HISTORY OF ELECTRIC STARTER DEVELOPMENT FOR INTERNAL COMBUSTION ENGINE START-UP

Tarasov R.D., magister, Tsyvinskyi S.S., Ph.D., associate professor, Geraskin O.A., Ph.D., associate professor
Igor Sikorsky Kyiv Polytechnic Institute, Department of Electromechanics

Introduction. In the modern world, the car has become an integral part of our daily lives, but few people think about what technologies have developed to make cars so convenient and affordable. One of the key innovations that made it easier to use a car was the electric starter. This article is devoted to the history of electric starter development from its first prototypes to modern technologies.

Purpose of the work. The aim of the work is to thoroughly study the history of electric starters for internal combustion engines, to reveal the key points of the emergence and improvement of this important technology, as well as to note its impact on the automotive industry.

The beginning of the journey. Today, starting a car by turning a key or pressing a button is already considered commonplace. However, a hundred years ago, starting a car was not so easy. Before the electric starter, it took a lot of physical effort and a little bit of hope to get going. In those days, starting a car with an internal combustion engine was in many ways similar to starting a lawn mower today. It was not only physically difficult, but also dangerous. Then there were cases of injuries and even deaths of people when trying to start a car.

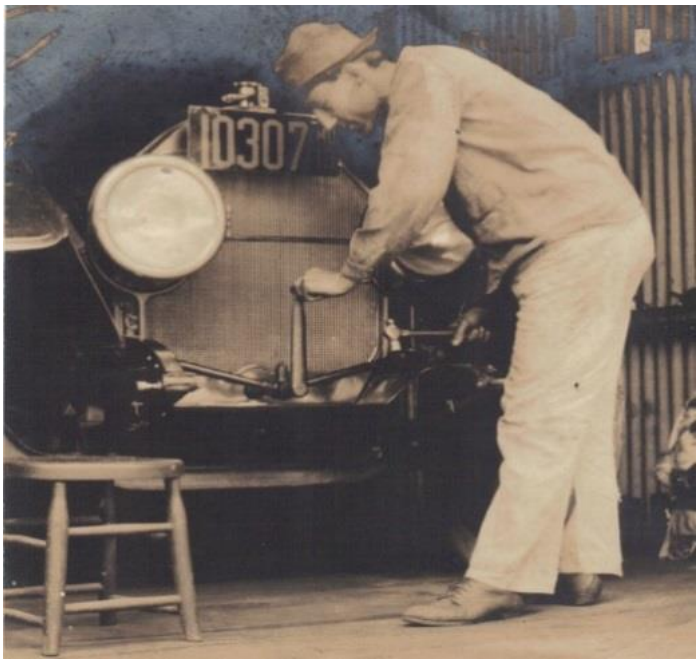

Figure 1 – Internal combustion engine mechanical start

Gradually, cars became more popular, and along with this, there was a need for more convenient and safe engine starting systems. Manual starters were inefficient and unacceptable for many drivers, and these factors prompted engineers to develop new ways to automate this process.

Appearance of the first electric starters. In 1911, Cadillac first introduced a car equipped with an electric starter to the world. This invention simplified the life of drivers by allowing them to start the engine using an electric motor that was activated by pressing a button. This was the first step in the development of automotive technologies aimed at improving the convenience and reliability of driving.

Figure 2 – The first electric starter

This was an unusual system that used four six-volt batteries combined together (24 volts) to power the starter. It also had a rotary switch that, once started, allowed the generator to charge each battery at six volts. In the late 1950s, car electrical systems switched from six volts to 12 volts and have remained so ever since.

In the following decades, electric starter technologies have become much more complex. They received improved security systems, a more reliable connection to the power grid and a longer service life. Modern electric starters can start the engine even at the lowest temperatures, ensuring stable operation of the car in various operating conditions.

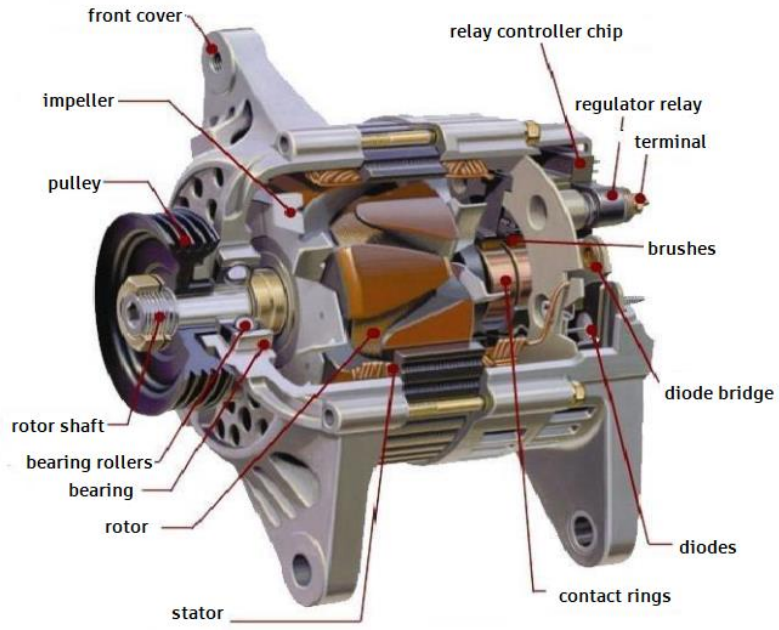

Figure 3 – Car starter

The "start-stop" system. This is a system that detects that a car has stopped and turns off its engine. When the driver wants to start again, the engine automatically restarts so that you can continue driving. That is, the engine starts quickly when the clutch pedal is pressed (in a car with a manual transmission) or when the brake pedal is released (in a car with an automatic transmission). This solution allowed you to:

-reduce fuel consumption,

-reduce carbon dioxide and other exhaust gas emissions,

-increase the engine life.

Starting a cold engine causes a heavy load. However, the warmed-up drive unit is properly lubricated, so subsequent starts are not harmful to it. When the engine is not running, it does not consume fuel and does not emit exhaust gases and does not wear out. Thanks to this technology for gasoline and diesel cars (not electric vehicles). Fuel economy is 5-10 %. The "start-stop" system has an additional task in plug-in hybrid vehicles. In addition to controlling engine operation during shutdown, it is also responsible for the combustion unit when switching drive types between electric and hybrid drive. The system is most effective for vehicles moving around the city, spending a lot of time at traffic lights and in traffic jams.

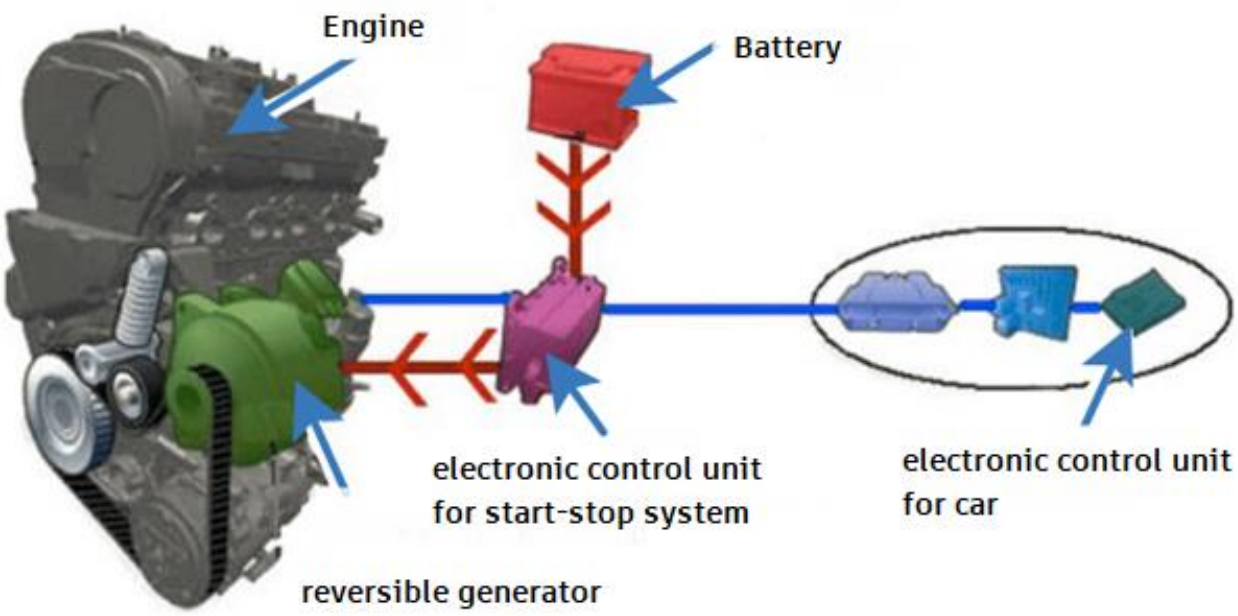

Figure 4 – Start-stop system

1. The vehicle is ready to start and the electronic control unit starts the engine. The reverse generator, having received energy from battery A, starts the engine as a starter.

2. In driving mode (the driver does not intend to brake), the reverse generator operates in the mode of a conventional generator, converting mechanical energy into electrical energy and charging the battery.

3. When the vehicle speed drops to 8 km/h during braking, the StARS system control unit shuts down the engine.

4. After the pedal is released, the StARS control unit gives the command to start

the engine. The power from the battery goes to the reverse generator, and it starts the engine like a normal starter.

5. The ride is over and the control unit shuts down the engine

Starter-generator sets. Currently, combined electromechanical converters-starter-generators are widely used. The use of starter generators on cars can improve a number of characteristics. Replacing two electric machines-a starter and a generator-reduces the weight and dimensions of the unit and its cost. To reduce the emission of harmful substances into the atmosphere during frequent stops in urban traffic conditions, modern cars are equipped with a STOP-START system. Reducing the size of an electric car and the amount of current in the starter mode of operation is achieved by using a starter generator at a voltage higher than the voltage of the on-board network of the car. In this case, two onboard mains voltages are assumed. Communication between two electric energy storage devices and starter-generator control is carried out by an electronic system.

The 42 V non-geared starter-generator with an asynchronous electric machine and a control semiconductor module, designed by Continental and BMW AG, develops a maximum starting torque of 200 Nm in the starter mode of operation and a maximum power in the generator mode of operation of 2 kW at 14 V and 2.2 kW at 42 V.

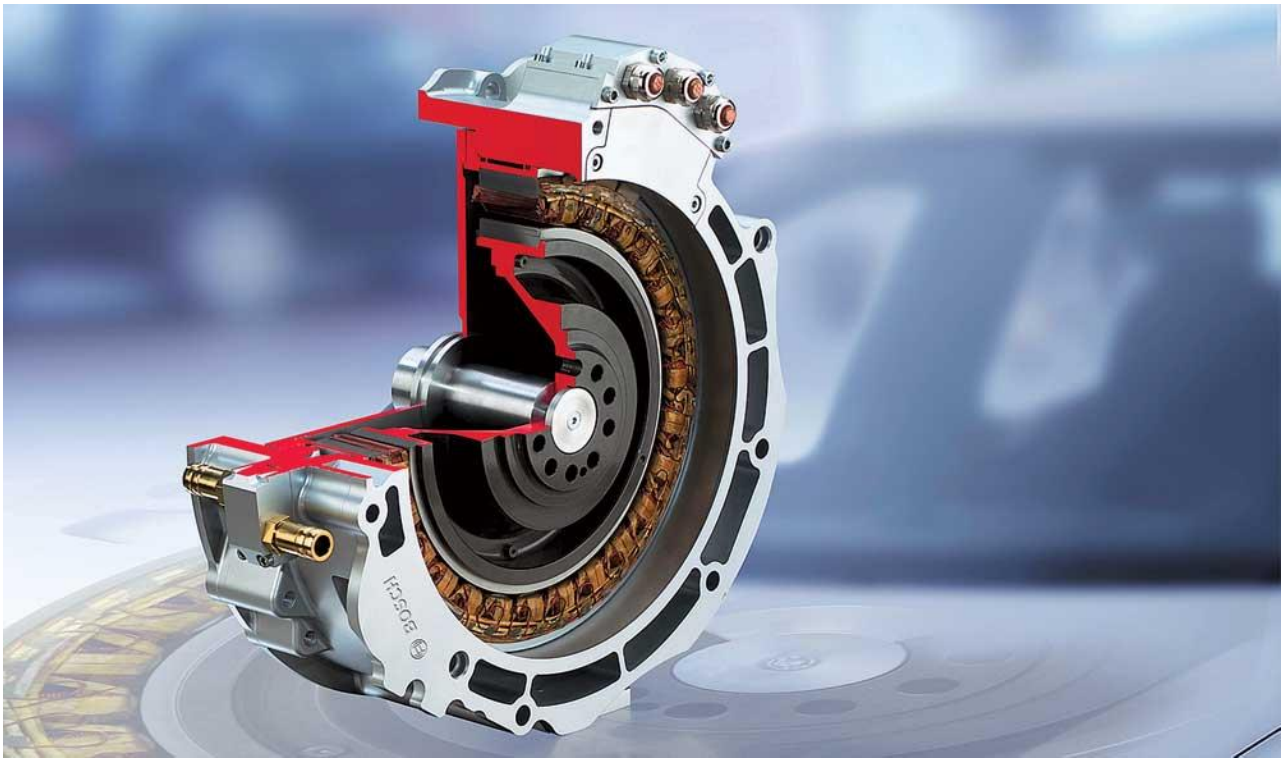

Figure 5 – Starter-generator set

The tests carried out confirmed the efficiency of the starter-generator in various modes and operating conditions. Synchronous machines with permanent magnet excitation can be used in gearless starter generators. Two synchronous starter-generator designs with an internal rotor and an external rotor are possible. A synchronous starter-generator with an external rotor has the advantages of easier and more reliable mounting of magnets on the rotor and good cooling.

In the starter mode of operation, the linear load can be increased by 3.5 times compared to the generator mode, and the rotation speed in the generator mode is an order of magnitude higher than the rotation speed in the starter mode. With the same values of other values, the power of the starter-generator in the generator mode of operation will be three times greater than in the starter mode. In an electric car, the starter-generator is calculated for the main mode of operation – the traction motor mode, powered by a battery. When braking the car, the starter-generator is switched to generator mode and recovers electrical energy from the battery. The vehicle can be equipped with several starter generators with a total power of up to 100 kW or more.

Non-contact asynchronous or synchronous machines with permanent magnets, powered by inverters, are used as traction motors and starter generators in hybrid vehicles. In order to reduce the size, they can be made with a built-in gearbox and have water cooling.

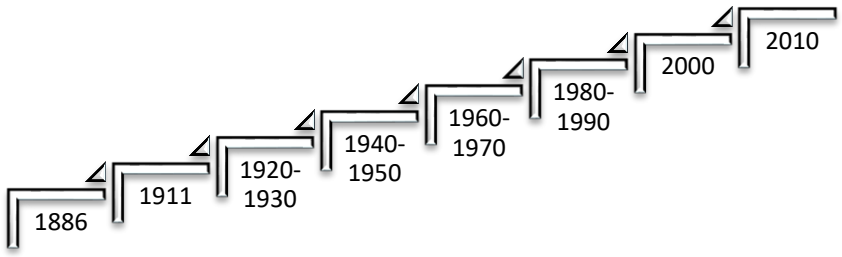

Figure 6 – Timeline of electric starter development

Late 19th century:

1886: Karl Benz patented the first automobile powered by an internal combustion engine. To start it, you had to manually turn the lever.

Early 20th century:

1911: Cadillac introduced the first electric starter motor in mass-produced automobiles, eliminating the need for manual torsion.

1920s-1930s:

1920s: Electric starters became standard on most cars, making it much easier and safer to start the engine.

1930s: The 12-volt electric system became the standard in automotive design, providing more power to electric starters.

1940s-1950s:

1940s: Automobile manufacturers introduced key-operated starting systems, replacing push-button starters. This simplified the process of starting the car.

1950s: Electric starters became more reliable and durable, which led to their widespread adoption in various types of vehicles, including trucks and buses.

1960-1970s:

1960s: Remote start systems were introduced that allowed the engine to be started

from a distance, this was implemented as a luxury feature in some premium cars.

1970s: the use of electronic ignition systems became more common, which increased the efficiency of the start-up process.

1980-1990-ies:

1980s: Advances in electronics led to keyless entry systems that combined engine start and door opening functions.

1990s: immobilizers were introduced, which improved the overall safety of the car by requiring an electronically encoded key to start the engine.

2000-present:

2000s: Push-button startup systems became popular, replacing the traditional key. Drivers can start the engine by pressing a button when a non -key remote is nearby.

2010s: Starter-generator sets for passenger cars

Modernity: Continuous improvements are aimed at integrating electric starters with hybrid and electric vehicle systems, ensuring efficient and continuous operation of the engine start and stop system, especially in environmentally friendly vehicles.

Conclusions. In the course of studying the history of electric starters, it is revealed how this technology has come a long and difficult way from manual mechanical systems to modern high-tech devices. Starting with the first cars that required physical effort to start the engine, engineers have continuously improved the starting systems, ensuring reliability and user-friendliness. Consequently, the history of electric starters attests to the continuous progress in automotive technology, which simplifies the lives of drivers and contributes to the creation of environmentally friendly automotive solutions in the future.

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