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Trijenerasyon Santrallerinde Gaz Türbini Giriş Havası Sıcaklığının Elektrik Üretim Verimine Etkisi

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ÖZ

Bu çalışmada, trijenerasyon santrallerinde enerji üretmek için kullanılan gaz türbinlerinin, çeşitli sıcaklıklardaki türbin giriş havası ile çalışması araştırılmıştır. Günümüz dünyasında enerjinin ve enerjiyi verimli kullanabilmenin önemi gittikçe artmaktadır. Gelişen nüfus ve teknolojiler ihtiyaç duyduğumuz enerjiyi arttırmış ve bununla birlikte enerji maliyetleri ciddi seviyelere ulaşmıştır. Tüm bunlar enerjinin verimli kullanılmasının gerekliliğini ortaya koymuştur. Trijenerasyon santralleri yüksek verime sahip olması, yerinde elektrik üretimi ile hat kayıplarının önüne geçmesi ve bileşik enerji üretimi sağlaması sebebiyle konvansiyonel üretime göre daha az fosil yakıt tüketimi sağlamaktadır. Çalışmamızda trijenerasyon santralinde kullanılan Solar Turbines Taurus 60 gaz türbininin giriş havasının soğutularak elektrik üretim verimindeki artış incelenmiştir. Türbin giriş havasının 41,2 °C'den 9,1 °C'ye soğutulmasıyla elektrik üretiminde aktif güç veriminde %30,08 artış olduğu tespit edilmiştir.

The Effect of Gas Turbine Inlet Air Temperature on Electricity Production Effiency in Trigeneration Power Plants

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ABSTRACT

In this study, the operation of gas turbines used to generate energy in trigeneration plants with turbine inlet air at various temperatures was investigated. In today's world, the importance of energy and its efficient use is increasing. Developing population and technologies have increased the energy we need, and thus energy costs have reached serious levels. All these reveal the necessity of using energy efficiently. Trigeneration power plants provide less fossil fuel consumption than conventional production because they have high efficiency, prevent line losses with on-site electricity generation, and provide combined energy production. In our study, the increase in electricity production efficiency by cooling the inlet air of the Solar Turbines Taurus 60 gas turbine used in the trigeneration power plant was examined. It was determined that there was a 30.08% increase in active power efficiency in electricity production by cooling the turbine inlet air from 41.2 °C to 9.1 °C.

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1.Introduction

Energy is one of the cornerstones of modern life and is used in a large part of our daily activities. However, effective and efficient use of energy is an important issue due to limited energy resources and environmental effects. The effective and efficient use of energy provides many benefits both economically and environmentally.

Efficient use of energy means doing the same job by consuming less energy. This means that increasing energy efficiency has direct economic benefits. As energy efficiency increases, energy costs decrease and businesses, households and industries consume less energy to provide the same services. At the same time, dependence on energy imports is reduced and energy security is increased. Energy efficiency also increases the competitiveness of businesses, creates new job opportunities and supports economic growth.

In this study, we have examined the active power increase in electricity generation by cooling the turbine inlet air in gas turbines in order to use energy effectively and efficiently, and we have observed and discussed the results together.

Cooling the turbine inlet air is a technique used in power generation facilities, especially in gas turbines. This technique aims to increase the performance and efficiency of the turbine. Turbines are important equipment used to generate electrical energy. However, turbines may have high operating temperatures, which may result in some energy losses. To solve this problem, the method of cooling the turbine inlet air is used (Çiftkaya, 2010; Özdemir, 2017; Demirel, 2019; Kareem, 2023).

First, cooling the turbine inlet air increases the density of the air. With the cooling process, the air temperature drops and the density of the air increases. Denser air carries more oxygen molecules in the same volume. This optimizes the combustion process and allows fuel to burn more efficiently. As a result, more energy is produced and the efficiency of the turbine increases. Second, cooling the turbine inlet air reduces the expansion effect on the turbine blades. The heated air expands as it passes through the turbine blades, which can cause energy loss. However, with the cooling process, the temperature of the inlet air decreases and this expansion effect decreases. This enables the blades of the turbine to operate more efficiently, reduces energy losses and increases turbine efficiency (Kutbi, 2022; Al-Affas, 2016).

In order to examine all these in detail, in our study, data were collected by observing the operation of a 5.2 MW Solar Turbines Taurus 60 model gas turbine at various temperatures. By analyzing data we have obtained, clear findings and conclusions on the subject have been revealed.

2.Material and Methods

Energy is one of the most important of modern society and is widely used in industry, commerce, housing and transportation sectors. However, the use of energy can cause depletion of natural resources, environmental pollution and global climate change. Therefore, energy management is important to ensure the effective use of energy and to minimize these negative effects. Energy management can be defined as a disciplined and organized work in which energy use is structured efficiently, without compromising product safety, quality, environmental conditions and reducing production. Designing highly energy efficient buildings today is much more cost-effective than in the past. Due to the energy savings they will provide during operation, additional costs for energy savings will pay off in a short time. These positive developments will directly reduce the amount of energy needed and contribute positively to air pollution and greenhouse gas emissions (Yıldırım, 2022).

2.1. Trigeneration Plants

Trigeneration power plants are one of the most efficient systems used for power generation. These systems are designed to simultaneously produce electricity, hot water, steam and cooling. These four different forms of energy can be used for different aspects of energy needs. For example, electrical energy can be used for building lighting, electronic equipment, and motor vehicles, while hot water and steam energy can be used for industrial processes, heating and cooling purposes (Figure 1). Trigeneration plants run on fossil fuels such as natural gas. The heat generated by the combustion of fossil fuels is used in a gas turbine. The gas turbine generates electrical energy via a generator, using the high-speed gas flow. This process continues by directing hot gases towards a steam turbine. A steam turbine uses steam to generate more electrical energy with a generator (Kandemir, 2019).

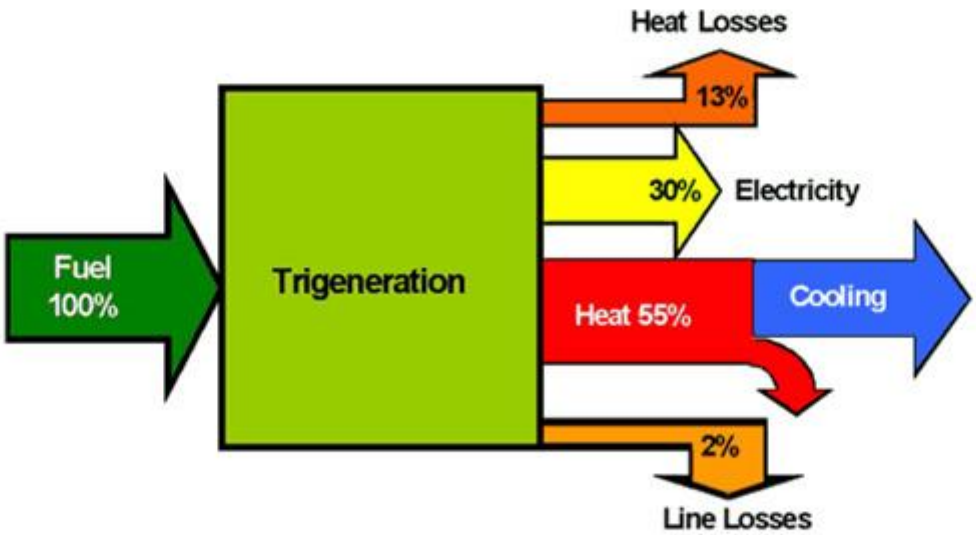

Figure 1. Trigeneration diagram (int. res. 2)

2.2. Generators

Electric generators, also known as dynamos, are devices that convert mechanical energy into electrical energy. Their primary purpose is to transmit and distribute electricity through power lines to residential, commercial, and industrial customers. In addition, generators provide the necessary electrical power for vehicles such as cars, airplanes, ships, and trains. The mechanical power required for an electric generator is typically obtained from a rotating shaft multiplying the shaft torque by the rotational or angular velocity.

The construction and speed of generators can vary significantly based on the specific characteristics of the mechanical setup. When it comes to feeding electrical power grids, most generators produce alternating current (AC) with a fixed frequency of either 50 or 60 Hertz per second. This alternating current periodically reverses its polarity. It is crucial for multiple generators connected to the power grid to operate at the same frequency to enable simultaneous generation. As a result, these generators are referred to as synchronous generators or alternators in some cases (Tufan 2013).

An alternator or synchronous generator operates based on the principle of electromagnetic induction. According to this principle, when the flux linking with a conductor changes, an electromotive force (EMF) is induced in the conductor. In the case of an alternator, when the armature winding is exposed to the rotating magnetic field, voltage is generated in the armature winding. By energizing the rotor field winding with direct current from the exciter, alternating north and south poles are formed on the rotor. As the rotor rotates counterclockwise driven by a prime mover, the armature conductors placed on the stator are intersected by the magnetic field created by the rotor poles. Consequently, due to electromagnetic induction, an alternating EMF is induced in the armature conductors. This alternating EMF is a result of the alternating passage of the north and south poles of the rotor through the armature conductors (Uçmaz, 2008).

The direction of the generated EMF can be determined by Fleming's true rule, and its frequency is given by:

$$f=(Ns \cdot P)/120 \quad (1.0)$$

2.3. Gas Turbines

A gas turbine engine operates in a similar manner to an internal combustion engine and utilizes gas to generate rotational motion. This engine type is specifically designed to turn a turbine by employing gas as its working fluid. The term "gas turbine engine" is also used to refer to a complete internal combustion engine that consists of at least one compressor, a turbine, and a combustion chamber.

The gas turbine engine is capable of producing useful work or propulsive thrust. It can drive various devices such as generators, pumps, or propellers. In the case of a pure jet aircraft engine, the turbine accelerates the exhaust flow through a nozzle, resulting in the development of thrust. Despite being smaller and lighter than reciprocating internal combustion engines, gas turbine engines can generate a significant amount of power. Unlike reciprocating engines, which rely on the piston's up and down movement, gas turbine engines provide direct rotary shaft power. This eliminates the need for converting motion through a crankshaft arrangement.

While a gas turbine engine may seem conceptually simple, the components of an efficient unit must be meticulously designed and manufactured using expensive materials due to the high temperatures and stresses experienced during operation.

Most gas turbine engines operate in an open loop cycle. In this cycle, the engine draws air from the atmosphere and compresses it using an axial flow or centrifugal compressor. The compressed air is then directed to the combustion chamber. Inside the combustion chamber, fuel is introduced and burned together with a portion of the compressed air at a consistent pressure. Additional compressed air is diverted around the combustion section and mixed with the high-temperature combustion gases. This extra compressed air helps to lower the temperature at the outlet of the combustion chamber, allowing the turbine to run continuously. If the engine aims to generate shaft power, the combustion products expand to atmospheric pressure within the turbine. In most cases, the turbine's output is utilized to provide the necessary power for operating the compressor, with only the remaining portion used to perform shaft work for devices such as pumps, generators, or other equipment. Jet engines are designed to deliver sufficient output to drive the turbine, compressor, and auxiliary devices. Finally, the gas flow exits through an intermediate pressure level nozzle, generating thrust (Toprak, 2007).

2.4. Transformers

A transformer is an electrical energy converter. It is used to increase or decrease the amplitude level of AC electrical energy while keeping the frequency constant. Transformers are widely used in the electrical power distribution system and are also used in many industrial applications such as electric motors, lighting systems and electronic devices. A transformer consists of two or more coils and these coils are surrounded by an iron core or air gap. Transformers can come in different shapes and sizes depending on their function and the application they are used in. Transformers are inductive devices and their operation OR transmformer is an inductive device and its operation begins when the AC voltage applied to the primary (input) coil creates a magnetic field in the primary coil. This magnetic field moves through the iron core or air gap of the transformer, causing the magnetic field to induce a voltage in the secondary (output) coil. This secondary voltage is directly proportional to the ratio of the voltage at the primary. The working principle of a transformer is based on Faraday's law of electromagnetic induction. This law says that a magnetic field will induce an electric current due to a changing magnetic flux through a loop or coil. Transformers can be used for many different applications and are available in different sizes and powers. Small transformers are used as power sources in electronic devices, while large transformers are used in electrical power distribution system.

2.5. Method of Study

In this study, the operation of a gas turbine has been examined in detail in order to examine the effects of inlet air cooling in gas turbines, and the effects of turbine inlet air changes on the increase in the power value and efficiency of the electricity produced in the turbine examined. Taurus 60 gas turbine and Leroy Somer generator connected to it were used in the system to be studied and analyzed. With this system, the thermal and electricity needed of the enterprise are met by on-site production. An absorption chiller system with Li-Br solution was used for cooling and this entire system works with trigeneration.

The operating structure of the system was to produce electricity with a generator connected to the same shaft by providing combustion in the gas turbine with natural gas, and by using the 510 °C hot gas taken from the gas turbine in paper drying, after consuming its energy, steam was produced in waste heat boilers at 320 °C. Then, by entering the economizer at 220 °C, the hot water production of the enterprise was met and waste gas was released to the atmosphere at 115 °C (int. res. 3). With the hot water produced in the economizer, the hot water requirement of 100 degrees for the absorption chillers is met, and the absorption chiller cools the cold water to 7 degrees with its own cycle and works to cool the water that returns as 12 degrees on the return (Figure 2). The inlet air cooling method was examined in order to increase the electricity production and increase the electricity efficiency by using the cooling provided from the trigeneration system for the cooling of the turbine inlet air, and to positively affected the total power plant efficiency (ECC, 2023).

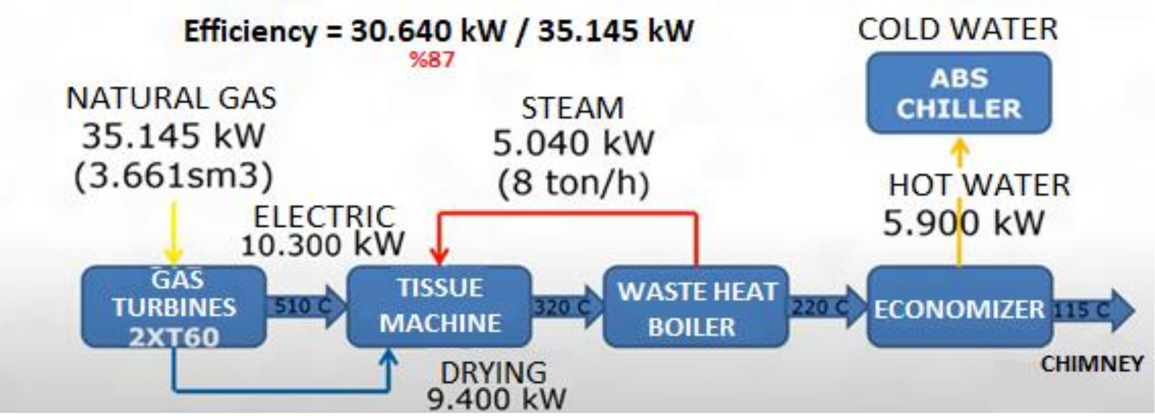

Figure 2. Flow chart of the system (int. res. 3)

We were examined that the change in the amount of electricity generation of the turbine inlet air at various temperatures in 1 gas turbine belonging to this system and discuss the results.

The data of the Taurus 60 gas turbine in ISO conditions, that is, at 15 °C and at sea level, are shared (Figure 3). These data may vary as altitude, temperature, relative humidity and turbine operating hours change. It has the capacity to meet the data specified in the general conditions.

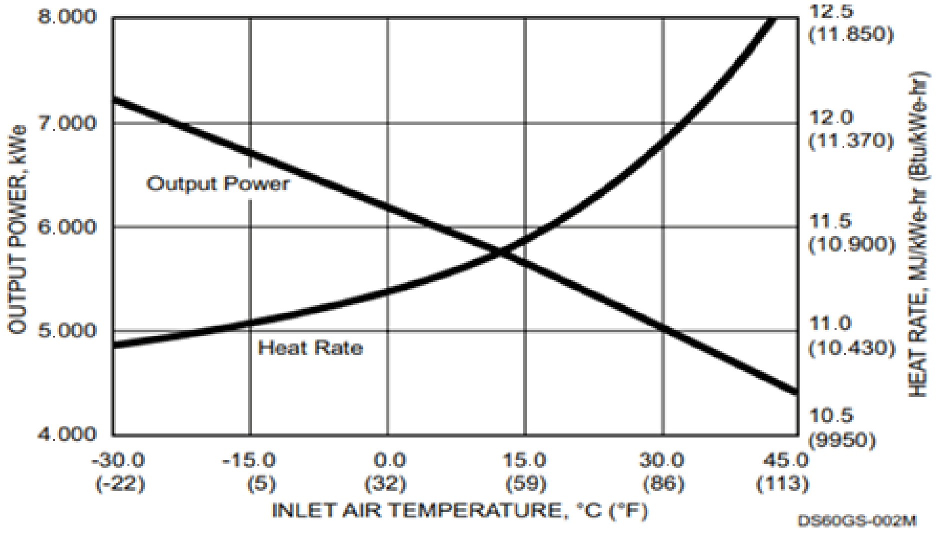

Figure 3. Taurus 60 performance graph (int. res. 1)

By using an absorption chiller, both the operating and turbine inlet air are cooled. With this cooling, the electrical efficiency of the turbine has been increased and also the trigeneration efficiency has been increased by making more use of waste heat (Ashley et al., 2011).

We examined with data how turbine inlet air temperature change affects production. Due to the nature of gas turbines, as the inlet air gets colder, the amount of air per unit area that can enter the compressor becomes greater. The reason for this is that the amount of air per unit area increases as the air gets colder, and as the gas expands as it warms up, the amount of air per unit area decreases. Air enters the turbine combustion chamber by being compressed in the compressor, and since it is cold, it provides better combustion due to the high amount of unit air inside. Since combustion takes place in cold air, the turbine can reach the limit temperature that the combustion chamber can reach by producing more power (Ünver et al., 2005; Rabeea, 2016; Karaali et al., 2017; Effiom et al., 2019).

3. Results and Disscussion

In this study, we collected the data of turbine electricity generation active power values at various inlet air temperatures in Solar Turbines Taurus 60 gas turbine to examine the effect of the change of inlet air temperature on electricity production in gas turbines. We examined and observed the change in electricity generation active power at turbine inlet air temperatures between 9.1°C and 41.2 degrees with data. We analyzed these observations as to whether they were compatible by performing regression and correlation analysis and determined that the data were compatible with the graphs. Turbine electricity production varied between 5098 kW and 3919 kW at temperatures between 9.1 °C and 41.2 °C, depending on the turbine inlet air temperature change (Figure 4).

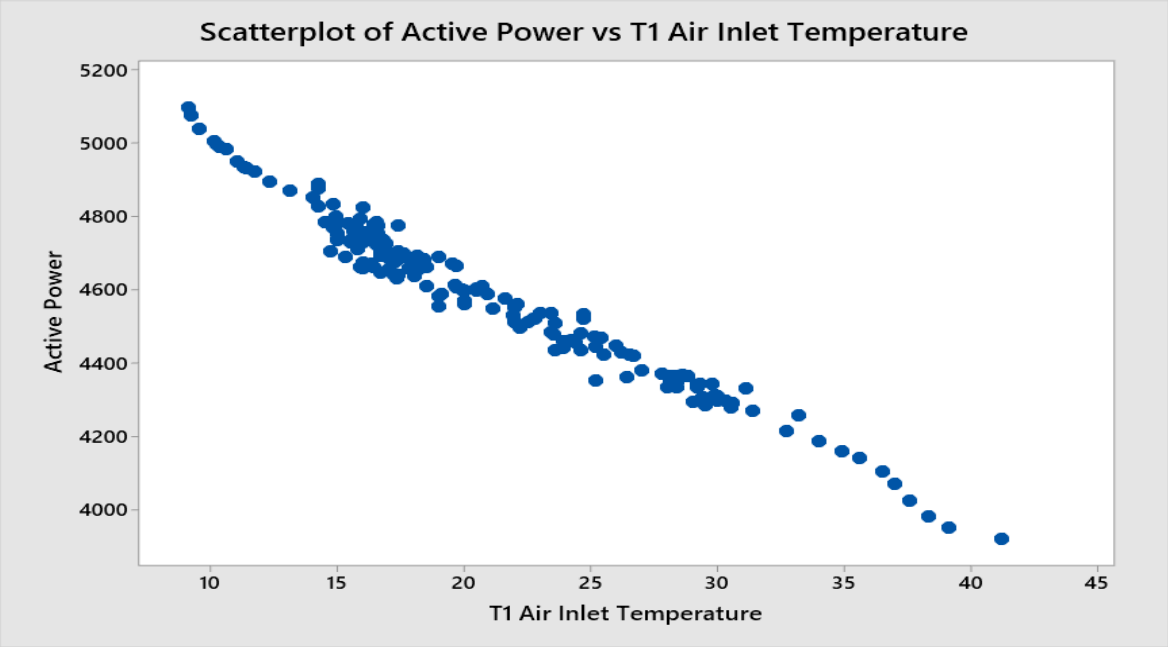

Figure 4. Active power/turbine inlet air temperature relationship

When we were analyzed that the temperature and active power data taken at 174 different times in the graph, we observe that the findings of the data give us an increase in electricity production with the cooling of the turbine inlet air, with the T1 turbine inlet air cooled at the turbine T5 temperature of 677 °C, where the turbine combustion chamber reach the maximum.

We can say that this increase was compatible with the decrease in turbine inlet air temperature and the increase in electricity production. The point that should be known here was that when making this comparison, the highest level of the turbine combustion chamber will give the healthiest result. All the data we receive are data taken at 677 °C, which is the T5 temperature at which the turbine can reach its maximum. The generator adjusts the excitation current in order to produce the maximum electricity it can produce at the shaft power that it can maintain its frequency and speed in electricity production.

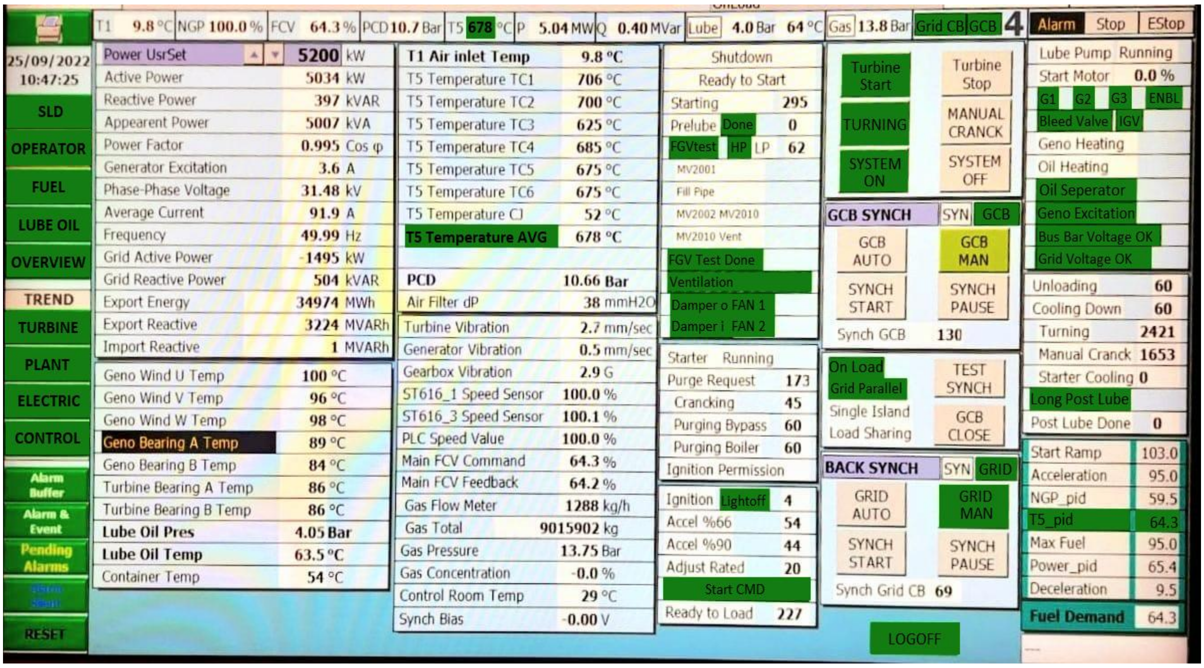

Figure 5. Turbine control screen

In the turbine control interface shared above, the T1 turbine inlet air temperature is 9.8 °C and the T5 combustion chamber was at a maximum temperature of 678 °C (Figure 5). In the cooled inlet air, the electricity generation performance of the gas turbine increased, resulting in 5034 kW active power generation.

If gas consumption is to be evaluated and efficiency analyzes are to be made in power plants using natural gas, the actual consumed natural gas consumption should be determined by making a consumption correction according to the calorific value of natural gas. The natural gas measurement volume corrector device calculates the consumption by assuming the natural gas is at a standard value of 9155 kcal. In order to find the correct consumption, we must divide the current average calorific value by the amount of 9155 kcal and multiply it by the value in the volume corrector.

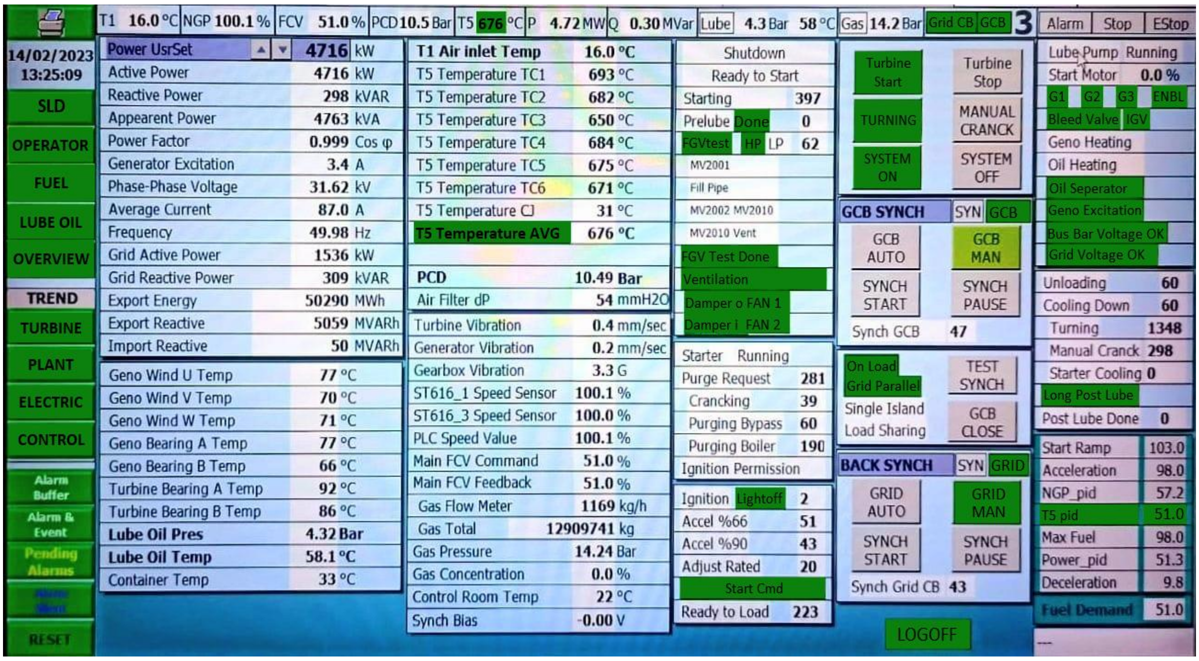

Figure 6. Turbine control screen

In Figure 6, the turbine inlet air was (T1) 16 °C and the combustion chamber is at T5 temperature, and 4716 kW of electricity can be produced.

Table 1. Turbine control panel difference data

Value	Turbine inlet air (T1) °C	Electricity generation (kW)
Value 1	9.8	5034
Value 2	16	4716
Difference	6.2	318
Difference %	%-38.75 temperature decrease	%6.74 production increase

For the 2 data compared, a temperature drop of 6.2 °C showed a significant increase in turbine electricity production (Table 1). 318 kW of power generation gain and when we look at it from another dimension, we actually increase the capacity. We would not have a chance to produce more than 4716 kW at 16 °C. By cooling the inlet air, we increased the dynamics of the turbine and provided power gain. We performed the regression analysis of 174 data that we mentioned before. These data were taken at the maximum temperature of the turbine combustion chamber (T5) and the active power generation with turbine inlet air (T1) at different temperatures was investigated.

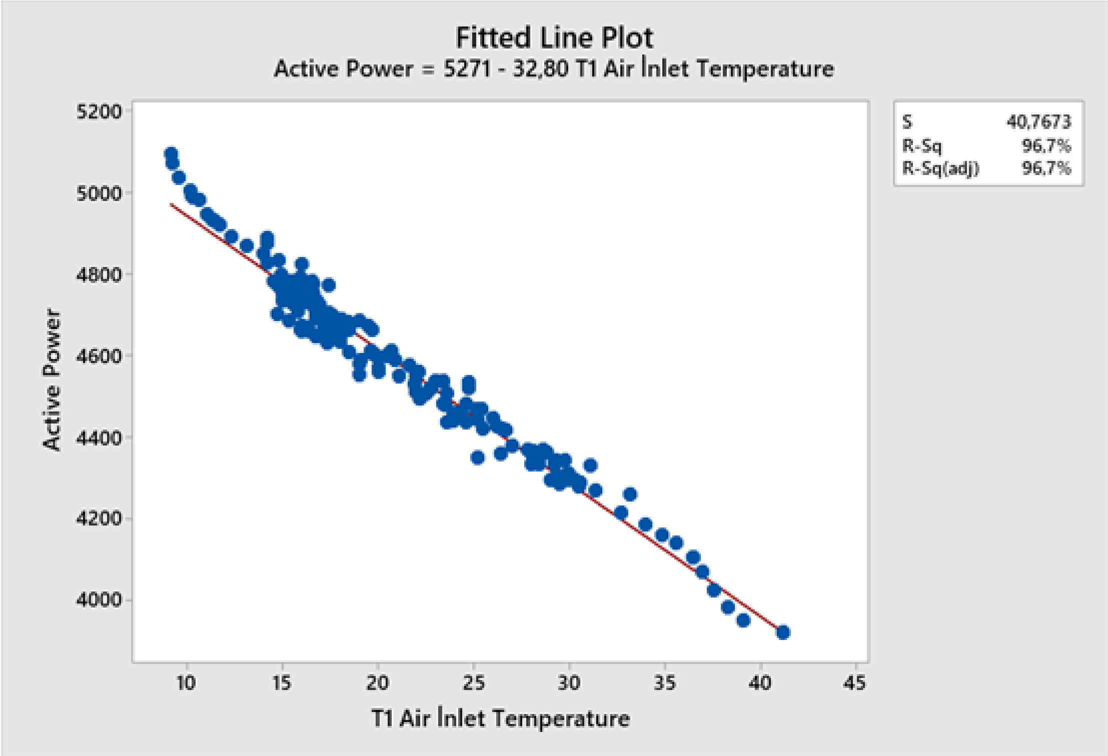

Figure 7. Active power/T1 temperature regression

The regression graph of the electricity production amount data according to 174 turbine inlet air seems to be compatible. With the cooling of the turbine inlet air temperature, the increase in electrical active power generation was confirmed with 96.7% agreement. Here, the dependent variable is the active power, while the independent variable T1 is the turbine inlet air temperature. As a result of the regression analysis, the following formula was formed (Figure 7).

$$\text{Active Power} = 5271.2 - 32.797 \cdot (\text{T1 Inlet Air Temperature}) \tag{1.1}$$

We also observed a relationship between turbine inlet air temperature and PCD pressure. We have tested the regression analysis of the turbine inlet air temperature and PCD data to see if this relationship is significant. PCD refers to the pressure value that the compressor compresses and sends to the combustion chamber. This value decreases with the increase of turbine inlet air.

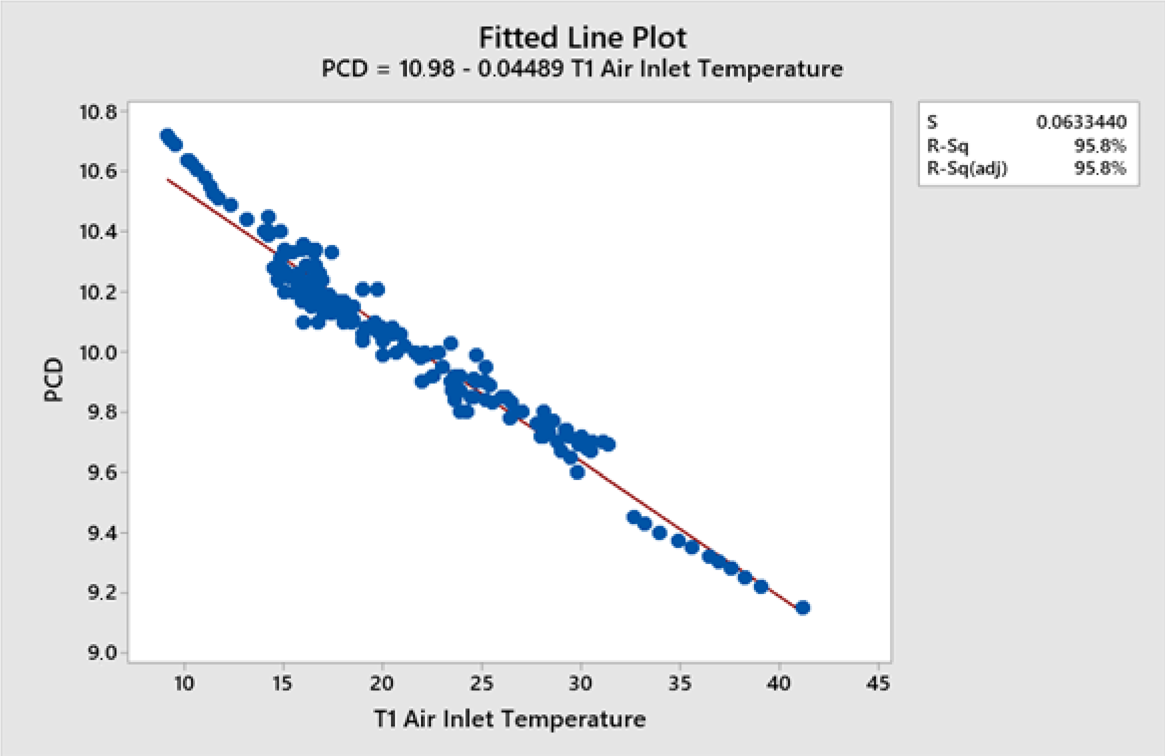

Figure 8. PCD/T1 temperature regression

With the regression analysis, we can say with 95.8% agreement that the cooling of the gas turbine compressor inlet air increases the PCD, that is, the compressor outlet pressure (Figure 8). Compressor pressure was varied between 10.72 bar and 9.15 bar between 9.1 °C and 41.2 °C temperatures. Here, the dependent variable was PCD, while the independent variable T1 is the turbine inlet air temperature.

The regression formula for T1 inlet air temperature with PCD is the following formula.

$$PCD = 10.98 - 0.04489 \cdot (T1\ Inlet\ Air\ Temperature) \qquad (1.2)$$

There was a direct relationship between turbine intake air, PCD and active power. In order to make sense of this relationship, we examined PCD and active power variation from a different perspective.

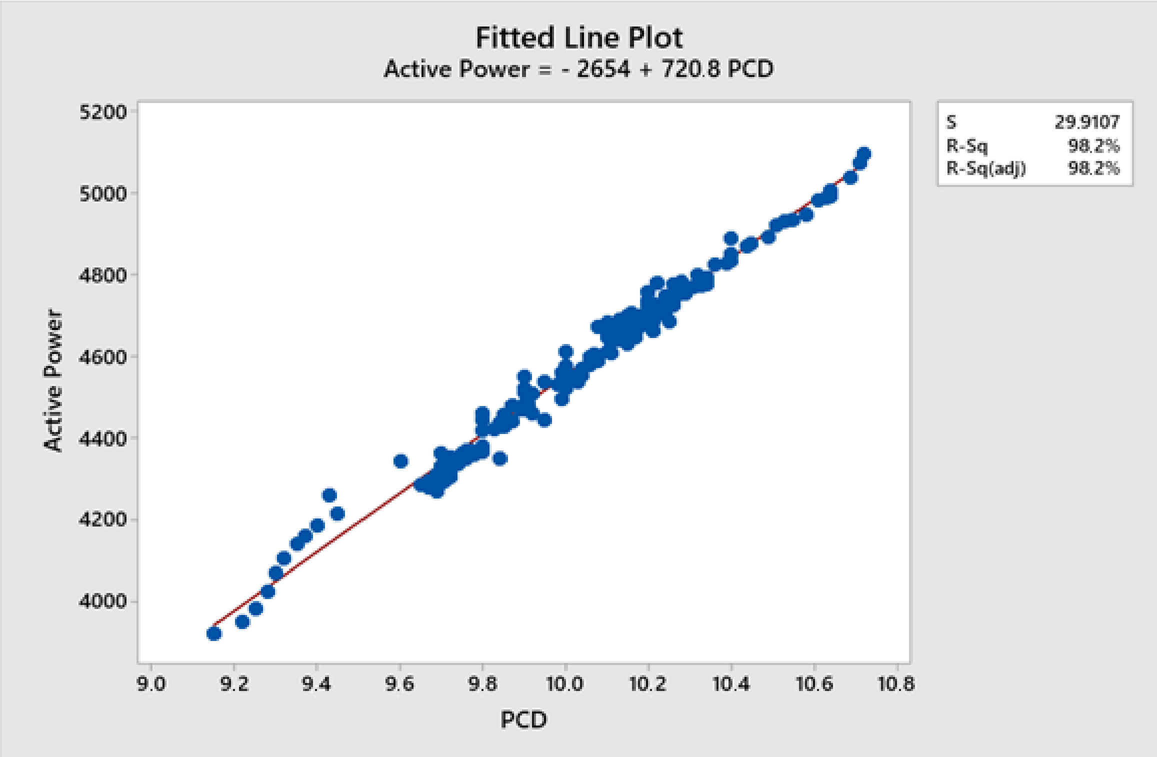

Figure 9. Active power/PCD regression

We can say with 98.2% agreement that the increase in compressor pressure also increases the active power. Here, the dependent variable is the active power while the independent variable was the PCD data. When we take PCD and T1 inlet air temperature as the dependent variable and two independent variables, we found a 98.6% agreement between them (Figure 9).

Model Summary

S	$R-sq$	$R-Sq(adj)$	$R-sq(pred)$
26.1618	98.66%		98.60%

The regression formula for active power, PCD and T1 inlet air temperature is the following formula.

$$Active\ Power = -161 + 494.6\ PCD - 10.60 \cdot T1\ \ Inlet\ Air\ Temperature \tag{1.3}$$

When we have examined the received data, it is observed that 5098 kW active power generation at 9.1 °C and PCD pressure is 10.72 bar. It has been observed that the active power generation of 3919 kW at 41.2 °C and the PCD pressure is 9.15 bar.

Table 3. Turbine inlet air and active power generation difference data

Value	Turbine inlet temperature (T1)°C	Electricity generation (kW)
Value 1	9.2	5098
Value 2	41.2	3919
Difference	32	1179
Difference %	%-77.67 Temperature decrease	%30.08 production increase

As we understood from the aforementioneddata, when we cooled down the turbine inlet air from 41.2 °C to 9.2 °C, we have increased the electrical active power output from the turbine by 1179 kW (Table 3).

Table 4. Turbine inlet air temperature and PCD difference data

Value	Turbine inlet temperature (T1) °C	PCD
Value 1	9.2	10.72 bar
Value 2	41.2	9.15 bar
Disparity	32	1.57 bar
Disparity %	%-77.67 temperature decrease	%17.16 pressure increase

When we cooled down the turbine inlet air temperature from 41.2 °C to 9.2 °C, the PCD (compressor outlet pressure) we have obtained from the turbine increases by 1.57 bar (Table 4).

4. Conclusion

The increase in energy efficiency achieved by cooling the turbine inlet air provides several advantages in the power generation process. First, more energy is produced. Increasing the density of the cooled air and burning the fuel more efficiently results in more power being produced. This means getting more electrical energy with the same capacity gas turbine.

Second, cooling the turbine inlet air reduces losses in the power generation process. Reduction of the expansion effect and more efficient combustion minimizes energy losses. This increases the energy efficiency of the facility and provides a more sustainable energy production.

In this study, we concluded that a 5.2 MW Solar Turbines Taurus 60 model gas turbine provided a significant increase in electricity production by cooling the turbine inlet air.

We analyzed the electricity productions at variable turbine inlet air temperatures with 174 different data using regression analysis. As a result of the regression analysis of the data taken from 41.2 °C to 9.1 °C, between 3919 kW and 5098 kW, we can say that the cooled turbine inlet air provided an increase of 96.7% in electricity production.

While we could produce 3919 kW of electricity at a turbine inlet air temperature of 41.2 °C, when we cooled the turbine inlet air temperature of 41.2 °C to 9.1 °C, we produced 5098 kW of active power.

By cooling the turbine inlet air by 32 °C, an increase was achieved from 3919 kW of electricity generation to 5098 kW, and an increase of 30.08% was achieved.

It has been determined that the compressor outlet pressure, which we define as PCD, is also increased by cooling the turbine inlet air. While the PCD pressure was 9.15 bar at 41.2 °C, a cooling of 32 °C was provided, and a 17.16% pressure increase was achieved as 10.72 bar when the turbine inlet air decreased to 9.2 °C. In addition, when we perform the regression analysis of the PCD pressure change according to the change in the turbine inlet air with the data we obtained, we can say that the cooling of the inlet air increases the PCD pressure by 95.8%.This is how we came to the conclusion that there is a direct relationship between the PCD pressure increase and the electricity production increase. Our regression analysis also supports this result with 98.2% agreement.

As a result, it showed that the cooling of the inlet air of the gas turbines used in trigeneration power plants provides an increase in PCD pressure and electricity production with 98.6% regression analysis compatibility.

In some literature studies on the cooling of turbine inlet air (Kwon et al. 2018, Dizaji & Pourhedayat 2019, Demiral 2019, Al-Affas 2016, Ünver & Kılıç 2005, Effiom et al. 2019), the effect of inlet air temperature on active power production is generally discussed. In my study, I determined that the compressor outlet pressure, defined as PCD, is also directly effective and provided the necessary data and findings to the literature.

Conflict of Interest Statement

The authors of the article declare that there is no conflict of interest.

Contribution Rate Statement Summary of Researchers

The authors declare that they contributed 50% to the article.

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Additional. Turbine temperature, electricity production in kW units and PCD data

Data received date time	Active power (kW)	Turbine inlet air (T1)	PCD (Bar)	Combustion Chamber Temperature (T5)
1.06.2022 00:00	4612	19.6	10.1	677
1.06.2022 06:00	4728	15.5	10.2	677
2.06.2022 10:00	4569	20	10.4	677
2.06.2022 12:00	4333	28.4	9.73	677
2.06.2022 14:00	4561	20	9.99	677
2.06.2022 18:00	4640	17.4	10.13	677
2.06.2022 20:00	4688	15.3	10.25	677
3.06.2022 00:00	4660	16	10.1	677
3.06.2022 02:00	4704	14.7	10.24	677
4.06.2022 12:00	4631	17.3	10.15	677
4.06.2022 14:00	4641	17.2	10.14	677
4.06.2022 22:00	4270	31.4	9.69	677
5.06.2022 02:00	4351	25.2	9.84	677
5.06.2022 04:00	4555	19	10.04	677
5.06.2022 06:00	4581	19	10.06	677
5.06.2022 12:00	4589	19.1	10.08	677
5.06.2022 14:00	4610	18.5	10.11	677
5.06.2022 18:00	4673	16	10.18	677
5.06.2022 20:00	4671	16.3	10.17	677
6.06.2022 16:00	4871	13.1	10.44	677
6.06.2022 18:00	4950	11	10.58	677
6.06.2022 20:00	4983	10.6	10.61	677
6.06.2022 22:00	4990	10.3	10.63	677
7.06.2022 00:00	5098	9.1	10.72	677
7.06.2022 02:00	4648	16.7	10,1	677
7.06.2022 06:00	4661	16.4	10.15	677
7.06.2022 08:00	4663	15.9	10.17	677
8.06.2022 12:00	4774	17.4	10.33	677
8.06.2022 20:00	4877	14.2	10.45	677
8.06.2022 22:00	4890	14.2	10.4	677
9.06.2022 02:00	4824	16	10.36	677
9.06.2022 06:00	4688	19	10.21	677

9.06.2022 22:00	4534	24.7	9.99	677
10.06.2022 02:00	4665	19.7	10.21	677
10.06.2022 04:00	4785	16.5	10.33	677
10.06.2022 06:00	4776	16.6	10.34	677
10.06.2022 08:00	4777	16.4	10.34	677
10.06.2022 10:00	4834	14.8	10.4	677
10.06.2022 12:00	4793	15.9	10.34	677
10.06.2022 20:00	4443	25.2	9.95	677
11.06.2022 02:00	4537	23.4	10.03	677
11.06.2022 04:00	4755	16.6	10.29	677
11.06.2022 10:00	4779	15.7	10.22	677
11.06.2022 12:00	4736	16.8	10.26	677
11.06.2022 14:00	4726	16.9	10.24	677
11.06.2022 16:00	4724	16.5	10.26	677
11.06.2022 18:00	4800	14.9	10.32	677
11.06.2022 20:00	4749	16.3	10.24	677
12.06.2022 14:00	4364	28.3	9.75	677
14.06.2022 08:00	4331	31.1	9.7	677
14.06.2022 10:00	4363	28.8	9.7	677
14.06.2022 14:00	4418	26.7	9.8	677
14.06.2022 18:00	4828	14.2	10.39	677
14.06.2022 20:00	4783	15.4	10.33	677
15.06.2022 06:00	4851	14	10.4	677
15.06.2022 14:00	4756	16.1	10.29	677
15.06.2022 16:00	4782	15	10.4	677
15.06.2022 20:00	4923	11.7	10.51	677
15.06.2022 22:00	4770	14.8	10.31	677
16.06.2022 12:00	4338	29.2	9.74	677
16.06.2022 14:00	4296	30	9.71	677
16.06.2022 16:00	4290	30.6	9.7	677
16.06.2022 18:00	4306	29.4	9.72	677
16.06.2022 22:00	4575	21.6	10	677
17.06.2022 00:00	4663	18.5	10.15	677
17.06.2022 04:00	4649	18	10.17	677
17.06.2022 08:00	4531	21.9	9.98	677

17.06.2022 10:00	4497	22.2	9.99	677
17.06.2022 14:00	4509	23.6	9.92	677
17.06.2022 16:00	4459	23.9	9.92	677
17.06.2022 20:00	3919	41.2	9.15	677
17.06.2022 22:00	3950	39.1	9.22	677
18.06.2022 00:00	3980	38.3	9.25	677
18.06.2022 02:00	4022	37.6	9.28	677
18.06.2022 04:00	4068	37	9.3	677
18.06.2022 06:00	4103	36.5	9.32	677
18.06.2022 08:00	4139	35.6	9.35	677
18.06.2022 10:00	4158	34.9	9.37	677
18.06.2022 12:00	4186	34	9.4	677
18.06.2022 14:00	4258	33.2	9.43	677
18.06.2022 16:00	4214	32.7	9.45	677
18.06.2022 18:00	4690	17.6	10.15	677
18.06.2022 20:00	4705	17.4	10.16	677
18.06.2022 22:00	4690	17.4	10.16	677
19.06.2022 00:00	4700	17.1	10.18	677
19.06.2022 02:00	4685	17	10.16	677
19.06.2022 04:00	4895	12.3	10.49	677
19.06.2022 06:00	4931	11.4	10.53	677
19.06.2022 08:00	4935	11.3	10.55	677
19.06.2022 10:00	5007	10.1	10.64	677
19.06.2022 12:00	4995	10.2	10.64	677
19.06.2022 14:00	5040	9.5	10.69	677
19.06.2022 16:00	5076	9.2	10.71	677
19.06.2022 18:00	4646	18	10.15	677
19.06.2022 20:00	4698	17.3	10.19	677
19.06.2022 22:00	4692	16.7	10.21	677
20.06.2022 02:00	4759	15.6	10.2	677
20.06.2022 04:00	4736	15	10.2	677
20.06.2022 06:00	4737	15.5	10.25	677
20.06.2022 08:00	4710	15.8	10.22	677
20.06.2022 10:00	4675	17.2	10.15	677
20.06.2022 12:00	4333	28	9.72	677

20.06.2022 14:00	4294	29	9.67	677
20.06.2022 16:00	4284	29.5	9.65	677
21.06.2022 00:00	4440	23.9	9.87	677
21.06.2022 02:00	4444	23.9	9.8	677
21.06.2022 04:00	4655	17	10.13	677
21.06.2022 22:00	4436	23.6	9.84	677
22.06.2022 02:00	4479	23.5	9.87	677
22.06.2022 06:00	4483	23.4	9.9	677
22.06.2022 12:00	4700	16.7	10.18	677
22.06.2022 14:00	4730	16	10.21	677
22.06.2022 16:00	4776	14.8	10.26	677
22.06.2022 18:00	4784	14.5	10.28	677
23.06.2022 04:00	4723	16.7	10.21	677
23.06.2022 06:00	4726	16.8	10.2	677
23.06.2022 08:00	4658	17.8	10.17	677
23.06.2022 12:00	4422	26.5	9.83	677
23.06.2022 14:00	4365	28.1	9.8	677
23.06.2022 16:00	4295	30.3	9.68	677
23.06.2022 18:00	4278	30.5	9.67	677
23.06.2022 20:00	4470	25.1	9.9	677
24.06.2022 04:00	4683	18.4	10.1	677
24.06.2022 06:00	4672	19.5	10.08	677
24.06.2022 08:00	4669	18	10.15	677
24.06.2022 10:00	4684	17.4	10.18	677
24.06.2022 12:00	4670	18	10.14	677
24.06.2022 14:00	4691	18.1	10.13	677
25.06.2022 16:00	4312	29.9	9.69	677
25.06.2022 18:00	4549	21.1	10.02	677
25.06.2022 20:00	4636	18	10.11	677
26.06.2022 10:00	4666	18.2	10.13	677
26.06.2022 12:00	4369	27.8	9.76	677
26.06.2022 14:00	4600	19.9	10.08	677
26.06.2022 16:00	4603	20.5	10.08	677
26.06.2022 18:00	4588	20.9	10.06	677
27.06.2022 02:00	4753	15	10.27	677

27.06.2022 04:00	4752	15	10.27	677
27.06.2022 06:00	4741	15.7	10.26	677
27.06.2022 08:00	4678	18.1	10.16	677
27.06.2022 10:00	4448	26	9.85	677
27.06.2022 12:00	4349	28.4	9.76	677
27.06.2022 14:00	4344	29.3	9.74	677
27.06.2022 16:00	4342	29.8	9.6	677
27.06.2022 18:00	4380	27	9.8	677
27.06.2022 20:00	4429	26.2	9.85	677
27.06.2022 22:00	4481	24.6	9.91	677
28.06.2022 00:00	4520	24.7	9.9	677
28.06.2022 02:00	4521	22.7	10	677
28.06.2022 04:00	4536	23	9.95	677
28.06.2022 06:00	4520	22.8	10	677
28.06.2022 08:00	4469	25.4	9.89	677
28.06.2022 10:00	4368	28.6	9.77	677
28.06.2022 12:00	4334	29.2	9.73	677
28.06.2022 14:00	4310	30	9.72	677
28.06.2022 18:00	4550	22	9.9	677
28.06.2022 20:00	4611	20.7	10	677
28.06.2022 22:00	4598	20.5	10.06	677
29.06.2022 00:00	4596	20	10.06	677
29.06.2022 04:00	4607	19.7	10.07	677
29.06.2022 16:00	4561	22.1	10	677
29.06.2022 18:00	4731	16.4	10.2	677
30.06.2022 00:00	4654	18.1	10.14	677
30.06.2022 08:00	4422	25.5	9.83	677
30.06.2022 10:00	4352	28.1	9.72	677
30.06.2022 12:00	4360	26.4	9.78	677
30.06.2022 14:00	4457	24.4	9.85	677
30.06.2022 16:00	4461	24.2	9.8	677
30.06.2022 18:00	4436	24.6	9.85	677
30.06.2022 20:00	4511	22	9.9	677
30.06.2022 22:00	4510	22.5	9.92	677