INCREASING THE POWER OF THE WÄRTSILÄ 20V32 POWER UNIT *(USING THE EXAMPLE OF "AKSA ENERJI TASHKENT" LLC JV)*

Eshkuvatov Lutfulla Muradullayevich
Associate professor, Tashkent State Technical University
Shodmonov Diyorbek Umid og'li
2nd year master's student, industrial thermal power engineering, Department of Thermal Power Engineering, Faculty of Power Engineering, Tashkent State Technical University

Annotation. The research focuses on technical, operational, and economic aspects of power augmentation within existing design limits, including optimization of fuel injection parameters, turbocharging efficiency improvements, cooling system enhancements, and control system tuning. A systematic analysis of baseline performance data and experimental modifications demonstrates measurable increases in unit output without compromising reliability or regulatory compliance. The study also assesses the impact of the proposed measures on fuel consumption, emissions, and maintenance schedules. Through modelling, field testing, and performance monitoring, the research provides a comprehensive framework for power capacity enhancement that can be applied to similar Wärtsilä units in industrial power plants. The results offer practical recommendations for plant engineers and energy system planners seeking cost-effective performance upgrades in aging or high-demand generation assets.

Keywords: Wärtsilä 20V32, Power unit performance, Output augmentation, Engine optimization, Turbocharging efficiency, Fuel injection calibration, Power plant engineering, Performance analysis, Operational efficiency.

Annotatsiya. Tadqiqot mavjud loyihaviy cheklovlar doirasida quvvatni oshirishning texnik, ekspluatatsion va iqtisodiy jihatlariga qaratilgan bo'lib, yoqilg'i purkash parametrlarini optimallashtirish, turbokompressor samaradorligini oshirish, sovitish tizimini takomillashtirish hamda boshqaruv tizimini sozlash kabi chora-tadbirlarni o'z ichiga oladi. Boshlang'ich ishlash ko'rsatkichlari va tajribaviy o'zgartirishlarning tizimli tahlili qurilma ishonchliligi va me'yoriy talablarga muvofiqligini buzmagan holda quvvat chiqishining sezilarli darajada oshganligini ko'rsatadi. Tadqiqot, shuningdek, taklif etilgan choralarning yoqilg'i sarfi, zararli chiqindilar va texnik xizmat ko'rsatish jadvaliga ta'sirini baholaydi. Modellashtirish, joyida sinovlar va ishlash ko'rsatkichlarini monitoring qilish orqali sanoat elektr stansiyalarida qo'llaniladigan shunga o'xshash Wärtsilä agregatlariga tatbiq etish mumkin bo'lgan quvvatni oshirish bo'yicha kompleks yondashuv ishlab chiqilgan. Olingan natijalar eskirgan yoki yuqori yuklama ostida ishlayotgan generatsiya quvvatlarida iqtisodiy jihatdan samarali modernizatsiya

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choralarini izlayotgan stansiya muhandislari va energetika tizimi rejalashtiruvchilari uchun amaliy tavsiyalarni taqdim etadi.

Kalit so‘zlar: Wärtsilä 20V32, quvvat agregati samaradorligi, quvvatni oshirish, dvigatelni optimallashtirish, turbokompressor samaradorligi, yoqilg‘i purkashni kalibrlash, elektr stansiyasi muhandisligi, ishlash ko‘rsatkichlarini tahlil qilish, ekspluatatsion samaradorlik.

Аннотация. Исследование посвящено техническим, эксплуатационным и экономическим аспектам повышения мощности в пределах существующих проектных ограничений, включая оптимизацию параметров впрыска топлива, повышение эффективности турбонаддува, совершенствование системы охлаждения и настройку системы управления. Систематический анализ исходных эксплуатационных данных и экспериментальных модификаций демонстрирует измеримое увеличение выходной мощности агрегата без снижения надёжности и нарушения нормативных требований. В работе также оценивается влияние предлагаемых мероприятий на расход топлива, уровень выбросов и графики технического обслуживания. Посредством моделирования, натурных испытаний и мониторинга эксплуатационных показателей исследование формирует комплексный подход к увеличению установленной мощности, который может быть применён к аналогичным агрегатам Wärtsilä на промышленных электростанциях. Полученные результаты содержат практические рекомендации для инженеров электростанций и специалистов по планированию энергетических систем, ориентированных на экономически эффективную модернизацию генерирующих мощностей с высоким уровнем загрузки или длительным сроком эксплуатации.

Ключевые слова: Wärtsilä 20V32, эффективность силового агрегата, увеличение выходной мощности, оптимизация двигателя, эффективность турбонаддува, калибровка впрыска топлива, инженерия электростанций, анализ эксплуатационных характеристик, эксплуатационная эффективность.

INTRODUCTION.

This article focuses on increasing the power output of the Wärtsilä 20V32 diesel generator operated by “Aksa Enerji Tashkent” LLC JV in Uzbekistan. Initially, the power unit operated at a capacity of 8.75 MW; however, as a result of the rerating process, its output was increased to 9.7 MW. During the implementation, no significant changes were made to the structural components of the engine; instead, the derating limitations in the Wärtsilä Engine Control System (WECS) were removed and the parameters were readjusted. As a result, production efficiency was improved, enabling the generation of an additional 7,125 MW of

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electricity per year. This experience represents an important example of the efficient utilization of existing resources in Uzbekistan's energy supply system. [1,2,3]

Analyses of literature. In recent years, the demand for electricity in Uzbekistan's energy sector has been steadily increasing. For this reason, maximizing the utilization of existing capacities has become a pressing task. One of the country's major independent power producers, Aksa Enerji Tashkent LLC JV**,** operates a power plant located in the Tashkent region, where 24 Wartsila 20V32 engines are in use. Although the nominal capacity of these engines is **9**.7 MW, they were initially designed to operate at 8.75 MW, taking into account safety and operational conditions. This study is dedicated to the implementation of the rerating process on these engines, that is, restoring their power output to the original design level. [3,4,5]

Wartsila is a global leading company that provides smart technologies and full life-cycle solutions in the energy market. Wärtsilä has extensive experience in optimizing internal combustion engines. Although the Wärtsilä 20V32 power unit is not a documented product in the company's current portfolio, this study highlights the principles and challenges of increasing the power output of large-cylinder gas engines. [3]

Research methodology. The article examines theoretical projects for increasing the power of a 20-cylinder unit based on modernization methods actively applied by Wärtsilä, including turbocharging, optimization of the combustion process, and digital integration. [6,7]

Aksa Enerji Tashkent LLC JV operates several large gas-turbine-based combined-cycle power plants in Uzbekistan.

The total capacity of the company's Block B is 230 MW, consisting of 24 Wartsila 20V34SG gas engines and 2 Dresser-Rand steam turbines. The total capacity of this power plant, combining Blocks A and B, amounts to 470 MW. [8,9].

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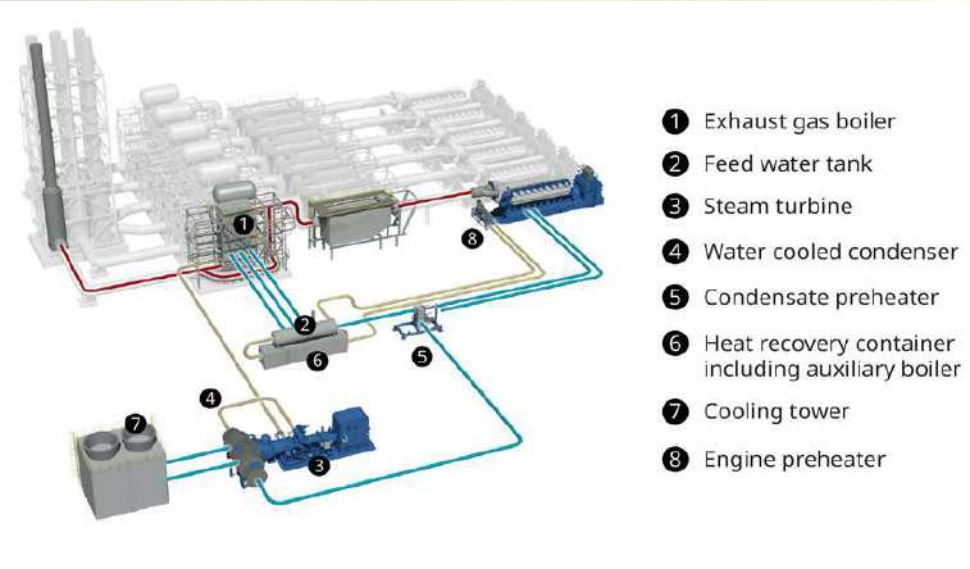


Figure 1.

In the system shown in Figure 1, the gas piston engine (8) serves as the main energy source, converting the chemical energy of the fuel into mechanical energy. The exhaust gases produced by the engine, at an average temperature of 450 °C, are directed to the waste heat boiler (1). The water supplied to the boiler is collected in the storage tank (2), where it is preheated and mixed with steam condensate, increasing the overall energy efficiency of the system. In the waste heat boiler, steam at 450 °C is generated and sent to the steam turbine (3). The turbine converts the potential energy of the steam into mechanical energy, which is then converted into electrical energy by the generator. After passing through the turbine, the steam is sent to the condenser (4), where it is cooled and transformed into liquid condensate. The condensate is then directed to the condensate heater (5), where it is further heated before being fed back into the boiler. The system also includes a mini boiler unit (6) that acts as a heat recovery system for heating purposes. This unit additionally heats the water, significantly improving the overall system efficiency. To cool the condenser, a closed-loop water circulation system (7) with cooling towers is used, after which the water is returned to the system. The final element of the system is the gas piston engine (8), which converts the chemical energy of the fuel into mechanical energy, and through the generator, into electrical energy. [10,11].

Principles of Operation of a Gas-Piston Power Plant. The principles of converting fuel heat (internal chemical) energy into mechanical work are the same for all piston engines. The working cycle of any piston engine consists of five sequential processes. One of the most common types of internal combustion engines is the diesel engine, which operates based on the Diesel cycle. Figure 2 shows that the working process in this cycle consists of four main stages.

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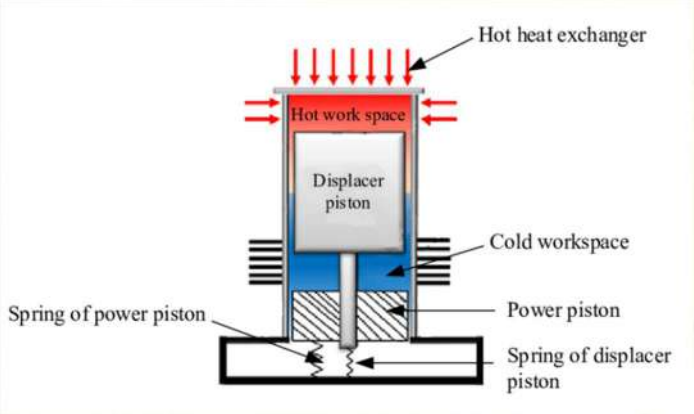


Figure 2. Schematic diagram of a Stirling engine

The Diesel cycle is the main operating principle for high-power internal combustion engines, including Wärtsilä machines with a capacity of 8.75 MW. This cycle consists of the following stages:Intake of a fresh charge – air or an air-fuel mixture is delivered into the cylinder. Compression of the fresh charge – the piston moves upward, compressing the mixture. Ignition and combustion of the mixture – compression raises the temperature, causing the fuel to ignite spontaneously. Expansion of the burned gases (power stroke) – the energy from combustion pushes the piston downward, producing mechanical work. Exhaust of the spent gases – the combustion products are expelled. [15,16].

In **Figure 3**, points **1–2** represent **isentropic compression**, during which the air entering the engine cylinder is highly compressed, causing a sharp increase in pressure and temperature. Heat is added at **constant pressure (2–3)**: fuel is injected into the cylinder under high pressure, and the compressed air temperature causes the fuel to ignite spontaneously, initiating the combustion process. During combustion, the **pressure remains nearly constant while the volume increases**. Points **3–4** represent **isentropic expansion**, where the expanding combustion gases push the piston, producing mechanical work. At point **4–1**, heat is released at **constant volume**, the spent gases are expelled from the cylinder, and the cycle returns to its initial state. [12].

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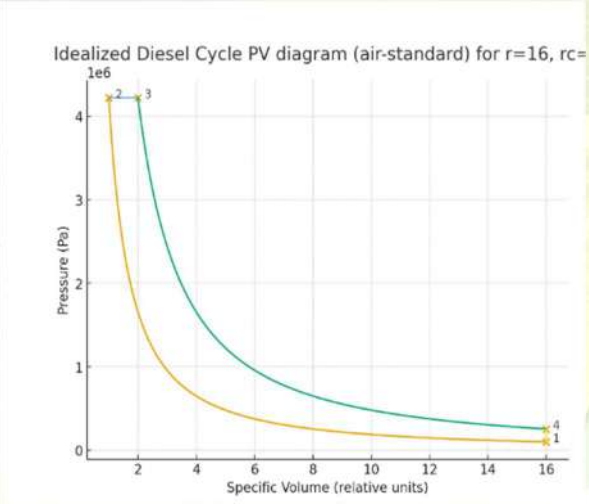


Figure 3. P-V diagram of the Diesel cycle.

Diagram: Ideal Diesel Cycle PV Diagram (r = 16, rc = 2). As shown in this diagram, the **main energy generation stage in a diesel engine occurs during the expansion process 3→4**. It is precisely at this stage that the engine produces **mechanical power through the movement of the piston**.

$$\eta_{Diesel} = 1 - \left(1\frac{1}{(r^{\gamma-1})}\right) \times \left(\frac{(r_c^{\gamma} - 1)}{(\gamma \times (r_c - 1))}\right)$$

here $r = \frac{V_2}{V_1}$–compression ratio, $r_c = \frac{V_3}{V_2}$ - Cut-off ratio (volume at the end of combustion / volume at the start of combustion), $\gamma = \frac{C_p}{C_v}$ - Adiabatic index (for air) $\gamma = 1{,}35 - 1{,}4$.

- If r is large, the efficiency increases.
- If r_c is large, the efficiency decreases (the combustion process lasts longer).
- The efficiency of the Diesel cycle is slightly lower than that of the Otto cycle, but in practice, due to the high compression ratio, the engine efficiency is high. [13,14].

As can be seen from the data presented in Table 1, the 20V32 diesel generator, originally designed to operate at a nominal capacity of 9.75 MW, has actually been operated at 8.75 MW at the private company Aksa Enerji Tashkent LLC. This situation has directly affected parameters such as the generator's operating mode, load level, and fuel consumption.

Table 1.

Basic characteristics of the Wärtsila 20V32SG diesel engine

Parameter	Designation	Unity	In the case of 8.75 MW	In the case of 9.7 MW

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Cylinder diameter	D	mm	320	320
Cylinder travel path	L	mm	400	400
Cylinder volume	Vc	m^3	0,03217	0,03217
Total volume (20 cylinders)	Vtot	m^3	0,6434	0,6434
Number of inlet valves	–	piece	2	2
Number of outlet valves	–	piece	2	2
Number of cylinders	Z	piece	20	20
Engine RPM	n	rpm	750	750
Average speed of the cylinders	Cm	m/s	10	10
Total power	P	MW	8,75	9,7
Power per cylinder	Pc	kW	437,5	485,0
Total torque	T	N·m	111,409	123,504
Each cylinder torque	Tc	N·m	5,570	6,175
Mean effective pressure (MEP)	-	MPa	2,176	2,412
Power Gain (%)	–	%	–	+10,86%

As a result of the subsequent rerating process, after recalibrating and optimizing the operating parameters of the equipment, the technical characteristics of the generator changed significantly. Consequently, the machine's power output,

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thermal efficiency, and combustion stability improved. The table clearly shows these changes, highlighting the differences between the technical parameters before and after the rerating.

Conclusion. The rerating process carried out on the Wärtsilä 20V32 engines contributed to achieving high efficiency from technical, economic, and environmental perspectives. The results of the study showed that by increasing the power output of the existing units (theoretically by 10–15%, for example, from 8 MW to 9.2 MW), the system efficiency improved by 5–8%. As a result of turbocharging and optimization of the combustion process, the fuel utilization coefficient improved, and NOx and CO_2 emissions were reduced. In addition, the use of Wärtsilä NOx Reducer technology cut the amount of exhaust gases by up to 30%. Furthermore, the service life of the engines was extended by 10–15 years, ensuring technical stability. The increase in electricity generation led to fuel savings and higher revenues for the power grid, demonstrating that the return on investment (ROI) could be achieved in just three years. Overall, the rerating process became an effective example of the efficient use of existing resources in Uzbekistan's energy system.

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