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GEOTHERMAL INVESTIGATION USES A DIPOLE-DIPOLE CONFIGURATION GEOELECTRIC METHODS WITH DELPHI PROGRAMMING

Sandy Vikki Ariyanto
Department of Informatics Engineering*
E-mail: sandy@unira.ac.id
Idon Joni
Department of Informatics Engineering*
E-mail: idon@unira.ac.id
Erwin Prasetyowati
Department of Informatics Engineering*
E-mail: erwinprasetyowati@unira.ac.id
Adi Susilo
Associate Professor
Department of Geophysical Engineering
Brawijaya University
Jl. Mayjen Haryono, 167, Malang, Indonesia, 65145
E-mail: adisusilo@ub.ac.id
Fredy Yunanto
Training and Teaching program*
E-mail: fredyyunanto2@gmail.com
*University of Madura
Jalan Raya Panglegur Km 3.5, Barat, Panglegur, Tlanakan, Kabupaten Pamekasan, Indonesia, 69317

Положення Індонезії, яка розташована на злитті трьох плит (Євразійської, Індо-Австралійської і Тихоокеанської), викликає утворення ряду вулканів в деяких частинах країни і джерел геотермальної енергії навколо вулкана. Геотермальна енергія – це енергія природних ресурсів у вигляді гарячої води або пари, що утворюються в резервуарі всередині землі в результаті нагрівання підземних вод магматичними породами (Team Pertamina, 2010). Геотермальна енергія може використовуватися безпосередньо для сушіння сільськогосподарської продукції, туризму і побутових потреб або опосередковано для приведення в дію електрогенеруючих турбін.

В даному дослідженні, зосередженому на Східній Яві, автор обговорює геотермальний потенціал з використанням геоелектричних методів в нескінченній зоні пожежі для надання інформації в якості одного з відповідей спільноті і уряду, що, як очікується, дасть уявлення про те, наскільки великий геотермальний потенціал при використанні геоелектричного методу в зоні пожежі, яка ніколи не гасилася в Памекасані, Мадура. Довгострокова мета цього дослідження полягає в отриманні енергії нафтового палива в районі Памекасана.

В даному дослідженні використовується геоелектричний метод диполь-дипольної установки за допомогою програми Delphi. Результати цієї програми придатні для оперативних розрахунків при обробці геоелектричних даних. Ця програма оснащена опціями установок Веннера, Шлюмберже, диполь-дипольної і поль-польної, що дозволяє вибрати потрібну установку. Результати даного дослідження – лінія 1, що тягнеться з півночі на південь. Підземна лінія 1 має низький питомий опір 72,3–98 Ом·м. Значення питомої опору цього шару є резервуарним носієм з глибиною 12,8–78,8 метра нижче поверхні грунту. Лінія 2 тягнеться зі сходу на захід. Підземний шар 2 має низький питомий опір 75,5–112 Ом·м. Значення питомої опору цього шару є резервуарним носієм з глибиною 2,5–67,5 метра нижче поверхні грунту. Лінія 3 – це лінія, що йде зі сходу на захід. Підземний шар 3 має низький питомий опір 94,2–110 Ом·м. Значення питомої опору цього шару є резервуарним носієм з глибиною 10,5–24,9 метра нижче рівня землі

Ключові слова: геотермальний, геоелектричний, диполь-дипольний, програмування в Delphi, Памекасан Мадура Індонезія

1. Introduction

Electricity is generated from recyclable energy or energy that cannot be recycled. Energy reserves that cannot be recycled, such as oil and natural gas will increasingly run out. According to [1] using geothermal rather than fossils reduces the greenhouse effect and atmospheric pollution. According to [2] geothermal energy can reduce electricity bills. One of them is the use of geothermal energy to drive the absorption of steam has been accepted by the world [3]. according to [4] Geothermal energy is an alternative and useful way to increase the energy crisis. According to [5] the US, Indonesia, Iceland, and New Zealand are enthusiastic countries to increase geothermal energy. According to [6]. It is very important for the country to look for the availability of geothermal resources. For the Indonesian government committed in 2025 the use of EBT is 25 %, among the EBT targeted by the government is *geothermal* which is targeted at 10 %. Estimating the potential for electrical energy that can be produced for at least 20 years.

The non-volcanic system is a geothermal system not included in the quaternary volcanic pathway [7]. The *geothermal* system is which *hydrothermal* is hot water and heating rock. Heating rock serves as a source for heating water, the rock is in the form of granite rock, clay rock if non-volcanic and other batholite rocks. There are three types of geothermal temperature is a high temperature of 61–100 °C, a

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medium temperature of 41–60 °C and a low temperature of 25–40 °C [8].

One of the geothermal prospect areas in East Java is Pamekasan district on the island of Madura. Madura Island has 4 regencies, namely Bangkalan, Sampang, Pamekasan and Sumenep. For Pamekasan regency there is a natural fire tour that never goes out. Travel distance from the city of Pamekasan towards the south 4 kilometers. This geothermal location was identified because the presence of fire never died and the emergence of hot springs. Even though this hot spring has already been around for 10 years or not.

To find out the magnitude of the geothermal potential, it is necessary to conduct research around hot springs and sources of fire on the surface of the land on a fire tour that never goes out. Therefore, specialized research is the making of data processing programs when data collection in the field produces resistivity values, datum points and layers, all of this data is stored in the format .dat.

2. Literature review and problem statement

The first problem we took was to look for geothermal potential in the country of Indonesia, in Indonesia there are several potentially geothermal regions, because the country of Indonesia is surrounded by active use. At present, Indonesia is pursuing a target for the construction of steam power plants. Indonesia's target country is that in 2040 the transition from power plants uses coal to power plants using steam. so that the Indonesian state instructed all researchers in Indonesia to examine the potential of the area that produces steam to be used as a steam power plant.

According to [9] recent exploration efforts focusing on unconventional geothermal systems that target greater depths to reach adequate temperatures. According to [10] Electricity production from geothermal power plants with almost 12.8 GWe can take place in 26 countries, and by the end of 2014 reached 73,700 GWh. This is still only 0.31 % of all electricity produced in the world, and it will be interesting to monitor the future share. From this statement, so we decided to look for geothermal sources as electricity production for Indonesia, especially in poverty.

At present there are no other researchers who conducted research on fire tourism which has never been exhausted, so we researched this place to conduct an initial study with the aim of determining the potential of geothermal energy in the past. why did we take this place, because this place has issued a fire where this fire has never been extinguished so the idea to do research in this place appeared.

The initial characteristics which show that in this region have geothermal potential are the presence of geothermal manifestations on the surface. According to [11] the most important indication of geothermal resources is the presence of surface manifestations. According to [12] the physical mechanism of determining the distribution of the initial composition in the reservoir volume from the Vuktylskoye field requires further analysis. From this statement, hot springs are the easiest sign to determine the geothermal system that is transferred to the surface. In wisata api tak kunjung padam pamekasan madura, in 2005 there was hot water, but in 2018 hot water became a fire, the appearance of the fire was caused by very strong subsurface activity.

The second problem is the selection of geophysical methods that are suitable for determining geothermal carrier rock types. Until now, there are still many studies that examine suitable and accurate methods for exploiting geothermal energy.

According to [13] we often experience difficulties in exploiting geothermal energy, which is associated with additional costs and reduce investment efficiency. According to [14] Model intrusion also contribute to the flow pattern of the mass flux of water from the reservoir to the surface as the zone upflow (ie manifestation hot water Sileri and zone outflow disposed to wards the south and the north. According to [15] information on an ongoing basis on the condition of thermodynamic soil layer will provide complex which is reliable for operational forecasting of natural geophysical disasters.

According to 3 information obtained continuously regarding the thermodynamic conditions of the soil layer, it will provide a reliable complex for the operational forecast of natural geophysical disasters. From this statement, according to us, the integrated geophysical method is very suitable for determining geothermal potential at a relatively cheaper cost, one of which is the geoelectric method, this method allows to predict geothermal carrier rock types. Most of the researchers we found used the geoelectric method using Wenner and Schlumberger configurations to determine geothermal potential, but the data produced was not optimal. Therefore we use the geoelectric method using a dipole-dipole configuration. This configuration is very suitable for determining geothermal potential because this configuration can see in detail.

The problem when processing geoelectric data with dipole-dipole configuration takes a long time, so we make a geoelectric data calculation program using delphi programming.

The Delphi program draws wide attention because this method is simple and reliable. Delphi is a third generation Pascal language and is also known as a strict type of language. this program can produce consistent and reliable programming to create various applications. According to [16] the results of the Delphi program simulation show the effectiveness of the improved method. According to [17] collaborations between computer scientists and geophysicists needed to solve geothermal problems. According to [18] 2D inversion of MT data on regional geological results and seismic images can be seen clearly. According to [19] the Delphi method was designed for qualitative predictions. The description of the research above in Delphi programming is very effective to be improved and designed for qualitative predictions. Therefore we use Delphi programming to create a geoelectric data processing program.

3. The aim and objectives of the study

The aim of the study is to determine the potential of geothermal energy in wisata api tak kunjung padam pamekasan Madura using geoelectric method. Determining the type of carrier rock geothermal in wisata api tak kunjung padam pamekasan Madura and create a geoelectric calculation program using Wenner, Schlumberger, dipole-dipole, and pole-pole configurations to shorten processing time.

To achieve this goal, the following objectives are achieved:

1. The research team analyzed in Api Tak Kunjung Padam Pamekasan Madura the initial survey, this is important because in geothermal research requires considerable resources.

2. The research team examined the geothermal carrier rock types at Api Tak Kunjung Padam Pamekasan Madura.

3. The research team developed a way to calculate geoelectric data by creating a geoelectric calculation program.

4. Research Methods

To achieve all our goals, we determine several methods including the first, we determine the design location of the research, this must be done because for data acquisition must be measured and precisely targeted to geothermal potential points. the second method is the dipole-dipole configuration geoelectric method. the third method is the geoelectric data processing algorithm.

4. 1. Research Location Design

Geoelectric surveys conducted in the fire area have not gone out of Madura. For the acquisition of yellow data, there are 4 tracks. the first track consists of 400 data with a 300-meter path length and 10 meters spacing. The second track consists of 400 data with a 300-meter path length and 10 meters spacing. The third track consists of 400 data with a 300-meter path length and 10 meters spacing (Fig. 1).

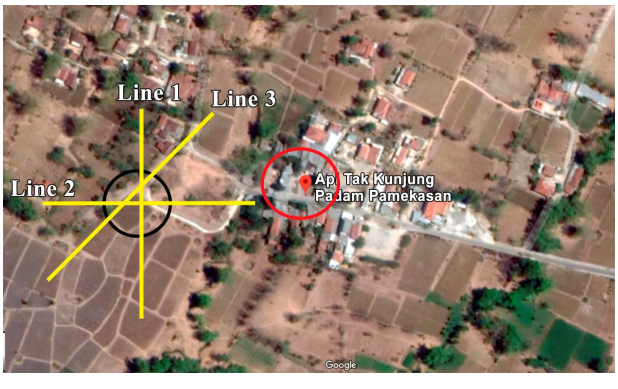

Fig. 1. Research Design: — Research path near hot water that has been lost, — hot water that has been lost, — Location in Api Tak Kunjung Padam Pamekasan Madura (Source: Google Maps)

4. 2. Geoelectric Method Configuras Dipole-dipole

Data acquisition was performed using a Resistivity Meter OYYO type McOhm-EL (Japan). The electrodes used are arranged based on the dipole-dipole configuration in Fig. 2 with C2 and C1 as currents while P2 and P1 are potential The measured parameters obtained in the data acquisition process include the injection current value, potential difference, resistance and distance between electrodes. In addition, the GPS coordinates of each datum are also determined on each acquisition line. The position of the coordinates will be used in data processing and 2D modeling.

The parameters that have been obtained from data acquisition are continued to the data processing stage. According to [20] this data processing aims to determine the apparent resistivity value with ρ=apparent resistivity (ohm·m), *K*=geometry factor, *V*=potential difference (volt), *I*=current strength (ampere).

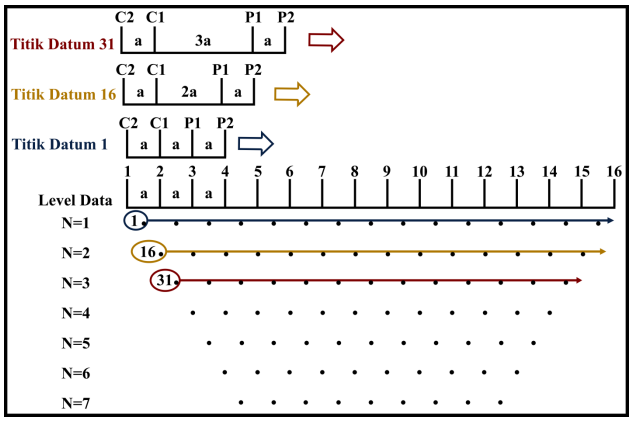

Fig. 2. Dipole-dipole configuration (Source: Program)

4. 3. Geoelectric Program Algorithm

Formulation of mathematical models on Geoelectric programming through three stages, namely:

a) determine mathematical variables into the program;

b) calculate the input of mathematical variables into the formula of the geoelectric method with the configuration of Wenner, Schlumberger, Dipole-Dipole and Pole-Pole;

c) specify the format save with the file format .dat. In general, the geoelectric programming mathematical formula model [1–8], can be defined as:

1. Wenner Configuration Geoelectric Method (1), (2)

$$k = 2 \times \pi \times S, \tag{1}$$

$$Rho = \frac{k \times V}{i}, \tag{2}$$

2. Schlumberger Configuration Geoelectric Method (3), (4)

$$k = \frac{\pi\left(S^2 - B^2\right)}{2 \times B}, \tag{3}$$

$$Rho = \frac{k \times V}{i}. \tag{4}$$

3. Dipole-dipole Configuration Geoelectric Method (5), (6)

$$k = \pi \times N \times (N+1) \times (N+2) \times A, \tag{5}$$

$$Rho = \frac{k \times V}{i}. \tag{6}$$

4. Pole-Pole Configuration Geoelectric Method (7), (8)

$$k = 2 \times \pi \times A, \tag{7}$$

$$Rho = \frac{k \times V}{i}. \tag{8}$$

5. Research Results of Program and Analog

Comparison of the results of the Program with different Analog calculation results, on line 1 using the Program

produces a 15.1 % error (Fig. 3) while the Analog produces an error of 42.6 % (Fig. 4). On line 2 using the Program produces a 14.4 % error (Fig. 5) while the Analog produces a 45.4 % error (Fig. 6). On line 3 which uses the Program produces an error of 7.8 % (Fig. 7) while the Analog produces an error of 59.7 % (Fig. 8).

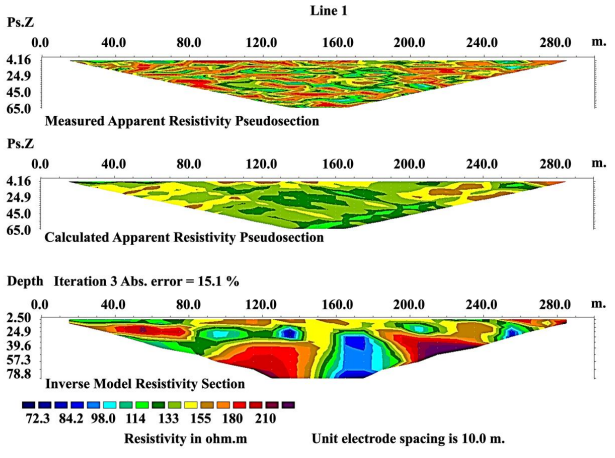

Fig. 3. Program Calculation Results Line 1

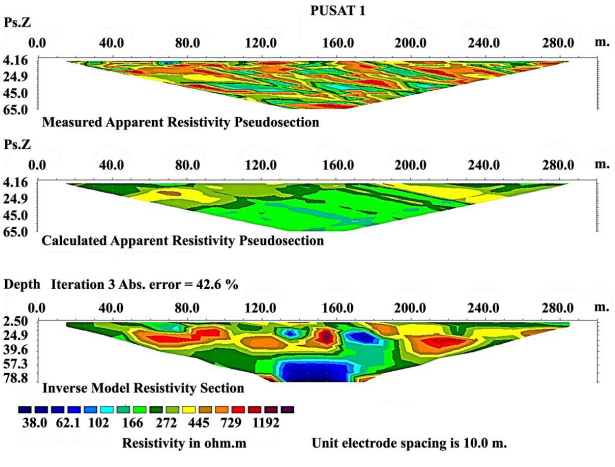

Fig. 4. Analog Calculation Results Line 1

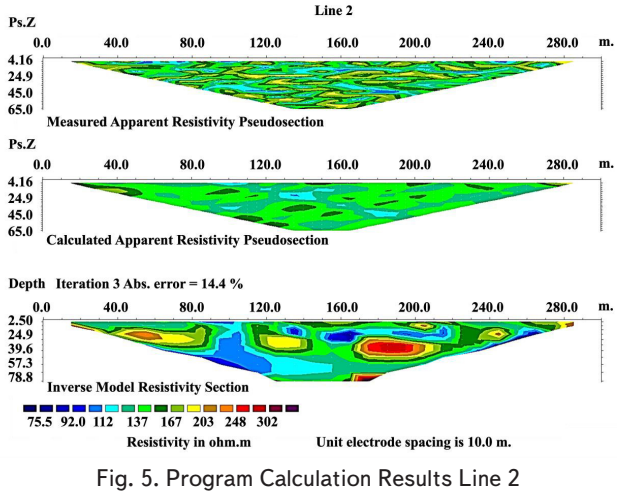

Fig. 5. Program Calculation Results Line 2

Inversion of data using Res2div produces resistivity distribution data of the subsurface layer of the study area. Fig. 2 shows the results of three lines that are in region 1. All three lines have a track length of 300 m with 4 layers in the form of clay rock, sandstone, quartz, and conglomerate. According to stone Telford the value of rho clay stone between 20 Ωm to 200 Ωm, sandstone 50 Ωm to 500 Ωm, quartz 20 Ωm to 2000 Ωm. According to [21] the conductor layer 40 Ωm is a type of clay rock and sandstone. According to [22] based on its analysis sandstone is a reservoir formation in Mamuniyat. this model is a resistive zone ~100 meters in the conductive material of a geothermal system [23]. According to [24] it is divided into 3 geothermal parts, namely bedrock (≤32 Ωm), reservoir area (>32–512 Ωm), and the heat source (>512 Ωm). According to [25] Geothermal is in clay minerals due to hydrothermal changes during several tectonic events. The results of several researchers from various worlds can we conclude that the material of geothermal carrier conductivity is sandstone and clay. The results of this conclusion are the same as the results of the study that the carrier of geothermal material in this area is sandstone and clay with rho values of around 70–100 Ωm (Fig. 3 to Fig. 8).

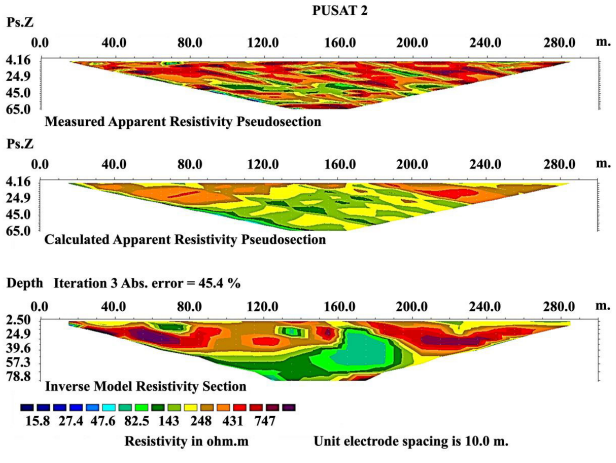

Fig. 6. Analog Calculation Results Line 2

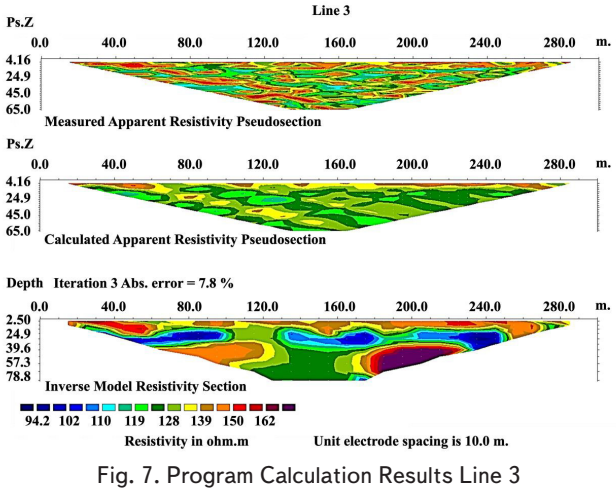

Fig. 7. Program Calculation Results Line 3

The central line 1 is a line that runs from North to South. the line is a subsurface that has a low resistivity of 72.3 Ωm to 98 Ωm is a reservoir carrier. This layer consists of 5 shapes of different sizes. This layer is located at a depth of 12.8 meters to 78.8 meters below ground level. The third layer is the strongest and longest reservoir with a depth of 12.8 meters to 78.8 meters below ground level. The third layer is located underneath the hot water which is now cold water (Fig. 3).

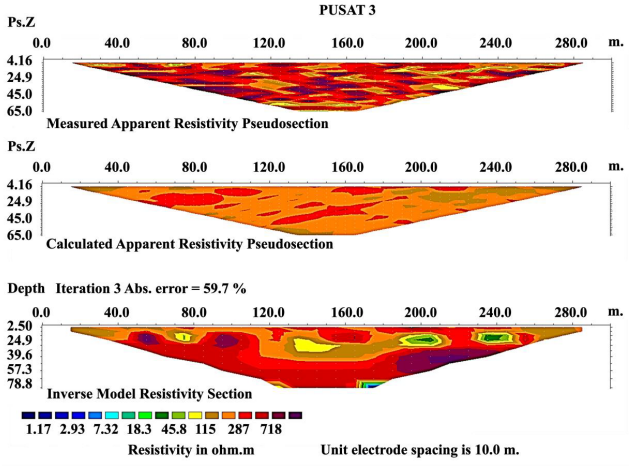

Fig. 8. Analog Calculation Results Line 3

The central line 2 is a line that runs east to west. This line has 4 layers in the form of clay rock, sandstone, quartz, and conglomerate. The subsurface which has a low resistivity of 75.5 meters to 112 Ωm is a reservoir carrier. This layer consists of 3 shapes of different sizes. This layer is located at a depth of 2.5 meters to 67.5 meters below ground level. The 1st layer is the strongest and longest reservoir with a depth of 2.5 meters to 67.5 meters below ground level (Fig. 5).

The central line 3 is a line that stretches from the east to west direction. This line has 4 layers in the form of clay rock, sandstone, quartz, and conglomerate. The subsurface which has a low resistivity is 94.2 meters to 110 Ωm which is a reservoir carrier. This layer consists of 3 shapes of different sizes. This layer is located at a depth of 10.5 meters to 24.9 meters below ground level. The second layer is the strongest and longest reservoir with a depth of 2.5 meters to 67.5 meters below ground level (Fig. 7).

According to the geothermal gradient theory, the deeper the center of the earth, the higher the temperature. Likewise with the hydrothermal principle which should be getting lower the water resistivity value gets smaller because the water conductivity gets bigger. This indicates that in the zones in the three lines there is a superficial surface subsurface fluid source. At Line 1 a distance of about 160 meters and Line 2 a distance of about 95 meters the rho value is measured to be very small and resistive.

Quantitative interpretation is used to determine the parameters of an object so that the depth and angle of polarization can be obtained. The presence of hot springs in the hydrothermal area of the fire is not extinguished accompanied by the appearance of fire around hot water is an indication of the possibility of a geothermal system. Changes in reservoir rock physics such as porosity and permeability can occur due to hydrothermal alteration, while the effect of hydrothermal alteration is decreasing porosity. The characteristics and abundance of hydrothermal minerals formed during fluid and rock interactions depend on several factors, especially temperature, fluid composition (pH), fluid availability (permeability zone) and boiling temperature. Identification that has been carried out in this area includes the temperature of hot water that has become cold water measured at the ground surface ranging from 35 °C. The identification of the appearance of fire (on the surface) about 20 meters from the measured hot water area ranges from 80 °C to 90 °C.

6. Discussion of the research results of determine the potential of geothermal energy using geoelectric method

From the results of our study, we use the geoelectrical method that the fire tourism spot is never potentially geothermal. For geothermal carrier rock in the form of sandstone and clay. This geothermal carrier rock has a rho value of around 70–100 Ωm with a depth of about 20 meters. The results of our study compared with the results of other studies are geothermal carrier rock in the form of sandstone and clay but the difference is the position of depth, in other studies what position is at 70 meters more.

For the results of making the program that we named the geoelectric processing program is very accurate. and this program is very short to work on processing geoelectric data. There are still no researchers making geoelectric processing programs. so the making of this geoelectric program is still new. In the results of trial data processing in the field this program is suitable, because this program uses a combination of data calculation and data loading into res2div and formatting data into type .dat files, with this advantage we can take the time to process data and load data to res2div so that it is easy to process and present geoelectric data. With this program, we can reduce the time needed to process data and achieve data. this program is equipped with Wenner, Schlumberger, dipole-dipole and pole configuration options so that we can choose the configuration we need. However, this program still needs further development, including that there is still no data inversion from this program, so we hope for the researchers to continue the programming that we made.

The development of research in our place for the future is to map the zones that have geothermal energy potential in the Tlanakan District by using Clustering techniques, to provide a more accurate analysis of the distribution or mapping of the potential of geothermal energy into three clusters, namely High, Medium and Low. This method is very suitable for developing research because this method can separate low, medium and even high geothermal potential.

The results *of the output* program are similar to the calculations using Excel, for more efficient use of the program. Comparison of working time using the program with Excel is the program user takes 11 minutes 52 seconds and the Excel user takes 4 hours 5 minutes 16 seconds.

The special feature of making this program is the combination of the Wenner configuration, Schlumberger, dipole-dipole. The benefit of this feature is being able to choose the desired configuration during research in the field. The advantage of this research compared to analog is that the processing is more efficient. The limitation of this study lies in the part of the research work in the field which uses a configuration that is a dipole-dipole configuration.

7. Conclusion

1. The program results using Delphi programming that we made are very useful for the process of calculating the geoelectric method, with this program we can maximize our research and the results of our program are very accurate with an error rate of 4 % to 7 %. With our program, research work is very fast. The combination of the 2 sciences that we are working on, namely geophysical science (geoelectric method) and informatics engineering is very suitable to determine the position of geothermal potential.

2. The results of the dipole-dipole geoelectric configuration method are very suitable for determining geothermal potential, in our study indicated geothermal potential by using this method, in wisata api tak kunjung padam pamekasan madura Geothermal potential is Line 1 produced a Rho value of 72 to 98 with a depth of 12,8 meters; Line 2 produces a Rho value of 75 Ω to 115 Ω with a depth of 2,5 meters and Line 3 produces a Rho value of 94 Ω to 110 Ω with a depth of 10,5 meters.

3. The results of our research in wisata api tak kunjung padam pamekasan madura for geothermal carrier rock are sandstone and clay.

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Етанол є прийнятною заміною бензинового палива в двигунах з іскровим запалюванням. Етанол має високе октанове число, що дозволяє використовувати його при більш високому ступені стиснення двигуна. Перш ніж широко використовувати етанол в двигуні з іскровим запалюванням, необхідно краще зрозуміти характеристики його згоряння. Одним з найважливіших параметрів заміщуючого палива є швидкість горіння. Тому метою дослідження є експериментальне вивчення впливу додавання невеликої кількості зріджених вуглеводневих газів (ЗВГ) на швидкість ламінарного горіння водного етанолу. Характеристика горіння суміші етанолу і ЗВГ досліджувалася в циліндричної камері згоряння діаметром 10,8 см і довжиною 17 см. Полум'я мало сферично розширювану форму. Паливна суміш запалювалась іскрами всередині циліндра, а діаметр полум'я вимірювали по зображенню полум'я, отриманого високошвидкісною камерою. У дослідженні використовувалися два типи паливного етанолу, безводний етанол і водний етанол, що містить 0,3 % води. Частка ЗВГ в паливній суміші варіювалася від 0 % до 20 %. Результати показали, що додавання 10 % ЗВГ в етанол збільшує швидкість ламінарного горіння. Для безводного палива швидкість горіння етанолу вище, ніж для ЗВГ, а найвища швидкість горіння у етанолу, в який додано 10 % ЗВГ, найнижча – у ЗВГ. Крім того, вміст води в паливному етанолі призводить до значного зниження швидкості горіння. Однак додавання до 10 % ЗВГ робить водний етанол відносно більш стійким до підвищеного вмісту води за рахунок того, що реакції горіння сприяє більш висока концентрація радикалів в ЗВГ. Це обумовлено двома факторами: зоною часткового попереднього нагрівання, викликаного гідроксильною групою (OH) етанолу, яка поставляє більше теплової енергії, і високою концентрацією радикалів в ЗВГ, що сприяє реакції горіння

Ключові слова: водний етанол, зріджені вуглеводневі гази, циліндрична камера, швидкість ламінарного горіння

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ROLE OF SMALL ADDITION OF LIQUEFIED PETROLEUM GAS (LPG) ON LAMINAR BURNING VELOCITY OF HYDROUS ETHANOL

Muh Nurkoyim Kustanto
Doctoral Student in Mechanical Engineering*
E-mail: andisanata@unej.ac.id
Mega Nur Sasongko
Doctorate in Mechanical Engineering*
E-mail: megasasongko@ub.ac.id
I. N. G. Wardana
Professor in Mechanical Engineering*
E-mail: wardana@ub.ac.id
Lilis Yuliati
Doctorate in Mechanical Engineering*
E-mail: lilis_y@ub.ac.id
*Department of Mechanical Engineering
Brawijaya University
Jl. Mayjen Haryono, 167, Malang, Indonesia, 65145

1. Introduction

Fossil fuels are used in large numbers and rapidly increasing while reserves continue to decline, and some day will be depleted. Bioethanol is an appropriate replacement candidate, especially in terms of availability of raw materials and environmentally friendly emissions [1–3]. The advantage of ethanol as a replacement fuel is that it can be produced from renewable energy sources such as sugarcane, cassava, waste biomass materials, and corn. The combustion of ethanol has a lower emission than fossil fuels to reduce environmental pollution and greenhouse emissions. Currently, ethanol fuel is to be the focus research on internal combustion engine research. It could be a blended fuel in gasoline and diesel engines. The greatest advantage of Ethanol as a renewable fuel of spark ignition engines compared to gasoline fuel is an excellent anti-knock property, even the octane number exceeds 100. The high-octane number of ethanol allows it to be designed in the engine with a higher compression ratio [4].

Fundamental combustion properties of ethanol should be examined before its use on the engine. One of the key parameters which is an essential characteristic of fuel on the engine is the laminar burning velocity of ethanol. The measurement of laminar burning velocity describes how fast the flame propagates into the reactant mixture ahead of the flame at a specified pressure and temperature [5]. By the