INCREASE EFFICIENCY POWER SUPPLY FACILITIES COGENERATION APC

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The intensive growth and development of technologies combined heat and power generation observed in recent decades is the result of the realization that fuel the planet's resources may be exhausted, and further environmental degradation caused by increasing the volume of fuel consumed - is unacceptable. In Ukraine today is urgent need for energy efficiency measures in all industries, including in the agricultural sector, which is associated with a significant part of imported fuels in energy balance. This is a problem closely related issues: energy security, economic use of energy and environmental protection.

One of the most effective ways of saving that can effectively solve all three questions is cogeneration. The meaning of cogeneration is that the formulation of electricity creates the possibility to utilize concomitant heat and thus significantly increase the overall efficiency of the unit - up to 90-92%. In cogeneration plant (CHP) energy conversion occurs more efficiently, thus achieving a significant reduction in specific fuel consumption - up to 135 g ce / kW · h.

Heat loss in these plants do not exceed 10% and the primary fuel required in 1,6-2 times compared with separate production of the same amount of heat and electricity. Efficient use of fuel leads to a reduction of harmful emissions into the atmosphere. It is estimated emission reductions, such as CO2 from electricity for a combined technology compared to the separate production of more than 600 kg / MW · h. In addition, the reduced cost of production and cost of generating equipment and its maintenance in terms of 1 kW · h of energy produced.

Today in Ukraine, the share of electricity supply generated by the combined technology (mostly - at CHP) in full power issue all generating stations is about 2%. As for heat, CHP Ukraine produces about 70 million Gcal of heat per year, representing 21.6% of total heat production in the country. The main fuel for power plants is natural gas that most of them are imported fuel, of which the fuel balance is

80%. However, fuel efficiency is very low, some CHP specific fuel consumption for production of 1kW · h of electricity reaching 0,53-0,54 kg EF and 1 Gcal of heat supplied - 240-250 kg EF . This is a major demolition equipment worn in huge losses and extended networks, low working efficiency steam turbine units (below 30%). Most of the CHP used for power less than half, and the thermal capacity (except for a small number of industrial CHP) utilization rate does not exceed 30%. In the situation that is especially important that the national importance is the problem of creating a comprehensive and effective implementation of decentralized energy sources - primarily at the KSU gas turbines (gas turbines) and reciprocating internal combustion engines (ICE) because of their use created most efficient, competitive technologies other than short-term project. Comparing between these two types of CHP, the CHP based DIC compared to CHP based gas turbines, are more important electrical efficiency, allowing the fullest use exergic potential primary fuel. By reducing the load by 50% electrical efficiency of the gas turbine is reduced by almost 3 times, while for the change ICE mode load virtually no effect on both the general and the electrical efficiency. Electric power gas turbines depends on the ambient temperature, when the temperature of -30 ° C to +30 ° C electrical efficiency of gas turbines falls by 15-20%. Unlike gas turbines and internal combustion engines have higher electrical efficiency constant throughout the temperature range up to +25 ° C. In addition, CHP-based ICE characterized by lower unit cost and lower operating costs, relative ease of maintenance and management, the lowest run time in operation and high reliability. Therefore, it is based on CHP reciprocating internal combustion engines have become the most promising CHP facilities for APC.

However, efficient energy production in CHP does not mean effective energy facilities APC. The needs of the consumer in the electrical and thermal energy virtually no overlap with power CHP opportunities that produces these energy in a certain proportion, that does not answer, in most cases, the proportion of electric and thermal energy settlement. Diurnal and seasonal variations in the consumption of energy (especially heat) further complicate the problem of energy settlement. Also part of the energy produced may be lost during their transportation to the consumer.

The purpose of research - analysis capabilities increase efficiency cogeneration power facilities agriculture ..

Materials and methods research. It is possible to improve the efficiency of cogeneration power facility APC involves three stages:

1. Ensure the most efficient conversion of chemical energy of primary fuels for the generation of electricity and heat.

2. Minimizing energy losses in the transmission of the consumer.

3. Reconciliation of generating capacity CHP and energy needs of the consumer, which will be the smallest loss produced in CHP in their energy consumption.

Work on improving the efficiency of cogeneration power can be produced at each stage separately and the result of this work can be written as:

$$k = k_1 k_2 k_3,$$

where k - rate overall efficiency cogeneration power; k_1, k_2, k_3 - performance efficiency cogeneration energy on the stage of energy, transport and energy on the stage of approval consumer energy needs and opportunities for CHP, respectively.

Results. The main indicator of efficiency CHP at the stage of energy is the total coefficient of performance (COP). In terms of power it can be written as:

$$\eta = \frac{N_e + Q_m}{Q_{ког}} = \eta_e + \eta_m \quad ,$$

where N_e - electric power CHP, W; Q_t - CHP heat output, W; Q_{koh} - heat released during combustion in a cogeneration unit per unit time, W; η_e and η_t - electric and thermal efficiency of CHP, respectively.

In terms of thermodynamics efficiency CHP based on reciprocating internal combustion engines can be improved by:

1) an increase in the electrical and / or thermal power at the same cost of primary fuels;

2) reducing the cost of primary fuels while maintaining constant performance of electric and thermal power cogeneration system;

3) increase the generation of electric and \ or thermal energy while reducing the costs of primary fuels.

However, the improvement of these characteristics is a serious problem that is caused by several factors.

1. Thermodynamic parameters of modern reciprocating internal combustion engines are close to the theoretically possible limitation of this threshold and converts into useful work no more than 45-46% of the chemical energy of primary fuel. Other heat released during the combustion of fuel is dispersed in the environment or on the surface of the engine and its systems, or ejected from the exhaust gases. For CHP is not fatal because most of this heat can be returned to the consumer in HRSGs in the form of heat.

2. Much of the heat of the primary fuel in internal combustion engines is available for work, is in the exhaust gases. In CHP flue gas heat is used in part (up to 150-160 ° C) due to the fact that the use of heat recovery units at temperatures less than the specified results in a significant increase in heat transfer surface with trace amounts received heat and approximation to the dew point temperature. Consequently, when the temperature drops further possible condensation of water vapor in the exhaust tract, which can form compounds with aggressive substances exhaust gases and lead to the destruction of parts.

3. ICE exhaust gases released into the atmosphere, contain large amounts of toxic substances and soot. Although thermal utilization in CHP based on reciprocating internal combustion engines reduces the amount of harmful substances in exhaust gases, their value is still large compared to other CHP.

Directions for further development as a basis for ICE based CHP reciprocating internal combustion engines are increasing their power density and reduce harmful emissions into the environment, due to the further intensification of mixing and combustion processes. One of the most effective methods of improving mixture formation and combustion process intensification is the use of water as an additive for fuel.

Adding water cycle reciprocating internal combustion engines can make the introduction of water in the liquid state, in the form of water-fuel emulsions (VPE) and in the form of water vapor.

Putting water in the liquid state is now used mainly to cool engines in crossing their work by a large latent heat of vaporization of water. An example of this method is the use of adding water to force water injection engines racing cars and motorcycles. The main disadvantages of adding water in a liquid state are: uneven distribution of water in the working mixture due to low residence time of fuel in the cylinders of the engine (s 0,05-0,001 depending on the speed of the crankshaft) salt deposits using nedystylovanoyi water, leading to engine malfunction after 100-200 hours of work or the need for special water treatment system and additional energy costs by using distilled water.

Using VPE in ICE saves fuel and reduce the opacity of the exhaust gases and is seen as one way of improving the process of mixing. The most complete various aspects of the ICE and the processes occurring there, studied by adding water cycles in internal combustion engines with a VPE. There were both increase and decrease engine performance indicator, indicating the presence of both positive and negative impact on VPE workflow. Positive impact on cycle internal combustion engines is increasing specific volume and number of the gas mixture in the indicator in the process of vaporization of water, negative - the absorption of heat released during the combustion of fuel. The introduction of additional water as the working fluid promotes efficiency indicator, but is estimated at much less than the removal of heat by evaporation and heating. In addition, the indicators cycle indicator and efficiency affects the time the water additive. Figure 1 shows the nature of the change indicator of efficiency depending on the date of entry additive water in addition to its number ζ = GH2O / GP = 0.2.

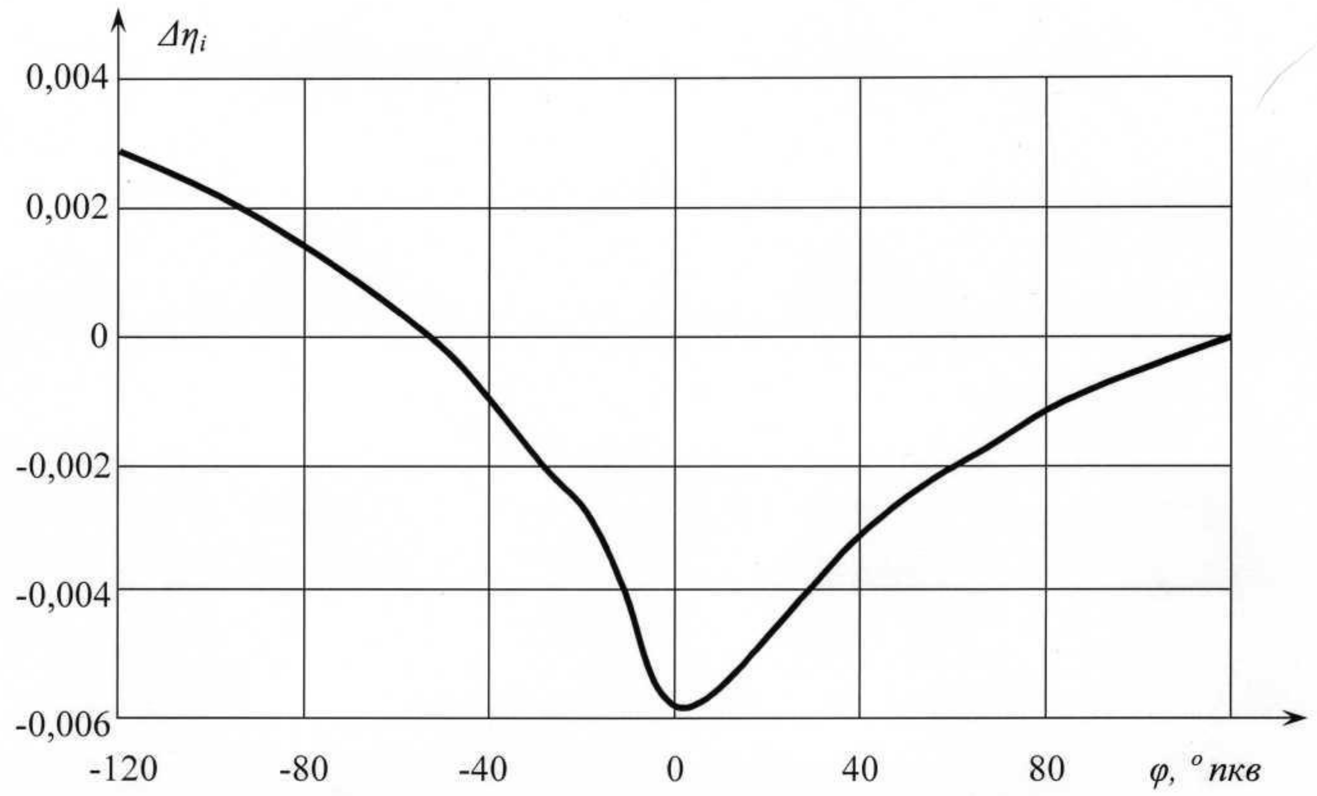

Рис.1. Вплив моменту введення присадки води на зміну індикаторного ККД для *ζ=0,2*

That is, from a thermodynamic point of view effectively introduce additive for water line compression -60º before PCI, and the most unfavorable point for water additive is in an area VMT. When using VPE its introduction occurs at 10-20º to TDC - in the worst place, resulting in the introduction of water has a negative impact on cycle efficiency and leads to its decline. In addition, there are other negative aspects of water use in internal combustion engines as VPE, namely the possibility of increasing wear and corrosion of parts fuel system; VPE instability and the possibility of separation over time due to the significant difference in the density of fuel and water, leading to deterioration of the VPE and reduce its positive impact on processes in internal combustion engines; negative effect of surface-active substances (SAS), which is an integral part of VPE, on the processes occurring in the engine.

Considering the effects of additives water, and it should be noted that in all the above embodiments, the addition of water applied distillate, which is due to the receipt of additional significant energy consumption and the availability of appropriate equipment.

Most of the shortcomings of water use in internal combustion engines while maintaining its positive effects on the combustion process can be eliminated if we use water as water vapor. In the case of water vapor distribution in the cylinders of the engine more uniform compared with injection of water, ensuring efficient combustion of the fuel mixture, stable and reliable operation of the engine. A significant positive development from the addition of water vapor is the ability of the engine without the use of surfactants, which prevents the formation of deposits in the engine that are associated with them. In addition, damp air does not lead to salt deposits in the cylinders of the engine, which positively affects its trouble-free operation. But the use of water vapor requires large energy cost of its acquisition, due to the large size of the latent heat of vaporization of water, and the corresponding steam generating equipment. These issues can be resolved by obtaining water vapor consisting of moist air using heat or ICE coolant heat exhaust. Figure 2 shows a diagram of the cycle reciprocating internal combustion engines without adding water and add water as moist air on the example of the diesel engine. Due to the higher heat capacity of water absorption in moist air is cooling bore to a lower temperature, resulting in reduced minimum temperature cycle. All other temperature cycle is also reduced, ie loop motor is a smaller range of temperatures. In the process of burning fuel water that is in the air-fuel mixture, delaying the process of combustion, which contributes some lengthening process 2 - 3 Pv-diagram, as in the case of VPE. Thus, increasing engine efficiency using moist air as opposed to using both PvE contributing factors: how to delay the combustion process and reduce the minimum temperature cycle. In addition, the absence of process water evaporation from the combustion of fuel in case of moist air reduce the maximum temperature cycle is not as significant as in the case of PVE, which also increases the efficiency of the engine.

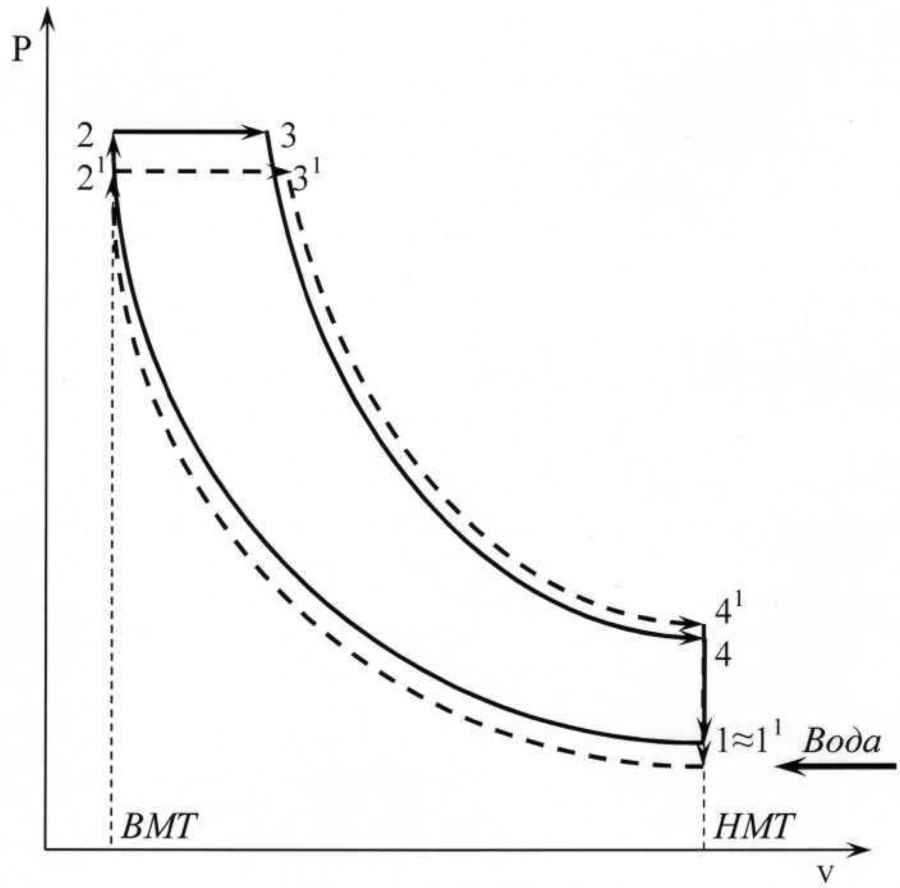

Рис.2. Схема циклу дизельного ДВЗ без додавання води (12341) та з додаванням води ($1^12^13^14^11^1$) у вигляді зволоженого повітря

Due to the above factors when adding water as moist air can get an increase in the efficiency of reciprocating internal combustion engines to 2,5-4,5%. This overall decrease temperature cycle opens the possibility to use fuel with a lower octane rating and thus cheaper. Even larger values of cycle efficiency and, consequently, greater fuel savings can be achieved when working on a standard fuel with air moisture by increasing the degree of compression of the mixture to the pressure, as in the ICE cycles without adding water. In this case, the addition of water in an amount of 20% of the weight increase of electric power consumption is about 10-15%.

It should be noted that the added water affects not only the processes occurring in the combustion chamber of the engine and changing environmental performance exhaust gases, but also improves conditions for intensification of heat exchange in heat recovery units CHP. Increasing the concentration of water vapor in the exhaust gases increases the dew point temperature, which allows for more efficient heat transfer in condensation mode and get more heat power cogeneration system. Thus, CHP based ICE working with the addition of water vapor has a higher electrical and thermal power, total efficiency can reach 0.98 at a higher calorific value compared with 0.82 for the existing CHP. Indicator efficiency cogeneration energy on the stage of energy can reach, respectively, k1 = 1,1-1,2 depending on the fuel used and the amount of water added.

The loss of energy in transmission of the consumer can minimize a cogeneration system at the consumers and conduct periodic routine maintenance to detect leaks and energy. As for agriculture, then the location of CHP in the vicinity of the facility ensures the reliability of its energy supply. It is known that power generation facilities located near or fuel supplier or near major consumers of energy produced - large industrial enterprises, cities, etc., which are not objects of AIC. Therefore, while thermal or electrical energy reaches the consumer, some of it is lost - and the greater the distance, the greater the loss. Rational distance, for example, the provider of thermal energy in the form of hot water to the consumer by the national data does not exceed 10 km, and the recommendations of foreign experts - should not exceed 1 km. In Ukraine heat losses during transportation make up 10-25% depending on the length of heating. Under these conditions, most of the potential heat consumers in agriculture forced to use the heat generated in local boiler units with significantly lower fuel efficiency than using CHP. Of the total amount of gas consumed energy in Ukraine, about two-thirds is spent in the district boiler to produce heat only. As for electricity, the power supply of this type of remote settlement depends not only on local losses in overcoming the distance to the consumer (10%), but also from adverse weather conditions that may substantially affect the reliability of power and sometimes leave town point entirely without electricity in some cases absolutely unacceptable - for example, in hospitals or in any industries with continuous power supply. Under these conditions, energy independence and self-sufficiency remote object AIC can be achieved using the method of cogeneration energy production in the facility or in the immediate vicinity using mainly local fuels. This indicator efficiency cogeneration energy on stage transportation of energy compared to the energy supply from CHP cogeneration will be k2 = 1,1-1,25.

A necessary condition for efficient cogeneration power generating capacity are agreeing CHP and energy needs of the consumer in order to maximize the use of energy produced. Given the fact that excess electricity generated in CHP in power in Ukraine adopted a law on cogeneration, can be directed to a single power grid and excess thermal energy generated in CHP - released into the environment and lost most promising consider adjusting capacity CHP and heat energy for consumers. With this kind of coordination capacity CHPs are regulated so that it produced thermal energy corresponding to the thermal needs of the consumer. As for electricity, the relationship CHP with a single grid can solve issues like excess and lack of electricity to consumers. When using CHP-based ICE CHP capacity can be adjusted according to daily fluctuations in consumption. However, the needs of the consumer's heat at different times of the year differ significantly - for objects APC heat consumption during the heating season increased by 3-4 times compared to unheated period is almost constant power consumption throughout the year. The existing power schemes on the basis of CHP capacity heating during the heating season is due to additional heat capacity that is not an efficient use of primary fuels.

The paper suggests a more efficient cogeneration power circuit (Figure 3), which consists of several CHP units.

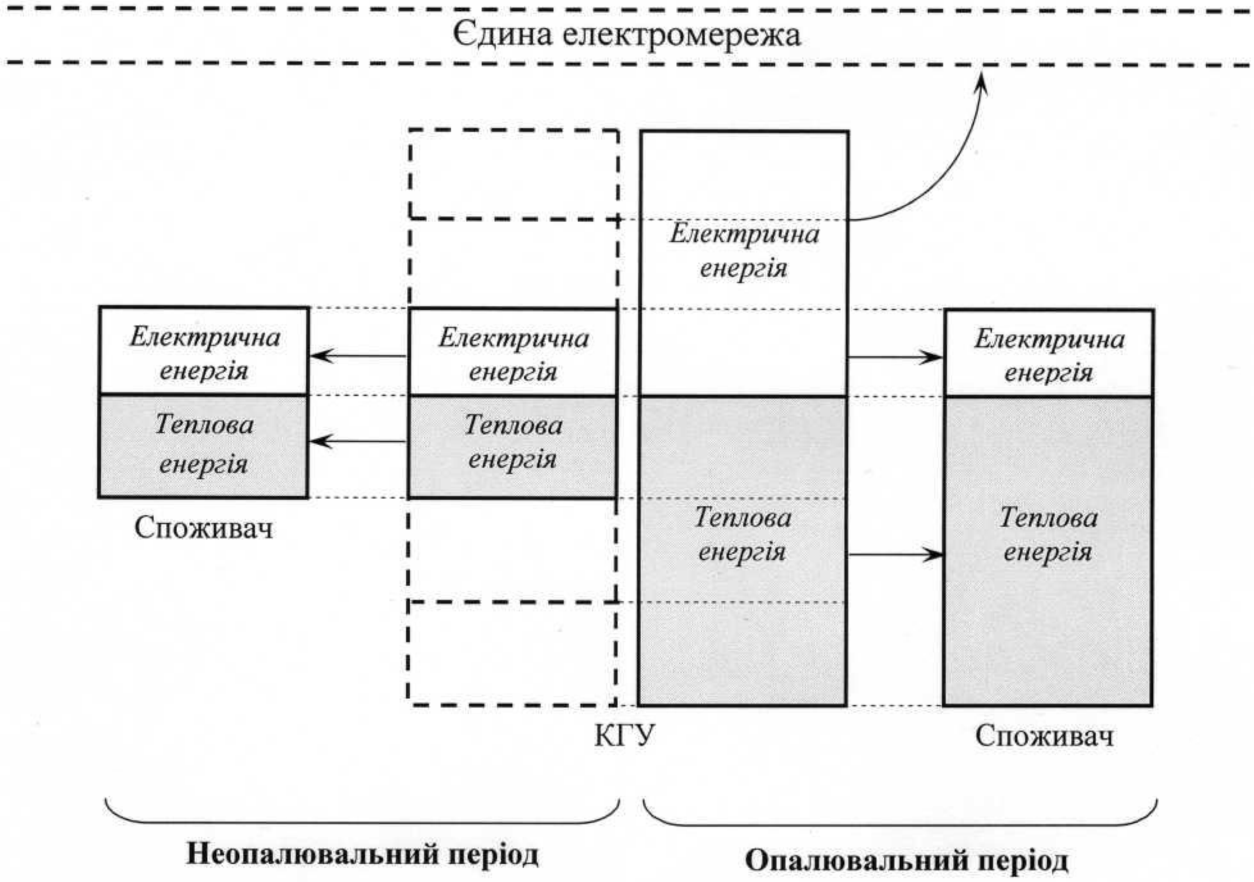

Рис.3. Схема енергопостачання на базі КГУ

Crushing CHP generating capacity allows for year-round supply of consumer energy produced by the CHP, compared with the existing version. Comparison of different schemes cogeneration power possible to confirm the high efficiency of the proposed scheme, which, despite the higher initial cost of the equipment is about the same payback period. This is due to a significant savings in primary fuels (more than 2-fold), resulting in significant reductions in the actual costs and gaining revenue after the payback period of CHP. In addition, the proposed scheme improves the reliability of energy supply and cogeneration allows for routine maintenance of individual units without stopping the entire CHP. Thus, implementation of CHP units consisting of several organization and coordination of appropriate energy consumer needs and opportunities KSU improves the efficiency of cogeneration power several times: k3 = 2-2,3.

Conclusions

Given the performance efficiency at every stage of cogeneration power get a general indicator of increasing its efficiency k = 2,42-3,45. That is due to the measures described above efficiency cogeneration power can be increased several times.