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A REVIEW ON COMPOUNDING OF STEAM TURBINE

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ABSTRACT

Steam Turbine is a mechanical device that extract kinetic energy from pressurized steam and convert into useful work as a rotary motion. A turbine consists of shaft, casing, fixed blade & moving blade. Moving blade mount on shaft & guide or fixed blade placed on casing. The theoretical steam turbine is considered to be an isentropic process, or constant entropy process. Turbines are often operational for long periods of time so that they can be considered as steady-flow devices which undergo a steady-flow process. During a steady-flow process the mass, volume, and total energy content remain constant. To improve the thermal efficiency of any power plant, generally high pressure, superheated temperature and high-velocity steam is used. This high-velocity strikes the turbines rotor and the speed of the rotor becomes high in few second, if it is single stage. Compounding of steam turbine is used to reduce the rotor speed. It is the process by which rotor speed come to its desired value. A multiple system of rotors is connected in series to a common shaft and the steam pressure or velocity is absorbed in stages as it flows over the blades. A turbine composed of blades alternating with fixed nozzles is called an impulse turbine. Nozzles appear similar to blades, but their profiles converge near the exit. This results in a steam pressure drop and velocity increase as steam moves through the nozzles. Nozzles move due to both the impact of steam on them and the reaction due to the high-velocity steam at the exit. A turbine composed of moving nozzles alternating with fixed nozzles is called a reaction turbine or Parsons turbine.

Keywords: Steam Turbine, Compound Turbine, Multistage Turbine, Impulse Turbine, Reaction Turbine.

I. INTRODUCTION

Steam turbine comes under the classification of a mechanical machine that isolates thermal energy form the forced steam and converts this into mechanical energy. As the turbine produce rotatory motion, it is most appropriate for the operation of electrical generators. The name itself indicates the device is driven by steam and when the vaporous stream flows across the turbine's blades, then the steam cools and then expands thus delivering almost the energy that it has and this is the continual process. Presently chronological technologies in the design and development [1] of steam turbines for modern power plants are under continuous improvement.

Figure 1: Industrial Steam Turbine

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Impulse Turbine

The Impulse turbine [2] wherein the available hydraulic energy is initially converted into kinetic energy by means of an efficient nozzle. The high-velocity jet emitted by the nozzle then impacts a series of appropriately designed buckets mounted around the rim of a wheel. The buckets change the direction of jet without changing its pressure. The resulting change in momentum sets buckets and wheel into rotary motion and thus mechanical energy is made available at the turbine shaft. The fluid jet leaves the runner with a reduced energy. Blades are only in action when they are in front of the nozzle. An impulse turbine runs at atmospheric pressure, with no change in static pressure across the turbine runner, and is also known as a free jet turbine. Important impulse turbines are: Pelton wheel, Turgo-impulse wheel, Girad turbine, Banki turbine and Jonval turbine etc., Pelton wheel is predominantly used at present.

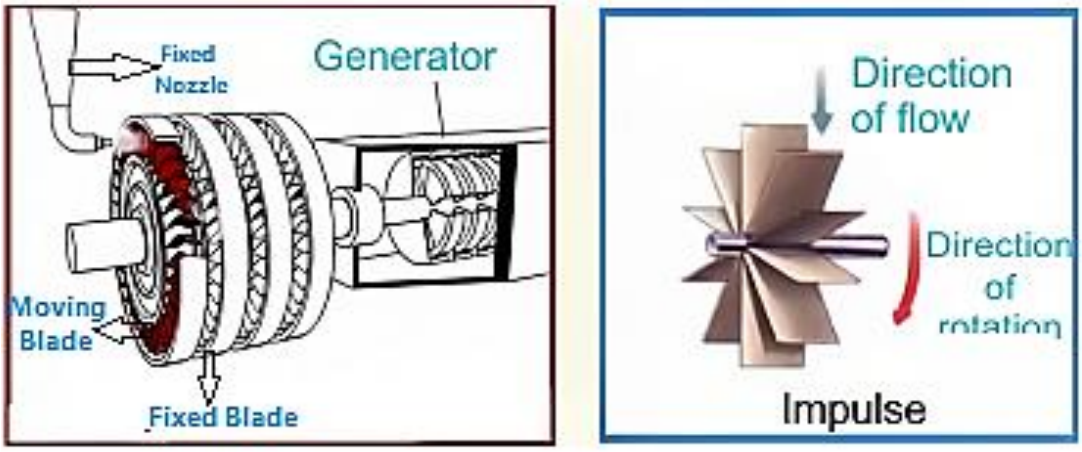

Figure 2: Impulse Turbine.

Reaction Turbine

The Reaction turbine [3] wherein a part of the total available hydraulic energy is transformed into kinetic energy before the water is taken to the turbine runner. A substantial part remains in the form of pressure energy. After that, both velocity and pressure change simultaneously as the water slides down the path of the turbine. The flow from the inlet to the outlet of the turbine is under pressure, and therefore the reaction turbine blades are closed channels that are sealed from atmospheric conditions. The blades work all the time. As the water exits through these tubes, its pressure energy decreases and its kinetic energy relative to the rotating disk increases. The resulting reaction force sets the disc in rotation. The disc and shaft rotate in a direction opposite to the direction of water jet. Important reaction turbines are, Fourneyron, Thomson, Francis, Kaplan and Propeller turbines Francis and Kaplan turbines are widely used at present.

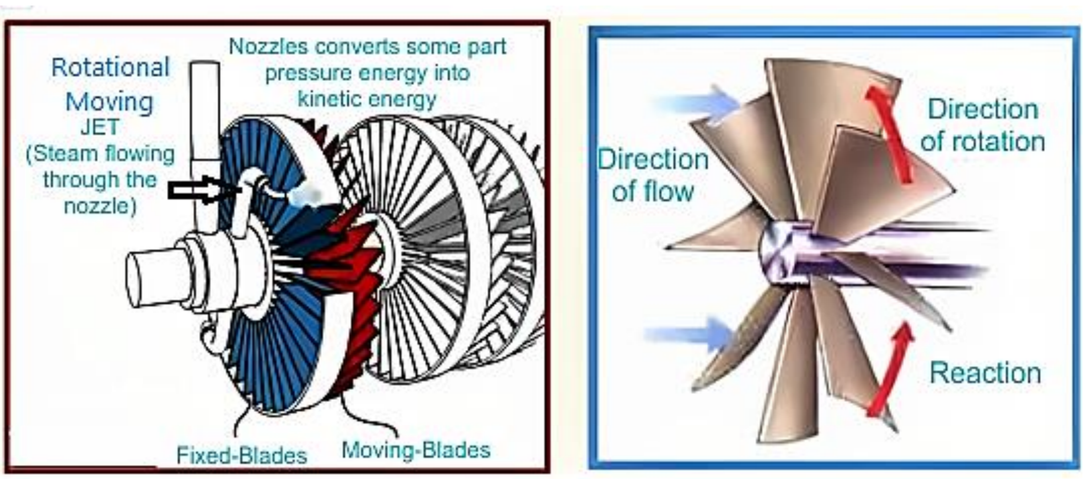

Figure 3: Reaction Turbine

Compounding Steam Turbines

Compounding of steam turbines [4] is a method of extracting steam energy in a number of stages rather than in a single stage in a steam turbine. A compounded steam turbine has multiple stages with more than one set of nozzles and rotors. These are arranged in series, either keyed to the common shaft or fixed to the casing.

II. REASON TO MODIFY AS A COMPOUND

In turbine the blade velocity [5] is directly proportional to the velocity of the steam passing over the blade. Now, if the entire energy of the steam is extracted in one stage, i.e. if the steam is expanded from the boiler pressure to the condenser pressure in a single stage, then its velocity will be very high. Hence the velocity of the rotor can reach to about over speed 30,000 rpm, [6] which is too high for practical uses due to very high vibration. Moreover, at such high speeds the centrifugal forces are immense, and can damage the structure. Hence, compounding is needed. The high velocity steam just strikes on a single ring of rotor that causes wastage of steam ranging 10% to 12%. To overcome the wastage of steam, compounding of steam turbines are used. Different types nozzle jets [7] are used application basis. Nozzle fixed such a way, its strike on blade at a particular area, from which we can get better output. Steam delivery technique depends on this also.

III. TYPES OF COMPOUNDING

- **In an Impulse steam turbine** [8-9]
  - Velocity compounding
  - Pressure compounding
  - Pressure-Velocity Compounding
- **In a reaction turbine**
  - Pressure compounding

Velocity Compounding of Impulse Turbine

In velocity compounding turbine, some moving blades, fixed blades and a set of nozzle are consisting. Moving blades are fixed to the shaft and fixed blades are attached to the casing. More than one rows of moving blades which are separated by fixed blades and these moving blades are just in reverse position from the fixed blades. Now steam pass through the nozzle or a set of nozzles where it is expanded from boiler pressure to the condenser pressure. Due to decreasing the steam pressure, its velocity becomes very high. This high-velocity steam first enters the first ring of moving blades where some portion of velocity is absorbed. Then it passes through the next ring of fixed blades. The fixed blades changed steam direction and direct to the second ring of moving blades. There is no change in steam velocity when it passes over the fixed blades. Improvement of steam condition effect on velocity compound system. [10]

Pressure Compounding of Impulse Turbine

It consists [11] of alternate rings of nozzles and turbine blades. The nozzles are fitted to the casing and the blades are keyed to the turbine shaft. Here nozzle act as fixed blade. The steam coming from the boiler is fed to the first set of fixed blades i.e. the nozzle ring. The steam is partially expanded in the nozzle ring. Hence, there is a partial decrease in pressure of the incoming steam. This leads to an increase in the velocity of the steam. Therefore, the pressure decreases and velocity increases partially in the nozzle. As the steam flows over the moving blades, nearly all its velocity is absorbed. However, the pressure remains constant in moving blade. After this it is passed into the nozzle ring and is again partially expanded. Then it is fed into the next set of moving blades, and this process is repeated until the condenser pressure is reached.

Pressure Velocity Compounding of Impulse Turbine

It is a combination [12] of the two types of compounding. The total pressure drop of the steam is divided into a number of stages. Each stage consists of rings of Fixed nozzle, moving blade, fixed blade & moving blade. Here nozzle, moving blade, fixed blade act as per their own characteristic.

Pressure Compounding of Reaction Turbine

A reaction turbine [13] is one in which there is both pressure and velocity loss in the moving blades. Here the characteristic of moving blade is fully different than other's previous compounding system.

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IV. PRESSURE-VELOCITY (P-V) CURVE

P-V Graph of Velocity Compound Turbine

The graph flows stage wise, through Nozzle (fixed entry section) → moving blade → Fixed blade → Moving blade.

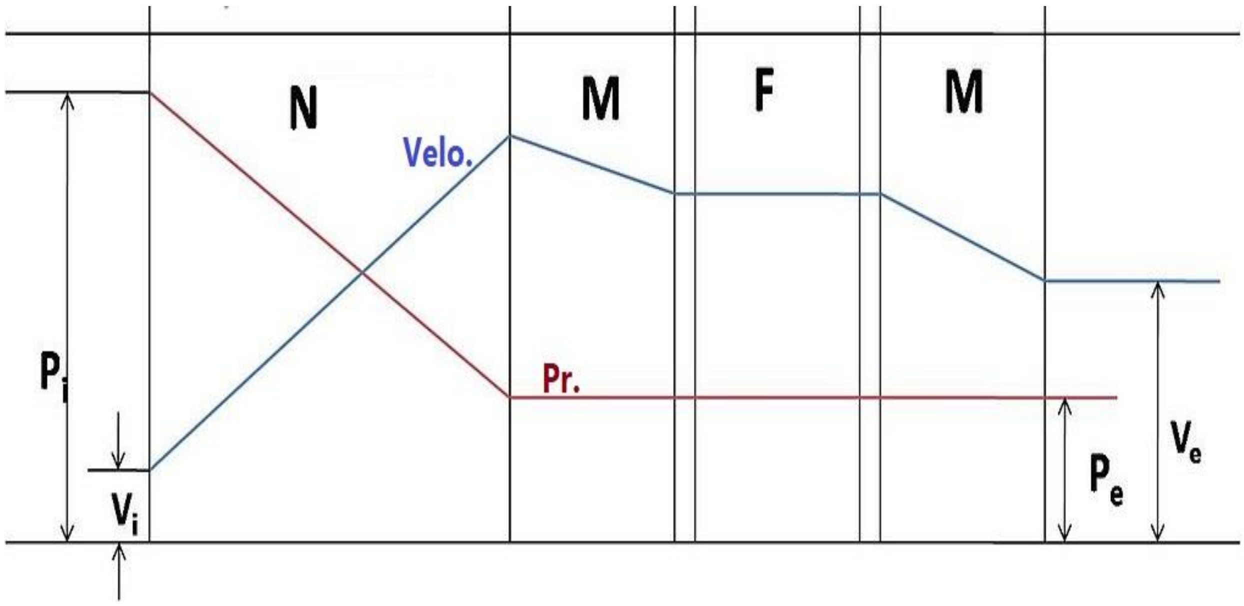

Figure 4: P-V diagram of velocity compound.

P-V graph of pressure compound turbine

The graph flow stage wise, through Nozzle (fixed) → moving blade → Nozzle (fixed) → moving blade.

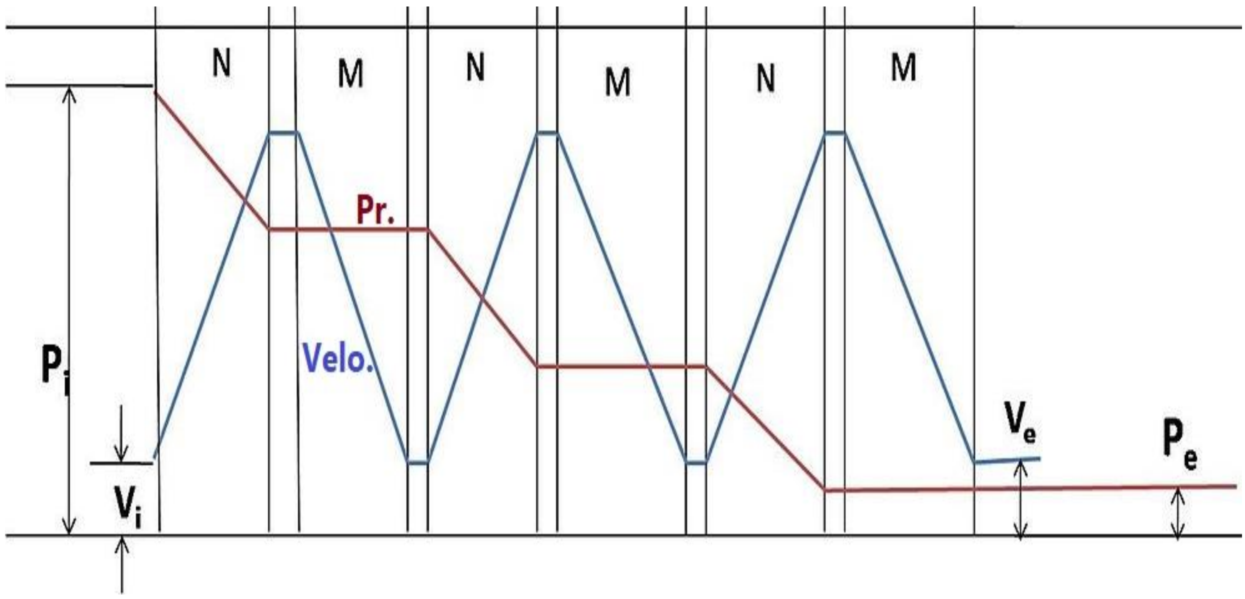

Figure 5: P-V diagram of pressure compound.

P-V graph of Pressure Velocity compounding

The graph flow stage wise, through Nozzle (fixed entry zone) → moving blade → Fixed blade → moving blade.

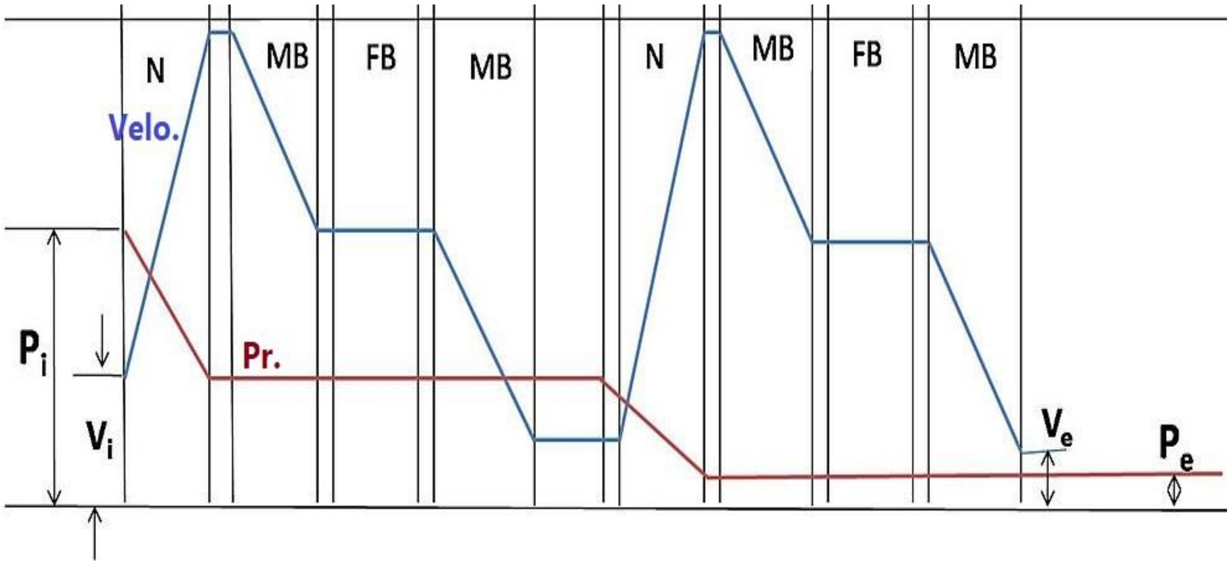

Figure 6: P-V diagram of pressure velocity compounding.

P-V graph of Pressure compounding reaction turbine

The graph flow stage wise, through Nozzle → moving blade → Nozzle → moving blade.

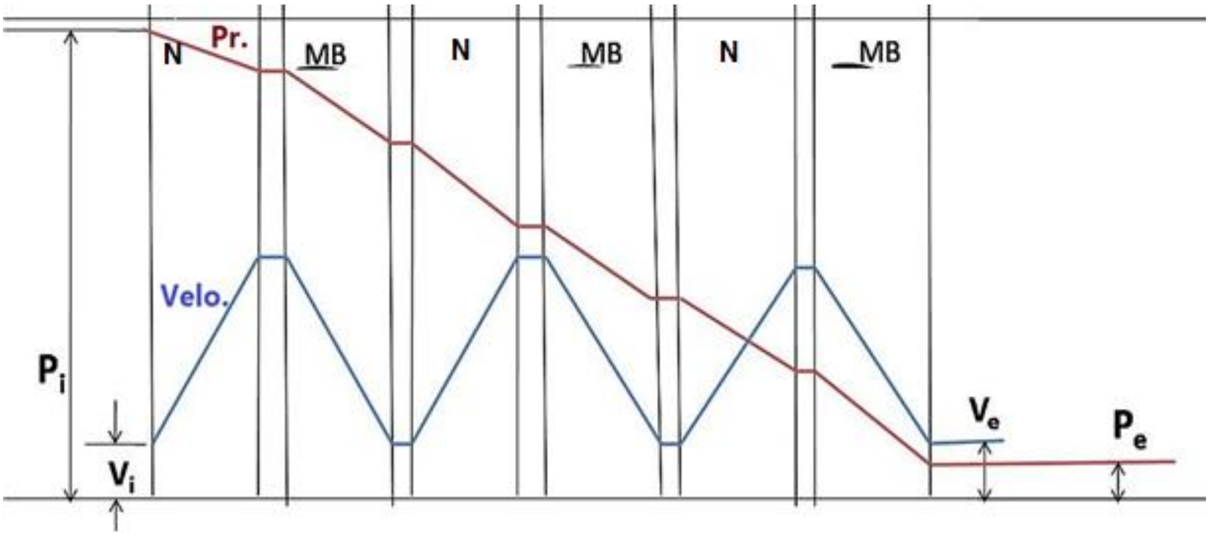

Figure 7: 3D view of building.

V. CONCLUSION

- The compound system reduces the wastage of steam and energy loss due to carry over loss & safe the turbine's structure from high rpm.
- Compounding system is also a good utilizer of super-heated steam as per thermodynamics Rankine cycle.
- High friction loss & high steam consumption at velocity compound
- Low friction loss & low steam consumption at Pressure compound.
- Pressure compound is more efficient than velocity compound.
- Velocity compound efficiency is low because the ratio of blade velocity and steam velocity is not optimum. Friction loss is high due to high velocity of steam of nozzle.

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VI. REFERENCES

[1] Tanuma T, (2022) "Introduction to steam turbines for power plants", Advances in Steam Turbines for Modern Power Plants (Second Edition), Pp 3-10. https://doi.org/10.1016/B978-0-12-824359-6.00024-X

[2] Raja A. K, Srivastava A. P, Dwived M, (2006) "Power_Plant_Engineering", New Age International (P) Limited, Publishers.
https://www.academia.edu/8836636/Power_Plant_Engineering_By_A_K_Raja_Amit_Prakash_Srivastava_Manish_Dwived

[3] https://en.wikipedia.org/wiki/Steam_turbine

[4] Jachens W. B, (1966) "Steam Turbines - Their Construction Selection and Operation", Proceedings of the South Afvican Sugar Technologists' Association, Pp 113-131.
doi=39f44b5c84c438b57f5be577f3a510d4cd7571bb

[5] "Compounding of steam turbines"
https://en.wikipedia.org/wiki/Compounding_of_steam_turbines#:~:text=The%20velocity%20compounded%20Impulse%20turbine,by%20rings%20of%20fixed%20blades

[6] Younkins T. D. and L. H. Johnson, (1981) "Steam Turbine Over Speed Control and Behaviour During System Disturbances," in IEEE Transactions on Power Apparatus and Systems, vol. PAS-100, no. 5, pp 2504-2511, doi: 10.1109/TPAS.1981.316778

[7] Bag S., & Saha A. K. (2022) "A review on environmental friendly cutting fluids and coolant delivery techniques in grinding". In Proceeding International Conference on Religion, Science and Education, Vol. 1, pp. 627-632. DOI: 10.14421/icrse.v1.2022.846

[8] Subbarao P M V, "The Curtis Turbine & The Parson Turbine", Indian Institute of Technology Delhi, Mechanical Engineering Department. https://web.iitd.ac.in/~pmvs/courses/mel346/mel346-39.ppt

[9] https://www.mechanicaltutorial.com/steam-turbine-compounding-of-steam-turbine

[10] Saito E, Matsuno N, Tanaka K, Nishimoto S, Yamamoto R, Imano S, (2015) "Latest Technologies and Future Prospects for a New Steam Turbine" Mitsubishi Heavy Industries Technical Review Vol. 52 No. 2, https://power.mhi.com/jp/randd/technical-review/pdf/index_15e.pdf

[11] Breeze P, (2018) "Chapter 4 - Hydropower Turbines", Hydropower, Academic Press, Pp 35-46.
https://doi.org/10.1016/B978-0-12-812906-7.00004-1

[12] "Difference Between Velocity Compounding Turbine & Pressure Compound Turbine"
https://www.mecholic.com/2018/12/velocity-compounding-pressure-compounding.html

[13] Chaplin R.A, "Thermal Power Plants– Vol. III - Steam Turbine Impulse and Reaction Blading" Department of Chemical Engineering, University of New Brunswick, Canada, Pp 1-9.