natural fibers." International Journal for Research & Development in Technology 8.4 (2017): 2349-3585.

17. Venkatesh, N., M. Srinivasa Rao, and A. Lakshumu Naidu. "Evaluation of High Speed Diesel Engine Performance and Charecteristics of its Emissions with Carbon Nanotubes Added Ethanol-Diesel Blends." International Journal of Mechanical and Production Engineering Research and Development (IJMPERD) ISSN (P): 2249-6890; ISSN (E): 2249 8001 (2017): 439-446.
18. Venkatesh, N., M. Srinivasa Rao, and A. Lakshumu Naidu. "Evaluation of High Speed Diesel Engine Performance and Charecteristics of its Emissions with Carbon Nanotubes Added Ethanol-Diesel Blends." International Journal of Mechanical and Production Engineering Research and Development (IJMPERD) ISSN (P): 2249-6890; ISSN (E): 2249 8001 (2017): 439-446.
19. Srinivas, K., A. Lakshumu Naidu, and MVA Raju Bahubalendruni. "A review on chemical and mechanical properties of natural fiber reinforced polymer composites." International Journal of Performability Engineering 13.2 (2017): 189.
20. Naidu, A. Lakshumu, V. Jagadeesh, and M. R. Bahubalendruni. "A review on chemical and physical properties of natural fiber reinforced composites." Journal of Advanced Research in Engineering and Technology 8.1 (2017): 56-68.
21. Rao, D. Venkata, K. Srinivas, and A. Lakshumu Naidu. "A review on jute stem fiber and its composites." Int. J. Eng. Trends Technol 6 (2017): 1-9.
22. Rani, Annepu Shobha, et al. "Experimental investigation on the performance and emission characteristics of di-diesel engine using diesel-ethanol blends and aluminium oxide nano particles." Int J Mech Product Eng Res Dev 7.5 (2017): 301-310.
23. Suman, P., A. Lakshumu Naidu, and P. R. Rao. "Processing and mechanical behaviour of hair fiber reinforced polymer metal matrix composites." International Conference on Recent Innovations in Engineering and Technology (ICRIET-2k16), Organized by Gandhi Institute of Engineering and Technology, Gunpur on 5th & 6th November-2016. 2016.
24. Naidu, A. Lakshumu, B. Sudarshan, and K. Hari Krishna. "Study on mechanical behavior of groundnut shell fiber reinforced polymer metal matrix composities." International Journal of Engineering Research and Technology 2.2 (2013): 1-6.
25. Naidu, A. Lakshumu, D. Raghuveer, and P. Suman. "Studies on characterization and mechanical behavior of banana peel reinforced epoxy composites." Int J Sci Eng Res 4.6 (2013): 844-851.
26. Rao, M. Srinivasa, N. Venkatesh, and A. Lakshumu Naidu. "A Review on Performance of Diesel Engines by using Biodiesel blends from Different oils."