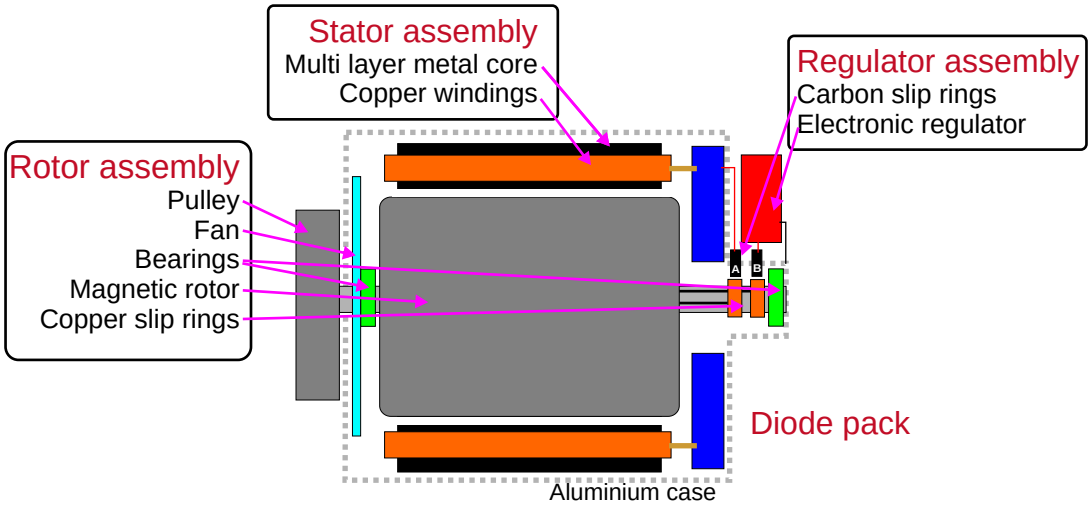
How to spot problems with alternators and find solutions

Alternators are one of the things on an engine which people shy away from and when there are problems they simply replace the whole alternator, that's a bit like having a flat tyre and rather than fix the tyre buy a new car. A lot of people get taken in by the alternator people who have long since lost the skill to fix a alternator (not that its hard to fix a alternator, the main problem is there are so may of them that companies could not possibly keep the parts) but they simply want to sell you a replacement box for 200 -500 £ and blame you for the fault, as if no one makes good alternators or bad alternators for that case, for example is a Iskera alternator (low cost alternator from Slovenia) as good as a Bosch (German alternator) and if not what's the difference. So this article is designed to give you some basic understanding about what breaks an alternator and where the fault lies that s causes that break, is it because the alternator is simply not suitable for the purpose for which it was sold? or something in the installation/operation of the unit . With a basic understanding you can ensure you do not simply replace a alternator without finding out why it broke in the first place to confirm if it's a warrantee issue, or a operational issue. also we will endeavour to kill a few old wives tales which are always rife in the absents good basic simple to under stand information.

So how do you break a alternator and what caused the break?

In order to know this you need to understand the basic parts of an alternator what they do there strengths and weaknesses

Lets break a alternator down into 4 parts simple parts. **Rotor , Stator , Diode pack and the Regulator**



Now lets break each part down and explain what does it do, and what are its weakness and any old wives tails about it

The Rotor:

What does it do?

The rotor is a simple electro magnet, its designed to create a lot of magnetic flux using some of its own power which it generates itself (back feed through the diode and regulator) , with some so called blushless alternators the rotor is simply a big permanent magnet and requires non of its own power however the vast majority of alternators you will come across are not brush less they have brushes (we will come to that later) . So having made a magnetic field the rotor is totally unless until it rotates , as you cannot induce electric into the sartor unless the rotor rotates making its magnetic poles (north and south) alternate across the stator windings and so induce alternating current (A/C) into the Stator. Apart from being the base generating point of the alternator the rotor is also its safety and control point. The rotor can only generate magnetic flux up to its maximum flux density, no more than that is possible, it cannot be overloaded , it will simply flux out, it produce its maximum and that is it . **So you cannot overload an alternator** , it's a current limiting device, and can product its current all day every day (if anyone knows how to do this illusive overloading of alternators please let me know as I could sell the technique to Bosch for a lot of money) . The other duty of the rotor is to increase or decrease its magnetic flux density to control the amount of current it will induce in to the stator , ie it regulates the output power / voltage of the alternator, its does this with the help of the alternators regulator (see later).

Weakness in the rotor assembly.

The actual rotor is a simple lump of iron with copper wound round it making an electro magnetic (the sort of thing which picks cars up at scrap yards). There is not much to go wrong with this, the bearings would be the only weak part in the assembly, the bearings are grossly over specified for rotating the actual rotor, in the overall scheme of things the force caused by the rotor rotation is little to nothing, the vast amount of the bearing wear is caused by the belt tension caused by the side ways force asserted by the belt and the engine drive, too much force here will excessively wear the bearing, so the best way to prematurely destroy your rotor bearings is to over tension your belt, ironically the other way to destroy your bearings is to under tension your belt, this will cause belt slip and cause the pulley to get very very hot, this in effect transfers the heat from you hot pulley to the rotor shaft and into your front end bearings and so over heats the internal grease and destroy the bearings. So putting to big an alternator on a single belt drive (I would say the max alt on a single V belt should not be more than 70-80 amps) is not clever as you will either over tension the belt to deal with the extra torque, or it will slip, either way it s a high road to no where .

So if the alternator fault is the premature destruction of the front bearing then look at belt tension either to much or to little (if to little then you will usually be eating belts on regular time frame due to the heat caused by the belt slip) or if it's a new alternator installation the pulley could be out of line with the crank pulley (not usual in production engine installations) (sub note belts are like everything else in the world there are good and bad, low cost belts will expand easily under pressure and so slip for the better range of belts look at belts such as the Fenner range as they have many more internal cords and not so prone to expanding under pressure) .

The only other weakness is centrifugal force, a conventional 70-100 amp rotor should be tested up to about 15-20,000 rpm ,(the larger the alternator the lower this speed) before the centrifugal force would actually cause the rotor windings to fly apart and cause a failure in this region, however its normal running speed would be about 2000-6000 rpm, so this would not be a common fault. What speed is your alternator doing? Measure the diameter of the main crankshaft pulley, divide this by the diameter of the alternator pulley, you should get a ratio of 2-5 to one. check your max engine RPM (for example 3000 rpm) the x rpm x pulley ratio. ie 3000 rpm x ration 2.8 to 1 = 8400 rpm. Another very important point to note about the rotor is that for an alternator to work it produces its power based on its power curve (amps against RPM, different for all alts, good alts have steep power curves which cause torque issues, bad alts have shallow power curves which require a lot of RPM to work), most alts “kick in” about 1600 rpm (the red ign warning light goes out) and give full power about 4000 rpm, so it important to make sure at your cruising speed you alt is doing at least 4000 rpm to get its max current out of it . So if we take the above example and have a narrow boat cruising speed of 850 RPM at 2.8 to 1 ratio the alt speed would be 2380 rpm, quite frankly if I had a 90 amp alt at this RPM the max current would be about 30 amps, so you could be cruising along thinking you have a 90 amps alternator when in fact you have effectively a 30 amp.

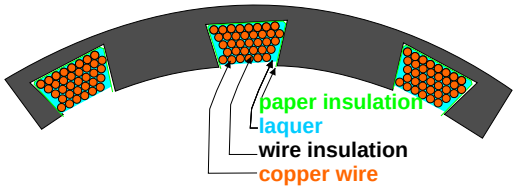
The Stator.

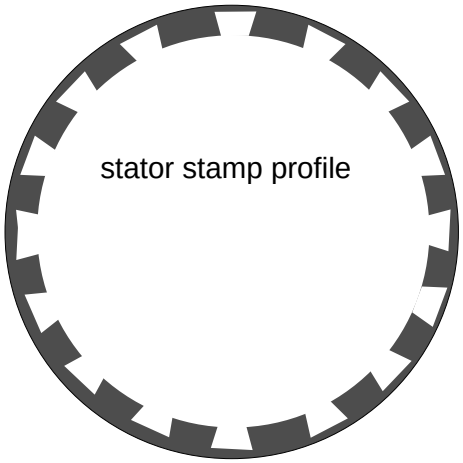
What does it do? The stator is a iron case made up from layers of metal connected together with copper wire wound inside the iron layers, each layer(Lamination) is a pre stamped sheet of metal, the more layers the less magnetic losses (better the products), as the rotor rotates and presents the north pole of the magnetic force then the south pole, the magnetic flux is captured by the outer iron core and a a/c current is induced into the copper wires, thus creating the alternator actual real power.

Weakness in the stator assembly. There are no actual moving parts in the stator and as such one would think it pretty much bullet proof, but you would be wrong, this is the part which separate the men from the boys when it comes to a good alternator and where the vast majority of alternator problems stem from. To understand this you must understand how the stator is made , the laminations (layers) are sheets of metal ,machine stamped to shape, then lined up to make a series of tunnels to accept the copper windings. The first problem arises from lining up the layers, they must be perfectly lined, ie one layer is a few thousands of a inch out of line then this raises a edge in the tunned for the internal copper wire to be pressed against, and second if the machine stamped edges from each laminates are not smoothed down after the stamping process there is a very sharp edge on the metal, add 20 of these together to make a stator and you have 20 razors surroundings each tunnel. Now lets examine what you are putting inside the tunnel, there is a thin sheet of paper like substance to shield the windings from the tunnel edge the copper wire has a insulation coating covering the wire (clear insulation), so to look at it you would thing its exposed copper wire when in fact its insulated . When the winding is complete then the stator, windings, paper shield are dipped into a bonding agent then cooked to try to lock everything together to prevent the wire moving inside the stator, this also helps to ensure the wires are 100% insulated from each other and from the metal stator, so even though the wires are tightly packed and look like they are touching the stator in fact they are not , **and must not** . So from the engineering point of view, you now

have a metal tunnel with potentially little sharp edges on the walls where you are now going to pack copper wire with a plastic coating a thousand of a inch thick into the tunnel full of razor blades, NOT GOOD. so the manufacturer , processing , lining up, finishing and the quality of the insulation surrounding the copper wires the dipping and baking the laquer are all absolutely critical to the survival of the product , poor quality in any aspect of the stator will result in failure.
So how does it fail, as you load up the alternator the copper wire carries more current , and so get hotter, and expands, (the laquer bonding everything together is meant to restrict movement but it cannot stop it)as you cool down the alternator the copper contracts, so there is minute movement of the copper wire against the insulation paper which is against the metal tunnel edge and also copper wire to copper wire , any flaw in the tunnel wall will result in the wire breaking past the insulation and shorting to the alternator case or if the insulation breaks down between copper layers they would cause a short between neighbouring wires, the much more serious event is the wire shorting with the stator case as this would be a dead short, resulting in instant alternator failure where as shorting with a neighbouring wire would not be desirable but would only result in a small % loss of power and may progress to a total failure as more and more connect but most likely not .
The dreaded term "**Your alternator is burned out** sir "usually refers to the stator (though I personalty think it's a general term used by the ignorant)
So how can I tell the difference between a genuine burned out stator and a poorly manufactured burned out stator ? Simple. with a truly burned out stator the total winding would be burned from top to bottom , a constant burn where all wires have heated up uniformly and the laquer was burned (giving that black burned look) a very rare event indeed. The poorly manufactured burnt out stator only has the burn in one set of the windings, ie the set that has rubbed through the insulation , the rest of the stator would appear as new with bright copper non burned laquer , the wire in the burned section has touched the metal stator internally in this section only, due solely to poor manufacturing and is clearly a warrantee issue without any doubt what so ever. So never accept the burnt out alternator statement make the person qualify the statement and ask to look at the stator yourself. If this has occurred in a short time frame ie a few mths then it's a warrantee, if its many years, then its just bad luck A total burn out (all coils burned) would be a sign of a very hot environment, and you would need to address the cooling of the engine room or fitting a 4 inch vent pipe at the rear of the alternator to supply external cooler air to the alt .

Close up of
stator section

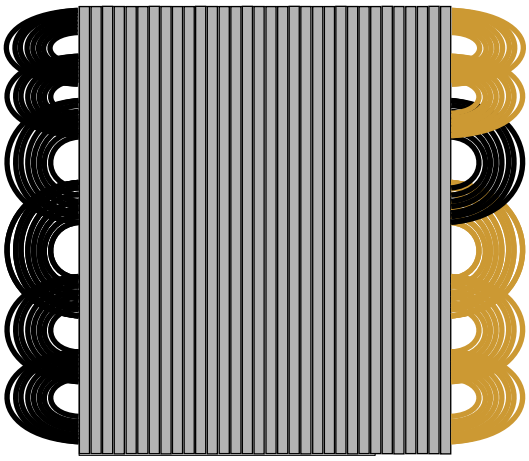




The regulator.

What does it do? The regulator is responsible for keeping the output voltage at a pre determined voltage, usually between 13.8 and about 14.4 volts (for a 12 v alt) depending on the manufacturer of the regulator.
So how does it do that, well if you remember back at the rotor section I said that the rotor is part of the control system of the alternator, if you have a rotor and want to get the maximum flux (magnetic field) from the rotor to product the maximum power from the alternator, then you would apply 14 volts to one side of the rotor (via the copper slip rings) and 0 volts to the other side of the rotor (via the copper clip rings) this would give a total of 14 v drop across the rotor and so give full flux, however if you reduced the total voltage drop across the rotor to for example to 6 volts then a lot less flux would be produced and so less power would be induced into the stator (reducing the output power) if the rotor voltage was reduced to 1 volt then again the power would be reduced all the way down to 0 volts where the alt will do nothing . The regulator does exactly this it controls the output voltage of the alternator by increasing or decreasing the voltage drop across the alternator rotor. it is working hardest when the alternator is doing little work, and it is working least when the alt is flat out, in fact if the alt is flat out the regulator is not regulating at all and is totally useless, this is a bit ironic for people who say things like "you have burned out your reg due to over use" .

Stator laminate side view with visual example
1 burned out coil on right hand side
Total burn out on left hand side



Weakness in regulators
How do you destroy them. To be honest regulators are pretty bullet proof things, they are simple solid state devices , and there is no relationship to how you use a alternator to how long a reg would last, any faults in a reg are simple internal faults due to poor internal soldering or parts used, and no external things have any real influence.
The only sure way to destroy a reg would be to switch of a engine isolator when the engine is working, this will cause a back voltage spike in the reg and 9 times out of 10 you will blow up the reg. the switching of the engine event could also be caused by a lose wire on the back of the alternator, if the main wire was to break or come loose this would have the same effect as isolating the engine when running.
The more likely area of fault around the regulator would be the carbon brushes which transmit the regulator power/signal to the rotor via the copper slip rings, these are consumable parts and one would not expect an issue in this area for many years, (other may be due to lack of use and dirt in and around the brushes) in the case of a leisure boat never in 20 years, on a vehicle about 100,000 miles +.
Another old wives tail is the idea that fitting a advanced reg in series with the standard reg some how overloads the standard reg, this is simply ludicrous, as if there are 2 regs doing the work of one, then most of the load will go through the new reg relieving the work load of the standard reg.

The Diode pack

What does it do?
The diode pack is a simple bridge rectifying diode set, it takes the three phase a/c being produced by the stator and converts it into half wave rectified d/c , which is what you get coming out your B+ terminal on the back of the alternator.

Weakness in the diode pack
The diode pack is where the end of the cables from the stator solder onto the diodes, its important that the solder used is of good quality and of high temperature , also the diodes themselves can be of poor quality, they can fail, the bottom line with any alternator is that the manufactures knows 2 things, they know the maximum amperage the alternator can product and they know that the ambient temperature under a car bonnet (in a car in the desert) can easily reach 150 deg C , so with these 2 facts they should ensure that the diodes used can deal with these 2 events, if the diodes are failing then why?? either the solder has melted on the connections or the diodes were badly specked for the alternator, there is no other real reason for this. The fan at the front of the alternator sucks air through the alternator from the back to the front ensuring the diode pack stays the coolest . so a diode failure over a long peroid of time is one thing but failing on a regular basis is another,

The big question : I am asked this question all the time.
Does having an inverter or fitting an advanced charging system overload and burn out or ware out the alternator faster . ? Well form the above information one should already know you cannot overload a alternator and so cannot burn it out that way. However does it wear it out faster? The truthfully answer to that is I do not know, however if you break the question into its extreme forms then you would have 2 questions which would be. Are you better running a 90 amp alternator at 90 amps for 1 hr or running it for 90 hrs at one amp. (the Engineering answer) Since there are no moving parts (other than the bearings) then there nothing to wear out, we know that a regulator is doing less at full power than at little power, and the load on the bearings will have a factor in it but the pulley tension is responsible for most of this whether or not the alternator is loaded so with 30 years in this field and hundreds of thousands of products sold into this market I can hand on heart say I do not know, because there is no evidence to conclusively support one way or the other I can only say its six of one half a dozen of the other (lots of scope for old wives tales in this one I am afraid) However there is one overing aspect which makes this totally irrelevant and unimportant and swings the answer 100% one way and that is the fact that I would rather run my engine for 1 hr than 90 hrs so for a totally personal answer I would say its better to run for 90 amps at 1 hr than 1 amp at 90 hrs...