# AN ASSESSMENT OF ELECTRICAL POWER RATING AND SHAFT SPEED (RPM) OF GAS TURBINE MODEL PRODUCTION

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## ABSTRACT

Gas turbine is an internal combustion engine used for industrial activities or mainly for the supply of electricity. The study was able to assess power rating and shaft speed of gas turbine production of MAN Diesel & Turbo SE model. The findings of the study showed that Low-pressure turbines and Standard Power Generation had a differential power rating of 70MW. Also, Air turbines CAES (compressed Air Energy Storage) and MARC 1 combined heat and power generation for renewable energy had a power rating difference of 86MW. Standard Power Generation had a shaft speed of 50/60Hz and low-pressure turbines power generation had a 5-90, 50/60Hz. Air turbines CAE renewable (compressed Air Energy Storage), MARC 1 combined heat and power generation for renewable energy, MARC 2 combined heat and power generation and MARC 4 combined heat and power generation all had a shaft speed of 50Hz as well. Finally, it was recommended amongst others that low-pressure turbines power generation of shaft speed of 5–90, 50/60 Hz, is suitable for powering small communities with less load and MARC 2 combined heat and power generation and MARC 4 combined heat and power generation with power rating difference of 10MW is suitable for powering industries and plants sites.

**Keywords**: ***Electrical Power Rating, Shaft Speed (Rpm) & Turbine Model Production***

## INTRODUCTION

Gas turbine is an internal combustion engine that makes use of air as the working fluid to generate power (1). The fluid is in the form of wet or dry steam. The turbine itself is designed as a blade through which the steam can drive its parts. The engine takes chemical energy from fuel and converts it to mechanical system of work using the gaseous energy of the working fluid (air) to drive the engine and propeller, which, in turn, propels the airplane (2). As air is allowed to flow through a gas turbine system, aerodynamic and energy requirements demand changes in the air's velocity and pressure. During compression process, a rise in the air pressure is required, but not an increase in its velocity. After compression and combustion have heated the air, an increase in the velocity of gases is necessary in order for the turbine rotors to develop power. The size and shape of the part through which the air flows influence different changes. Where a change from velocity to pressure is needed, the passages are spread. Conversely, if a conversion from pressure to velocity is required, a convergent part is used.

The variation between static, impact, and total pressures is as follows; Static pressure is the force per unit area exerted on the walls of a container by a stationary fluid. An example is the air pressure within a car tyre. Impact pressure, on the other hand, is the force per unit area exerted by fluids in motion (3). Impact pressure is a function of the velocity of the fluid. An example of impact pressure is the pressure exerted on one's hand held outside a moving car's window (4). Total pressure is the sum of static and impact pressures.

When air moves through a gas turbine system, aerodynamic and energy need demand changes in the air's velocity and pressure. During compression, a rise in the air pressure is required, but not an increase in its velocity. After compression and combustion have heated the air, an increase in the velocity of gases is necessary in order for the turbine rotors to develop power. The size and shape of the ducts through which the air flows affect these various changes. Where a conversion from velocity to pressure is required, the passages are divergent. Conversely, if a conversion from pressure to velocity is needed, a convergent duct is used.

Industrial gas turbines that are used mainly for mechanical drive or used in collaboration with a recovery steam generator differ from power generating sets in that they are often smaller and feature a "twin" shaft design as opposed to a single shaft. The power range is designed in between 1 megawatt up to 50 megawatts. These engines are connected through a gearbox to either a pump or alternatively compressor assembly, the majority of installations are used within the oil and gas industries. Mechanical drive applications provide a more efficient combustion raising around 2%. Oil and Gas platforms require these engines to drive compressors to inject gas into the wells to force oil up via another bore, they're also often used to provide power for the platform (5).

### Turboshaft engines

Turboshaft engines are mostly used to drive compression trains (for example in gas pumping stations or natural gas liquefaction plants) and are used to power almost all modern helicopters (4). The primary shaft bears the compressor and the high speed turbine (often referred to as the Gas Generator), while a second shaft bears the low-speed turbine (a power turbine or free-wheeling turbine on helicopters, especially, because the gas generator turbine spins separately from the power turbine). In effect, the separation of the gas generator, by a fluid coupling (the hot energy-rich combustion gases), from the power turbine is analogous to an automotive transmission's fluid coupling (6).

**Literature review**

**Microturbines**

Microturbines are small electricity generators that burn gaseous and liquid fuels to create high-speed rotation that turns an electrical generator (7). Today’s microturbine technology is the result of development work in small stationary and automotive gas turbines, auxiliary power equipment, and turbochargers, much of which was pursued by the automotive industry beginning in the 1950s (3). Microturbines entered field testing around 1997 and began initial commercial service in 2000 (4).

They are designated to be used widespread in distributed power and combined heat and power applications. They are one of the most promising technologies for powering hybrid electric vehicles. They range from hand held units producing less than a kilowatt, to commercial sized systems that produce tens or hundreds of kilowatts. Basic principles of microturbine are based on micro combustion.

Microturbines are ideally suited for distributed generation applications due to their flexibility in connection methods, ability to be stacked in parallel to serve larger loads, ability to provide stable and reliable power, and low emissions (1). Types of applications include:

- Peak shaving and base load power (grid parallel)
- Combined heat and power
- Stand-alone power
- Backup/standby power
- Ride-through connection
- Primary power with grid as backup
- Micro grid
- Resource recovery

Major users are financial services, data processing, telecommunications, restaurant, multifamily residential buildings, lodging, retail, office building, and other commercial sectors. Microturbines are currently operating in resource recovery operations at oil and gas production fields, coal mines, and landfill operations, where byproduct gases serve as essentially free fuel. Reliable unattended operation is important since these locations may be remote from the grid, and even when served by the grid, may experience costly downtime when electric service is lost due to weather, fire, or animals(4).

Microturbine systems have many claimed merits over reciprocating engine generators, such as higher power-to-weight ratio, low emissions and few, or just one, moving part. Advantages are that microturbines may be designed with foil bearings and air-cooling operating without lubricating oil, coolants or other hazardous materials (4). Nevertheless reciprocating engines overall are still cheaper when all factors are considered. Microturbines also have a further advantage of having the majority of the waste heat contained in the relatively high temperature exhaust making it simpler to capture, whereas the waste heat of reciprocating engines is split between its exhaust and cooling system(7).

Microturbine designs are mostly made of a single stage radial compressor, a single stage radial turbine and a recuperator. Recuperators are difficult to design and manufacture because they operate under high pressure and temperature differentials. Exhaust heat may be used for water heating, space heating, drying processes or absorption chillers, which create cold for air conditioning from heat energy instead of electric energy.

**Purpose of the Study**

The study was based on the assessment of electrical power rating and shaft speed (rpm) of gas turbine model production. Specifically, the study sought to:

1. Determine the various power rating of gas turbine production of MAN Diesel & Turbo SE model.
2. Determine the various Shaft Speed (RPM) of gas turbine production of MAN Diesel & Turbo SE model.

**Scope of the Study**

The study is limited to the assessment of power rating and shaft speed of gas turbine production of MAN Diesel & Turbo SE model. It is limited to the use of six models from MAN Diesel and Turbo SE production.

**Method**

The researchers used secondary data gathered from specification table of gas turbine design and production models. The study looked into differential analysis of maximum power rating of the six different models of MAN Diesel and Turbo SE production. Also, the speed of the shaft of various turbine design model was analyzed using revolution per minutes (RPM).

**Data Analysis**

**Table 1: Analysis of power rating of gas turbine production of MAN Diesel & Turbo SE model**

| MODEL | TYPE/APPLICATION | POWER RATING (MW) | DIFFERENCE IN MAX. | POWER OUTPUT |
|---|---|---|---|---|
| Standard Power Generation | | 2-160 | | |
| Low-Pressure Turbines Power Generation | | 5-90 | 70MW | |
| Air turbines CAES (compressed Air Energy Storage) | | 25-90 | | |
| MARC 1 | combined heat and power generation for renewable energy and WtE | 2-4 | 86MW | |
| MARC 2 | combined heat and power generation for RE and WtE | 5-10 | | |
| MARC 4 | combined heat and power generation for RE and WtE | 8-20 | 10MW | |

The data presented in table 1 revealed that Standard Power Generation had a power rating ranging from 2 to160 MW and low-pressure turbines power generation had a power rating of 5 to 90 MW. This resulted to a difference of 70MW. Air turbines CAES (compressed Air Energy Storage) had a power rating of 25 to 90 MW and MARC 1 combined heat and power generation for renewable energy had a power rating of 2 to 4MW with a difference of 86MW. Further, MARC 2 combined heat and power generation had a power rating of 5 to10MW and MARC 4 combined heat and power generation had a power rating of 8 to 20 MW with a difference of 10MW.

**Table 2: Analysis of various Shaft Speed (RPM) of gas turbine production of MAN Diesel & Turbo SE model.**

| MODEL | TYPE/APPLICATION | SHAFT SPEED (RPM) |
|---|---|---|
| Standard Power Generation | | 50/60HZ |
| Low-pressure turbines Power Generation | | 5-90, 50/60Hz |
| Air turbines CAES (compressed Air Energy Storage) | | 50/60Hz |
| MARC 1 | Combined heat and power generation for renewable energy and WtE | 50Hz |
| MARC 2 | Combined heat and power generation for RE and WtE | 50Hz |
| MARC 4 | Combined heat and power generation for RE and WtE | 50Hz |

The data presented in table 2 revealed that Standard Power Generation had a shaft speed of 50/60Hz and low-pressure turbines power generation had a 5-90, 50/60Hz. Air turbines CAES (compressed Air Energy Storage) had a shaft speed of 50/60Hz and MARC 1 combined heat and power generation for reneable energy had a shaft speed of 50Hz. Further, MARC 2 combined heat and power generation had a shaft speed of 50Hz and MARC 4 combined heat and power generation had a shaft speed of 50Hz as well.

**Conclusion**

In all, it would be concluded that Low-pressure turbines and Standard Power Generation had a differential power rating of 70MW. Also, Air turbines CAES (compressed Air Energy Storage) and MARC 1 combined heat and power generation for renewable energy had a power rating difference of 86MW. Further MARC 2 combined heat and power generation and MARC 4 combined heat and power generation had a power rating difference of 10MW.

In addition, Standard Power Generation had a shaft speed of 50/60Hz and low-pressure turbines power generation had a 5-90, 50/60Hz. Air turbines CAES (compressed Air Energy Storage), MARC 1 combined heat and power generation for renewable energy, MARC 2 combined heat and power generation and MARC 4 combined heat and power generation all had a shaft speed of 50Hz as well.

**Recommendations**

Based on the findings of the study the following recommendations were made:

1. The Low-pressure turbines power generation of shaft speed of 5–9050/60 Hz is suitable for powering small communities with less load.
2. MARC 2 combined heat and power generation and MARC 4 combined heat and power generation with power rating difference of 10MW is suitable for powering industries and plants sites.
3. Air turbines CAES (compressed Air Energy Storage) can be used to power large mechanized farm.

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