DIAGNOSING AND SOLVING CHARGING CIRCUIT PROBLEMS

One of the most common problems for a motorcyclist is finding himself with a dead battery. With the battery completely flat, a modern motorcycle, with the electronics and devices that need to be powered, leaves us on the street.

The purpose of this mini-guide is to describe in a simple way and with commonly used terms how the charging circuit works, how to identify the "culprit" (or culprits) of the failure to recharge and how to resolve the problems encountered.

CHARGING CIRCUIT: HOW IT WORKS

Il circuito di ricarica di una moto si compone di 3 elementi principali, più i collegamenti tra loro:

1. **GENERATOR (ROTOR/FLYWHEEL+STATOR)**
2. **REGULATOR/RECTIFIER**
3. **BATTERY**
4. **WIRING AND IN BETWEEN CONNECTORS (BETWEEN THE THREE COMPONENTS ABOVE)**

How it works:

- the generator with the engine running produces alternating current (AC) at a voltage that varies depending on the rotation speed, normally from around 20V at idle (measured on every possible pair of the three poles) up to values of hundreds of V near the limiter;
- the alternating current produced by the generator, usually in three-phase mode (there are also systems with single-phase generators, which are currently quite rare) is rectified by the direct current (DC) regulator and regulated to a value in volts normally between 13.5V and 15V (ideal average value above the minimum: between 14V and 14.5V);;
- the direct current output from the regulator recharges the battery and, via the same battery (which also acts as a buffer) powers the active loads on board (examples: ECU, headlights, instruments...).

GENERATOR

Generator consists of two elements:

ROTOR/FLYWHEEL – it is a component keyed onto the drive shaft (when it rotates it also rotates), it is normally a hollow cylinder with a series of fixed magnets positioned inside; i**t is extremely unlikely that the rotor is the cause of charging problems**.

Example:

STATOR – it is a component fixed to a crankcase (normally with three bolts), it remains stationary, it is made up of a series of coils with copper windings, **it is very often the main cause of charging problems**. For reasons that we will explain, it stops working properly when part of the insulation covering the copper is ruined/burned by excessive temperature, sending the copper itself to earth, no longer protected by the insulation. A stator with one (or more) grounded windings (or fused rather than isolated from each other) no longer works correctly and causes the entire system to fail.

Example:

VOLTAGE REGULATOR/RECTIFIER

Voltage regulators rectify alternating current into direct current, and regulate the output voltage to the battery within a predefined range of values (see above). The various regulators differ from each other due to a combination of these three main elements (plus other less significant ones):

- operating logic - **SHUNT** (oem) or **SERIES** (better in every respect);
- **maximum alternating current input voltage** that they can accept **(240VAC o 400VAC)**;
- **maximum amperage** they can handle (e.g.**35A** or **50A**).
- electronic components on board - **SCR** or **Mosfet**

SHUNT Regulators - In SHUNT type regulators the generator always works at maximum, delivering all the power it is able to generate at the various engine RPMs; **the SHUNT type regulator short-circuits to ground on the phases the input current in excess of that needed to recharge the battery and power the loads active at that moment** - the excess current produced is useless work for the generator, and the short-circuit on the phases **causes overheating of the entire three-phase section (wires, intermediate connectors, copper of the coil windings)** – overheating of the copper of the coils causes the copper itself to expand, the insulation covering the windings eventually gives way, cracks and burns > one or more windings go to ground on the chassis or between them > the stator stops working correctly > the charging system stops working.

SERIES Regulators - In SERIES type regulators, the connection to the generator is continuously disconnected/reconnected, so as to guarantee all the current required downstream, necessary for recharging the battery and, through it, for powering the loads active at that moment - **a SERIES type takes only the necessary watts from the generator at any time, freeing it from useless work - the phases are never short-circuited to ground, the stator consequently works at temperatures much lower on average (15-20°C) than if it were connected to a Shunt type regulator. The much lower working temperature prevents the stator from burning, but also from melting the intermediate connector on the three-phase wiring. A series-type regulator also "gives" a minimum of extra power with a charged battery and a slight drop in consumption (both due to the lower average magnetic friction of the generator on the crankshaft, which is freed from unnecessary work).**

Max AC Voltage – the components inside the regulator can be certified up to 240V AC max, or up to 400V AC max. The output AC Volts depends on the geometry of the stator (triangle or star), on the number of windings of each coil, on the thickness of the copper used, and always rise in proportion to the engine rpm - there are motorbikes with generators capable of delivering up to at 300V AC and above!

Max Amperage - Knowing the maximum Watts that the generator of our motorbike is able to deliver, **it is possible to calculate how many maximum Amperes the regulator must be able to manage**, according to this formula: A=W/VCC – examples: a 400W generator can reach an average of 14V to deliver up to 28.57A; a 600W generator at 14v average can deliver up to 42.85A. **Installing a voltage regulator capable of holding more amperes than those actually supplied by the generator (for example a 50A max regulator coupled to a 32A max generator) is not contraindicated, in fact it is recommended, as it makes the regulator work on amperages above below its maximum capacity, reducing its operating temperature and increasing its useful life.**

SCR – MOSFET – these acronyms identify the type of some of the electronic components present in the regulator - they have no relevance on the type of regulation (SERIES or SHUNT) - if of quality, they are both reliable, robust and long-lived **- Inaccurate information is often found online, where it becomes confusing erroneously the term Mosfet with the type of regulation SERIES - they are absolutely NOT synonymous!**

BATTERY

The battery continuously supplies power to the motorcycle's electrical system, also acting as a buffer; To avoid having problems, you must always ensure a voltage higher than 12V with the engine off (preferably around 12.5V/12.8V) and lower than 15V with the engine running (ideal around 14-14.5V on average). When you start the motorbike (i.e. with the charging circuit still inactive) it must have the necessary cranking power to start the engine.

There are two main families of batteries, **lead acid and lithium** - both if of good quality and in good condition are perfectly suitable for the purpose.

Note on lead-acid batteries: if you purchase a lead-acid battery with separated acid (the classic row of test tubes with a seal to be turned upside down), after you have completed the acid charging procedure and sealed the battery, wait at least 8 hours before putting the battery in in operation. It is essential that you give it time to stabilize before using it - the life of the battery will be significantly extended. If initially conditioned correctly and inserted into an efficient charging circuit, a lead acid battery can and should last well over three years.

<u>Note on lithium batteries</u>: they have two main advantages compared to lead batteries: the much lower weight and the ability to accumulate and store a higher quantity of energy (in Ah). Among the disadvantages are a tendency to lose cranking power in the presence of cold temperatures (sometimes in winter it is difficult to start the engine*) and a certain "pickiness" in terms of charging voltage (the ideal one for lithium batteries is in a range much narrower than that for lead batteries) which makes them more delicate. If you opt for a lithium battery it is essential to choose brands/models of safe and proven reliability (there are many products of questionable quality on the market), and accompany them with a very stable voltage regulator in terms of output voltage and which remains within the range required.

** there is a little trick to "warm up" the battery and find the cranking power again which usually works - before pressing the start button turn on the ignition and keep it on for a few tens of seconds (the headlights on will create a load) - then turn off the ignition, then turn it back on and try to start the engine.*

WIRING AND CONNECTORS

Three wires come out of the stator if three-phase, ending in a three-pole connector. The symmetrical connector connected to the first brings the alternating current to the voltage regulator. If an additional wire comes out of the stator it is usually the pickup signal, and has no function in the charging circuit.

Two (or four) wires come out of the voltage regulator which carry the direct current towards the battery. If four instead of two means that the manufacturer has preferred to put two twin cables for the positive and two twin cables for the negative, usually if they are single and not doubled they will have a larger section.

The wires (two or four) that carry the output current to the battery also end in a two or four pole connector. The symmetrical connector (female or male) connected to the first brings direct current to the battery to recharge it, passing through a protection fuse.

DIAGNOSING YOUR CHARGING PROBLEMS AND POSSIBILE SOLUTIONS

1. CHECKING BATTERY

First, before investing time in more complicated checks, check that the battery itself is still in good condition. However long-lived they are (if well maintained), sooner or later they lose the ability to conserve energy, be recharged correctly and provide the required cranking power.

To see if a battery is still valid, try putting it on slow charge overnight - in the morning unplug the battery charger, wait an hour for it to stabilize then measure (with the bike power off) the voltage at the poles, it should be between 12.5 and 12.8V if lead-acid (for lithium, check the data provided by the manufacturer). IF THE VOLTAGE IS LOWER THE BATTERY BEGINS TO SHOW SIGNS OF AGING, REPLACE IT.

Then try to start the engine; before doing so, disconnect the voltage regulator from the battery, so as to prevent any problems upstream from disturbing the control. If the battery still has good cranking power, the engine should start without any particular hesitations (unless there are problems elsewhere, for example freewheel, starter motor). IF THE CRANKING POWER IS POOR, REPLACE THE BATTERY.

2. CHECKING STATOR

Once the battery has been excluded as a possible cause, the most appropriate thing is to check the stator. As mentioned, a malfunctioning or non-functioning stator is the most likely cause of charging problems.

There are various tests that can be done to check a stator, the two most important in our opinion are:

First check: with the bike off, disconnect the three-pole connector (obviously you are working on the one on the stator side), then with the tester in diode test/continuity test mode, check (one at a time) **that none of the three contacts are grounded - to do this one test lead on one of the three contacts, the other on the negative pole of the battery (or on an unpainted screw on the chassis) - there must be NO continuity (if a buzzer is present, it must NOT sound). If there is continuity between one or more windings and the frame, even on just one of the three contacts, THE STATOR MUST BE REPLACED (IT IS BURNED).**

Second check: always work on the same contacts of the three-pole connector, stator side - tester in alternating current (AC) reading mode, scale at 200v - turn on the motorbike, keep it at idle, then positioning the probes respectively on two of the three contacts (the three possible combinations: 1-2, 2-3, 1-3) read the AC voltage - **the values must be around 20V for each possible combination, equal or close to each other in the three readings - then repeat the same test at 3000 revolutions, much higher readings must be obtained, 45-50V or more, but always close to each other. If the values found are very low compared to those listed, or with the same rpm significantly discordant with each other, THE STATOR MUST BE REPLACED**

NB: The burnt/malfunctioning stator can be sent to a specialized laboratory to be rewound and reconditioned as new.

3. CHECKING WIRING AND CONNECTORS

These elements are often overlooked when problems arise, but they should always be taken into consideration as, even if to a lesser extent, they can be the cause or contribute to making them worse.

First of all, all the intermediate connectors must be checked to make sure that they are not burnt/melted or have the contacts inside oxidized. If this is the case, they must be eliminated and replaced with new connectors (both the blocks and the fastons inside them), if possible putting some dielectric grease inside before reconnecting male to female.

The cables must also be inspected to make sure that there are no sections with cracked or open sheaths, or worse, real interruptions (severed cables). If the electrical system is very old, it is also necessary to take into account the fact that copper "ages", oxidizes and stiffens, losing part of its conductive capabilities. If one or more of these problems are encountered, it is always better to replace the entire section with a new cable, rather than repairing the old one.These elements are often overlooked when problems arise, but they should always be taken into consideration as, even if to a lesser extent, they can be the cause or contribute to making them worse.

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4. CHECKING REGULATOR

If the battery, stator, cables and connectors have passed the checks, the correct functioning of the regulator must be verified.

In Shunt type regulators, using a tester in Ohm reading mode, checks can be made (with the engine off) on the impedances capable of reporting any problems on the diode bridges present, with the aim of verifying that they are still functioning and with balanced performance between them. You can find videos on YouTube that explain the procedure in detail. SERIES type regulators cannot be checked with a tester.

In reality, if we are already sure that the battery, stator, connectors and wiring are in good condition (see previous points 1. 2. 3.) we can test the regulator in a very simple way: with all the elements of the charging circuit connected (stator > regulator > battery) let's turn on the motorbike and check the voltage at the battery poles at minimum - in order for battery charging to be guaranteed we must read values above 13V at idle, and around 14V at higher speeds. However, when revving up we should never exceed 15V. **IF THE REGULATOR DOES NOT DELIVER AT LEAST 13V AT IDLE OR IF IT EXCEEDS 15V AT HIGH SPEED, IT MUST BE REPLACED.**

USEFUL TIPS:

TO DEFINITELY AVOID THE STATOR BURNING PROBLEM, COUPLE A SERIES TYPE REGULATOR TO THE REPLACED NEW/REWINDED STATOR

To purchase SERIES type regulators and P&P wiring kits: https://www.sh775.it/gb/