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ROLE OF WASTE COOKING OIL ON PERFORMANCE OF DESILE ENGINE EXHAUST EMISSION

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ABSTRACT

This report gives us detail study on Artificial Neural Network (ANN) modeling of a diesel engine using waste cooking biodiesel fuel to know the brake power, torque, specific fuel consumption and exhaust emissions of the engine. To get data for training and testing the proposed ANN, a two cylinder four-stroke diesel engine was fueled with waste vegetable cooking biodiesel and diesel fuel blends and operated at variable engine speed. The properties of biodiesel generated from waste vegetable oil was measured based on ASTM standards. The experimental results showed that blends of waste vegetable oil methyl ester with diesel fuel provide better engine performance and improved emission characteristics. Using some of the experimental data for training, an ANN model was developed based on standard Back-Propagation algorithm for the engine. Multi-layer perception network (MLP) was used for non- linear mapping between the input and output parameters. Various activation functions and several rules were used to get the percentage error between the desired and the predicted values. It was seen that the ANN model can anticipate the engine performance and exhaust emissions quite well with correlation coefficient (R) 0.9487, 0.999, 0.929 and 0.999 for the engine torque, SFC, CO and HC emissions, respectively. The prediction Mean Square Error (MSE), the error was between the desired outputs as measured values and the assumed values were obtained as 0.0004 by the model. This paper also shows the development of Biodiesel fuels in this case Waste Cooking Oil in performance of Diesel engine and also different industries. The application of biodiesel in automobile industry, the challenges of biodiesel industry development and the biodiesel policy are discussed as well. This paper also shows the effectivity of Biodiesel fuel use in diesel engine and the difference in performance of engine.

KEYWORDS: BMEP, MSE, MLP, ASTM, ANN, SFC, EGT, Hydrocarbons, Particulate Matter, Continental Diesel, Oxides Of Sulphur, Oxides Of Nitrogen.

INTRODUCTION

Rudolf Diesel invented diesel engine in 1892 and received the patent on 1893. He originally developed his engine to work on unrefined biodiesel. In 1930s and 1940s vegetable oils were used as diesel fuels, but only in critical situations.

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Alternative fuels for diesel engines are having increasingly important due to finishing petroleum reserves and the environmental consequences of exhaust gases from petroleum fueled engines. A number of studies have given results that triglycerides hold assurance as alternative diesel engine fuels. So, many countries are showing interest in alternative fuels. For example, assessment of the production of biodiesel in Europe since 1992 shows an increasing trend. In this Waste vegetable oil-methyl ester is a biodiesel. Biodiesel is defined as the mono alkyl esters of long chain fatty acids derived from renewable lipid sources. Biodiesel is commonly produced through the reaction of a vegetable oil or animal fat with methanol in the existence of a catalyst to get output glycerin and methyl esters. The blend of 75:25 ester/diesel (B25) gave the fine achievement. Among the attractive features of biodiesel fuel are:

It is produced from plant and not petroleum-derived, and as such its combustion does not boost current net atmospheric levels of CO2 which is a "Greenhouse Gas";(ii)It can be domestically produced, contribute to the probability of reducing petroleum imports;(iii)It is biodegradable;(iv)Corresponding to current diesel fuel, its combustion products have been decreased to lower levels of particulates which are carbon monoxide and to some extent nitrogen oxides. It is nicely established that biodiesel allows a substantial reduction in SOx emissions and appreciable reductions in CO, Hydrocarbons, Soot, and Particulate Matter (PM). There is a little bit rise in NOx emissions, which can be certainly altered by delay of the injection timing in engines. Artificial neural networks (ANN) are used to solve a different variety of problems in science and engineering, specifically some of the areas have failed in conventional modelling methods. A well-functioning ANN can be used for specific application as an anticipating model, such as data-processing system activated by biological neural system. The anticipating ability of an ANN results from the coaching on experimental data and then validating the result by autonomous data. An ANN can improve itself by re-learning from the new data it is given. An ANN model has taken multiple input variables to get multiple output.

It can be altered from regular modelling access in its ability to learn about the system that can be shaped/ formed without having previous knowledge about the process of relationships. The predicting by a well-trained ANN is basically much quick than the regular simulation programs or mathematical models as no drawn-out repetitive calculations are needed to determine differential equations by using numerical methods but the selection of a proper neural network topology is important in terms of model accuracy and model directness. It is also possible to add or remove the input & output data in the ANN if it is required. The main aim of this study was to produce a neural network model to anticipate engine parameters which are emission, fuel consumption and torque using biodiesel.

OBJECTIVE

The main objective of this study is to investigate and have review of performance of Diesel engine operated by using Waste cooking oil as fuel.

The objective also is to investigate ANN method used for reduction of NOx emissions from the Diesel engine without increase in smoke emission and to check the change in its performance.

This study consists: -

- Biodiesel production and how it is used to check the parameters of the CI engine (Diesel Engine).
- Studying the parameters such as engine torque and emission of different exhaust gases to be tested. Comparison of performance and emissions of biodiesel-diesel fuel blends with diesel fuel.
- Determining the effect of injection timing

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and its pressure on emission & combustion parameters such as ignition delay, combustion time, emission gases released.

- Anticipating the performance and emission parameters of diesel engine fueled waste cooking oil fuel using Artificial Neural Network (ANN) trained with experimentally performance and emission parameters.

LITERATURE REVIEW

H. Sanli paper gave details about properties of fuel of ethyl ester met with the EN14214 diesel standard showing fuel quality obtain from ethanolysis. Brake specific fuel consumptions & thermal efficiencies of Ester fuels is high than petroleum-based diesel fuels. They give better results. CO, HC are emitted less but more NOx is emitted from Ester fuels. Emissions of CO2 test fuels are close to each other. The more comprehensive and intense studies on the ethyl ester usage should be performed by using diesel engines equipped with electronically-controlled fuel injection system (Common-Rail), especially for eliminating the advance injection timing and higher injection pressure effects of biodiesel fuels.

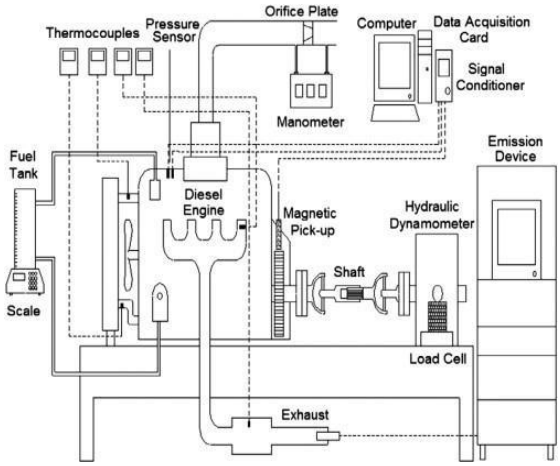

Figure 1.Schematic view of the experimental setup

Ozer Can gave details about the characterization of combustion, performance and exhaust emission behaviors of a diesel engine fueled with waste cooking oil biodiesel blends (5% and 10% in vol) were investigated in this study. The experiments were performed on four different types of engine loads (BMEP, 0.48 Mpa, 0.36 Mpa, 0.24 Mpa and 0.12 Mpa) and 2200 rpm engine speed. The results are observed as: -

1. The biodiesel addition to the No. 2 diesel fuel iteratively caused early SOC timing with combination of early SOI timing and shorter.
2. CD generally raised with biodiesel additions for the all engine loads.
3. Pmax did not vary remarkably with the biodiesel addition for the all engine loads, where as its locations were little bit changed away from TDC except at full load. Pmax values decreased between medium & high. 4) Nox emissions raised up to 8.7% whereas smoke emissions decreased with the biodiesel additions for the all engines.

Ali M.A. Attia paper gives details about the present work which is aiming to generate biodiesel from waste cooking oil at high economic efficiency. Then the received biodiesel has been blended with proper diesel fuel at different blending ratios. The fuel blends are supplied to engine test facility to observe the effect of blending ratio of mechanical engine and environmental performance as well as on the in-cylinder indicator.

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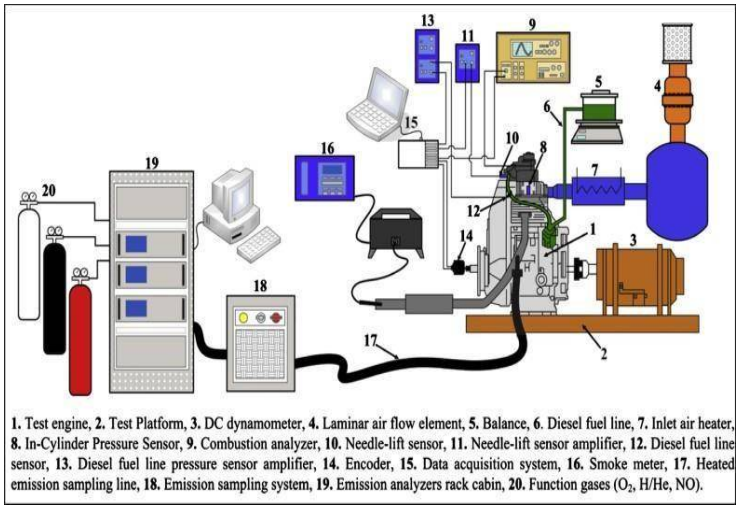

Figure 2.Experimental test rig setup

M. Majifur & Mohammad Rasul has given us details on biodiesel obtained from waste cooking oil represents a sustainable source of energy to be used in diesel engines. The following results could be drawn according to this study: The use of waste cooking oil biodiesel in diesel engine favors reducing the 28.30 % of CO emission compared to the diesel fuel. Such a tendency is attributed to the higher oxygen content and lower carbon to hydrogen ratio compared with diesel fuel. The PM emission for waste cooking oil biodiesel blend is decreased to a large extent compared to diesel fuel. The reduction is mainly due to the higher oxygen and lowers aromatic compounds present.

Figure 3.Engine test bed set-up

Samet Uslu & Mustafa Bahattin Celik gives us details on how ANN is applied in a diesel engine which is using biodiesel blends to estimate BSFC, EGT, BTE, NOx, HC, CO and smoke emissions in this study. The input data used in the ANN implementation was concluded by experiments. Experimental data show that biodiesel fuels increase BTE and BSFC when considering the engine performance, reducing EGT. In addition, the CO, NOx, HC and smoke emission concentrations were decreased with the use of biodiesel fuel blends. The ANN estimates for performance and emissions of the diesel engine tested provided good statistical performance. The results clearly show that, the anticipated results and the experimental results are close to each other. The results acquired with the ANN model for the experimental study show that the use of ANN for the prediction of BSFC, BTE, EGT and emissions is sufficient.

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An increase of NOx emission in waste cooking oil biodiesel blends was discovered due to the higher combustion temperature, higher cetane number and higher oxygen contents of biodiesel fuel. Finally, it can be concluded that 20% waste cooking oil biodiesel could replace diesel fuel partially to help in decreasing the air pollution to a great extent.

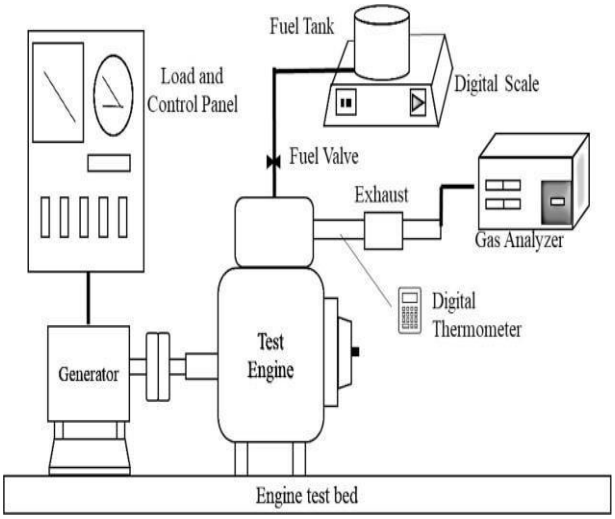

Figure 4.The schematic view of experimental equipment setup.

Therefore, overall review shows that's Biodiesel have become more attractive in present because of its environmental benefits and the fact that they are made from renewable resources. The cost of biodiesel is the main hurdle for commercialization of the product. The used cooking oils are used as raw material in adaption of continuous transesterification process and recovery of high-quality glycerol from biodiesel by- product (glycerol) which are primary options to be consider to lower the cost of biodiesel. The four basic ways to make biodiesel which are direct use and blending, microemulsions, thermal cracking (pyrolysis) and transesterification. The most preferred method used is transesterification of vegetable oils and animal fats. The transesterification reaction is affected by molar ratio of glycerides to alcohol, catalysts, reaction temperature, reaction time and free fatty acids and water content of oils or fats.

The above literatures showed the different experiments and test setups used to operate Diesel engines using Waste cooking Oils which is raw material in Biodiesel. The different parameters were tested and the results were observed and necessary improvements implemented. The literature gives us the rough idea of the uses of Biodiesel in Diesel engine using different methods in which Artificial Neural Network (ANN) is the preferred. This method gives better results when compared with other methods.

EXPERIMENTAL INVESTIGATION

Data reported in this paper shows the results of real experiments which were conducted in the R & D laboratory of Mega Motors Company which is the largest car engine manufacturer and gearbox–axel in Iran. The tests were conducted to test a two cylinder four-stroke diesel engine using various biodiesel-diesel fuel blends. The experiment is divided in two parts which are A) Biodiesel preparation & B) Experimental setup & test procedure.

BIODIESEL PREPARATION

In present examination, biodiesel is produced from waste vegetable cooking oil of a restaurant. It contains 1.8-gram KOH (as Alkali catalyst) & 33.5 cc methanol (as an alcohol) are applied for 120-gram waste vegetable oil in this reaction. Biodiesel production reaction time is 1 h with

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stirring and no heat. Up to one-week time is needed for separation and washing process. The Waste vegetable oil methyl ester is added to diesel fuel in 10 to 50 percent ratios and then used as fuel to examine diesel engine.

EXPERIMENTAL SET-UP & PROCEDURE

The experimental setup contains of a two-cylinder diesel engine, an engine test bed and a gas analyzer. The experimental setup is shown in Figure.

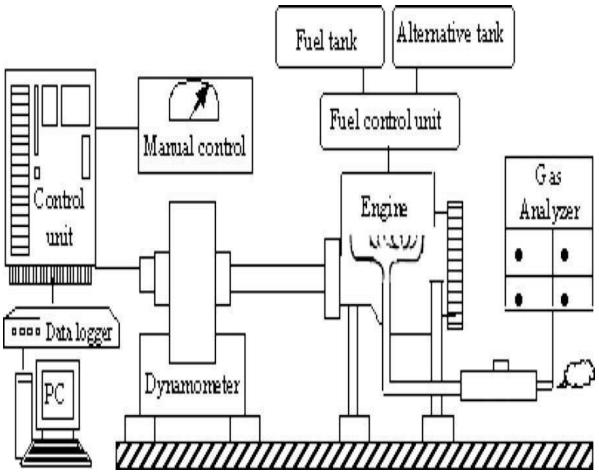

Figure 5.Setup of Experiment

Two fuel tanks are arranged to perform the experiments, one fuel tank contains diesel fuel and the other one contains fuel blends. The engine under examination is a commercial Diesel Engine, water cooled two cylinders, in-line, naturally pursued, RD270 Ruggerini diesel engine.

The main specifications of the engine are as shown-

Engine Type- RD270 Ruggerini diesel engine

- No. of cylinder- Two
- Stroke (in mm)- 85
- Bore (in mm)- 95
- Displacement(cc)-1205
- Compression Ratio- 18.1
- Rated Speed (rpm)- 3000
- Power (hp)- 23.4
- Torque (Nm/rpm)- 97/2300
- Cooling system – Air cooled.

The test engine is coupled to a Schenck W130 electric eddy current dynamometer. A Horiba gas analyzer model MEXA-324 GB is used to measure CO and HC emissions. Engine is run at different speeds at full load. The power, torque, fuel consumption and emissions are measured. The results of experimentation are shown in table.

Table 1.Parameters

Parameters	Levels						
	1	2	3	4	5	6	7
Speed (rpm)	1200	1600	2000	2400	2800	3200	3600
Load (%)	100	–	–	–	–	–	–
Biodiesel[a] (%)	0	10	20	30	40	50	–
Diesel fuel (%)	100	90	80	70	60	50	–

ENGINE EXHAUST EMISSIONS

Biodiesel contains oxygen in its structure. When biodiesel is added to diesel fuel, the oxygen content of fuel blend is increased and thus less oxygen is needed for combustion. However, oxygen content of fuel is the main reason for more complete combustion and hence CO and HC emission reduction. Figures 6 and 7 show the relationship between the fuel blends and CO and HC concentrations respectively. The graphs show the predicted values & measured values ratio.

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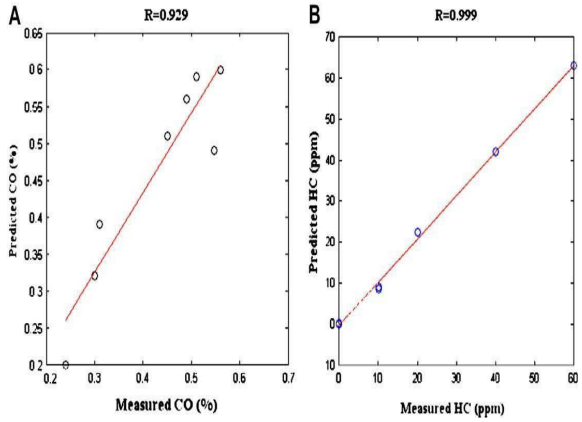

Figure 6.Graphs of CO & HC emissions

ARTIFICIAL NEURAL NETWORK (ANN) DESIGN

The ANN advancement has been applied to anticipate the performance of different thermal systems. The use of ANNs for modelling the operation of internal combustion engines is more present progress. This advance was used to anticipate the engine performance and exhaust emissions of diesel engines and the specific fuel consumption and fuel air equivalence ratio of a diesel engine. The effects of valve-timing in a spark ignition engine are seen on the engine performance and fuel economy was also investigated using ANNs.

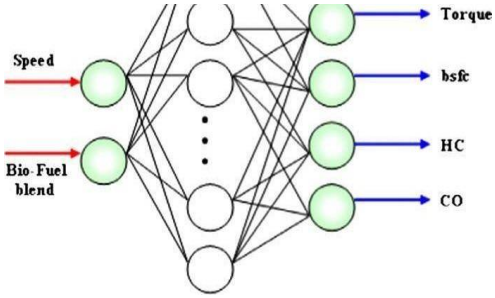

Figure 7.Artificial Neural Network Connections

Basically, a biological neuron receives inputs from various sources, combines them in some way, performs normally a non-linear operation on the result, and then gives the final result. The network commonly consists of an input layer, some hidden layers, and an output layer. A popular algorithm is the back-propagation algorithm, which has deferent possibilities. Back-propagation training algorithms gradient descent and gradient descent with momentum are often too slow for practical problems because they need small learning rates for stable learning. In addition, success in the algorithms depends on the user dependent parameters, learning rate and momentum constant. Faster algorithms such as conjugate gradient, quasi-Newton, and Levenberg–Marquardt (LM) use standard numerical optimization techniques. These algorithms eliminate some of the disadvantages mentioned above. ANN with back-propagation algorithm learns by varying the weights, these changes are stored as knowledge. This algorithm uses the supervised training technique where the network weights and biases are initialized randomly at the starting of the training phase. The error minimization process is gained using a gradient descent rule. There are 2 input and 4 output parameters in the experimental tests. The two input variables are engine speed in rpm and the percentage of biodiesel blending with the conventional diesel fuel.

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Table 2.Properties of Biofuel

Property	Method	Units	Diesel	Biodiesel
Flash point, closed cup	D 93	°C	64	182
Pour point	D 97	°C	0	−3
Kinematical viscosity, 40 °C	D 445	mm^2/s	4.03	4.15
Sulfated ash	D 874	wt. %		0.00
Total Sulfur	D 5453	wt. %	0.0500	0.0018
Copper strip corrosion	D 130	–	1a	1a
Cloud point	D 2500	°C	2	0

BIODIESEL FUEL CHARACTERISTICS & PROPERTIES-

Biodiesel is a safe, non-toxic, biodegradable and renewable fuel which can be easily used in unmodified diesel engine, and a various other application. The viscosity of waste vegetable oil is very high which to directly used as diesel fuel substitute. Transesterification of the waste vegetable oil decreases the viscosity from 31.8 mm2/s to 4 .15mm2/s. This achievement formed the way to use the produced biofuel as diesel engine fuel without any engine modifications. The biodiesel high flash point makes it possible for easy storage and transportation. It should be noted that the diesel fuel flash point is 64oC. The biodiesel sulfur content is another interesting advantage of the produced fuel which is 18 ppm only. Comparing the 18-ppm sulfur content of the produced biodiesel with the 500-ppm sulfur content of the diesel fuel used in Tehran operating diesel vehicles, the advantage of the biodiesel over the diesel fuel in terms of the environmental benefits can be justified. This comparison indicates that the sulfur content of biodiesel produced from the waste vegetable oil in Iran is 28 times lesser than the diesel fuels used in Tehran diesel vehicles. An easy way of reducing the diesel fuel Sulphur content is the biodiesel blend which is the subject matter of an ongoing research work. Fuel properties are mentioned in below table.

NECESSITY OF BIODIESEL

There are 4 main reasons which are as follows: -

COMBATING CLIMATE CHANGE

Combating climate changes forces the world to seek alternative, low carbon of energy & fuels. Since, traffic is one of the largest sources of pollution whose one of the reasons is greenhouse gas i.e. carbon emission, fossil fuels should be substituted with renewable alternatives such as biofuels. Biofuels reduce carbon emission.

RESPONDING TO HIGHER ENERGY CONSUMPTION

The rapid rise in world population, combined with significant economic growth in emerging economics will result in substantial increase in energy consumption. To meet the needs, we must try to use renewable source like biofuels more instead of natural resources which are getting scare.

SECURING ENERGY SUPPLY

Increase energy demands will pose challenge of security of supply as resources are scattered around the world. Biofuels help to enhance & safeguard energy security by reducing use of fossil fuels. Biomass is a resource that is distributed evenly around the world.

MAKING THE MOST OF SCARE RESOURCE

Using waste & residue as raw material for biofuels is an exemplary example of answering to needs of a circular economy. Decreasing the amount of waste & making the most of our valuable natural resources is crucial for the future survival.

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CONCLUSION

An artificial neural network (ANN) was developed and trained with the gathered data of this research work. The results showed that the training algorithm of Back- Propagation are sufficient enough in anticipating engine torque, specific fuel consumption and exhaust gas components for different engine speeds and different fuel blends ratios. It can be concluded that R values are very close to one for torque, SFC, CO and HC, while the MSE error was 0.0004. Examination of the experimental data by the ANN revealed that there is a good correlation between the anticipated data resulted from the ANN and measured ones. Therefore, the ANN proved to be a desirable prediction method in the evaluation of the examined diesel engine parameters. There is also a priority preference in using artificial neural networks, since other mathematical and numerical algorithms might fail due to the complexity and multivariate nature of the problem. Generally speaking, ANN provided accuracy and simplicity in the analysis of the diesel engine performance under test. Thus, ANN was very useful in analyzing the performance of diesel engine using waste cooking oil.

FUTURE SCOPE

As India is deficient in edible oils, non-edible oil is the main choice for producing biodiesel. According to Indian government policy and Indian technology effects, some development works have been carried out with regards to the production of Tran esterified non edible oil and its use in biodiesel by units such as Indian Institute of Science, Bangalore, Tamilnadu Agriculture University Coimbatore and Kumaraguru College of Technology. Indian Oil Corporation has taken up Research and development work to establish the parameters of the production of Tran esterified Jatropha Vegetable oil and use of biodiesel in its R&D center at Faridabad. The railway and Indian oil corporation has successfully used 10% blended biodiesel fuel in train running between Amritsar and New Delhi.

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