

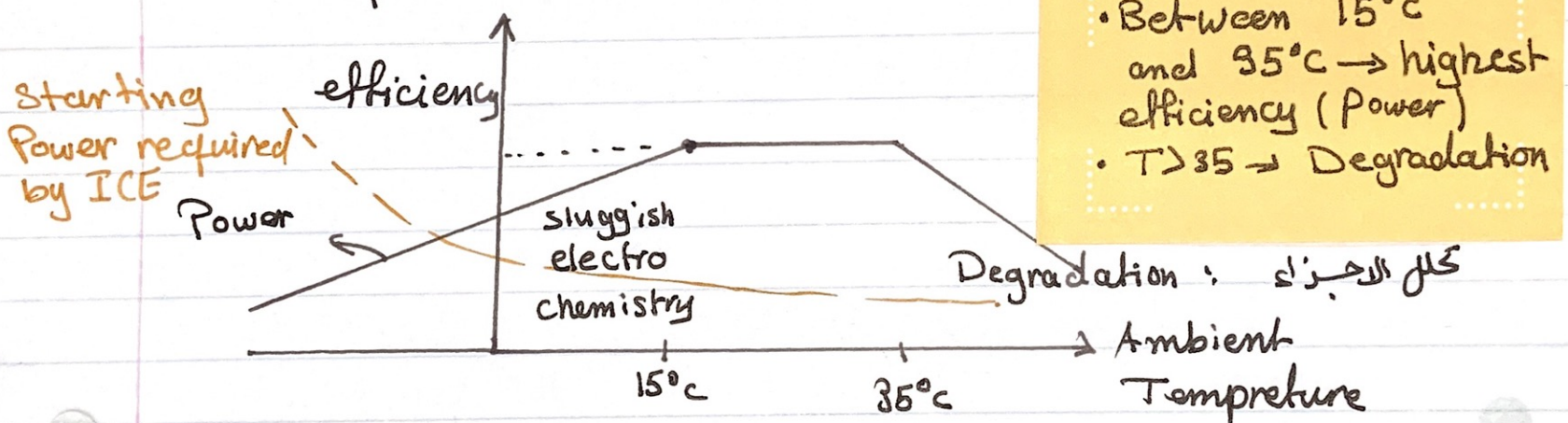
Chapter 2: Electrical power Supply

Battery: electrochemical storage facility for the excess electrical energy that is generated by the alternator while the engine is running

• The stored energy \rightarrow needed when the energy required $>$ energy generated by alternator

• Requirements:-

- 1- Provide electrical energy for the starter
- 2- Compensate for the deficit between generation and consumption
- 3- Damping of voltage peaks to protect sensitive components



$T \downarrow \rightarrow P \text{ for ICE } \uparrow$

Why? $T \downarrow$ viscosity of oil $\uparrow \rightarrow$ Friction \uparrow
so harder movement

• Positioning

- weight distribution of components (center of mass) of car
- Proximity to starter \rightarrow reduce losses
- Accessibility
- Protection against contamination

- [2]
- Ambient Temperature (Protect it from high Temperature coming from ICE)
 - Vibration protection (rubber helps to protect the battery)

Battery Construction

- Positive & negative terminal
- Cell divider
- Positive & negative electrode
- Dilute H_2SO_4

- 12 V Battery consists of 6 cells in Series
Each one 2 volts

$$V_{Tot} = V_{cell-1} + \dots + V_{cell-6}$$

- Plates & terminals are made of a lead alloy
- At starting process, V drops since I is high
- Power needed to overcome drag friction torque:-
 - Gasoline engines : 0.7 → 2 kW
 - Diesel " : 1.4 → 2.6 kW
 - Busses, commercial vehicles: 2.3 → 9 kW

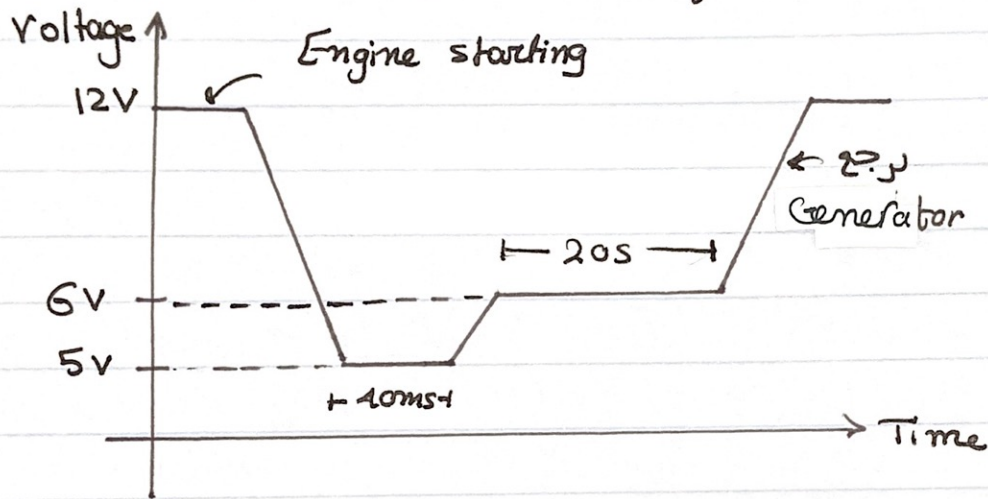
* $P_{Die} > P_{Gas}$? C.R. is higher → I need higher Pressure to cause the burning

- F.S Diesel > F.S Gasoline

Amount of current varies due to

1. Vehicle is off $\rightarrow (10-50 \text{ mA})$
2. Engine is running at idle speed or vehicle is running slowly $\rightarrow (20-70 \text{ A})$ (clock, antitheft alarm, remote controlled locking system)
3. Engine starting process $\rightarrow 300 \text{ A}$

Fuel pump, injection & ignition systems



• Vehicle cold
crank voltage
shape

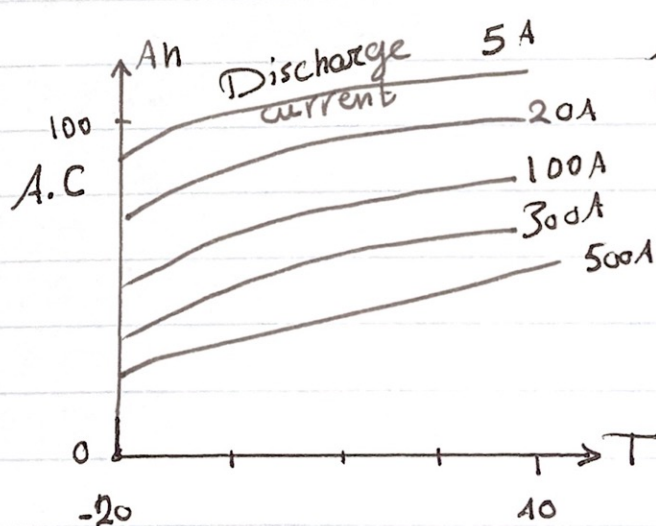
• We are not supposed to turn the car on & off many times \rightarrow Battery empties

Battery's Capacity

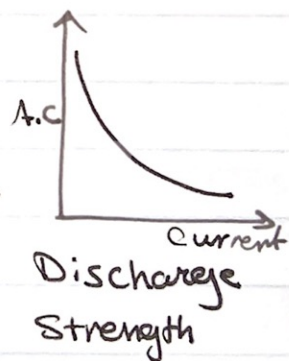
capacity $\downarrow \rightarrow T \downarrow$ when
Capacity $\uparrow \rightarrow I \downarrow$

Depends on:-

1. Discharge current strength
2. Density & temp of the electrolyte
viscosity \uparrow
depends on temp



A.C: Available capacity



Sulfuric acid ($\frac{2}{3}$ water, $\frac{1}{3}$ Sulfuric acid)

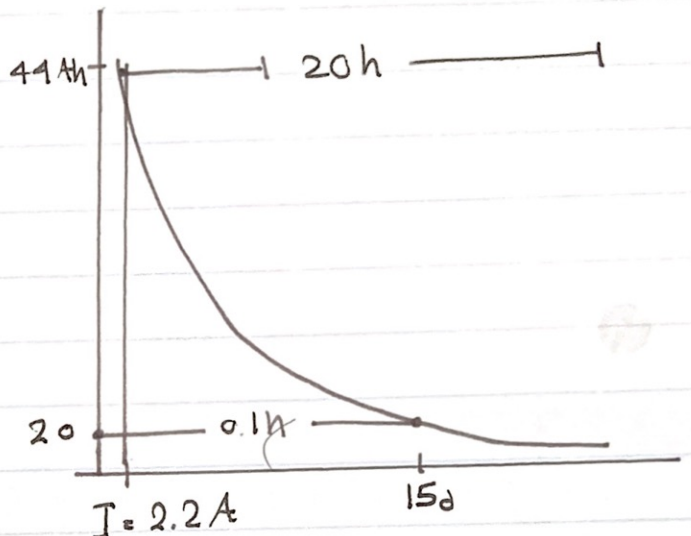
3. Discharging Process

4. Battery age : Stress, no stress on battery makes it have a service life \rightarrow Capacity \downarrow as it approaches the end of its service life

Back to 1

at $I = 2.2A \rightarrow A.C = 44Ah$
meaning we can use
 $I = 2.2A$ For 20 h

At $I = 150$, $A.C = 20Ah$
for 8 min at $20^\circ C$



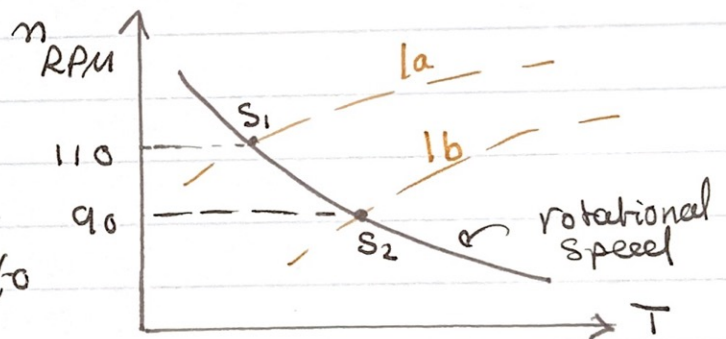
Back to 2

1a \rightarrow Battery 20%

1b \rightarrow \sim 0% (1, 2)

at 1b : I need 90 RPM to start engine at $-20^\circ C$

at 1a : I need 110 RPM to start engine at $-23^\circ C$



Engine lubrication System (see slide 14)

Crankshaft load (slide 13)

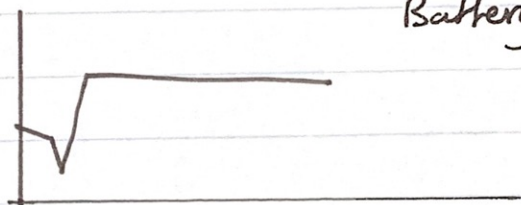
Cam shaft, coolant pump & high pressure pump \rightarrow timing belt
Crankshaft gear \rightarrow generator, air conditioning, compressor & auxiliary units

Battery Examples

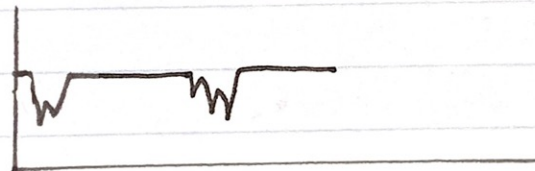
- ① For conventional vehicle :- Starting current = 330A
Capacity = 40Ah
- ② ~ ~ ~ ~ ~ (Better type) S.C = 600A
Capacity = 61Ah
- ③ For Vehicles with start-stop System:- S.C = 760A
C = 70Ah
- ④ " ~ ~ ~ ~ ~ (Better):- S.C = 800A
C = 80Ah

We can't use Type ① in start-stop System

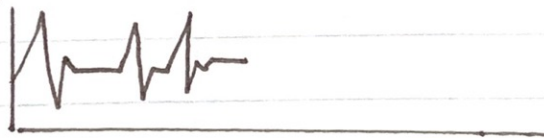
• for Type ①
Lead acid



• for Type ③



• For special hybrid cars (semi-hybrid) → Start-Stop Plus



- Generator transfers Mechanical energy to electrical energy

AGM Technology

AGM: Absorbent Glass Mat

EFB: Enhanced Flooded Battery

Alternator (Generator): Mechanical → Electrical
From engine

- Generates AC But DC at its terminals
- Supply the current to electrical loads when needed
- " " Charge current to battery when needed
- operates at idle speed → speed of engine when the car is not moving
- Supply constant voltage
- efficient power to weight ratio 600 - 800 RPM
- reliable, quite & have resistance to contamination
- Require low maintenance
- Indication of correct operation

• Connected to Auxiliary belt

Components

connected with belt → Pulley → Rotor → Stator
 Inboard ventilator: التبريد

How to convert AC → DC?

- Silicon diode does
- Regulator: controls rotor magnetic field strength by changing excitation current

• Two separate Belts
 • Because we don't always use Auxiliaries
 • At timing belts All components are important to start the car
 • Generator is not always needed

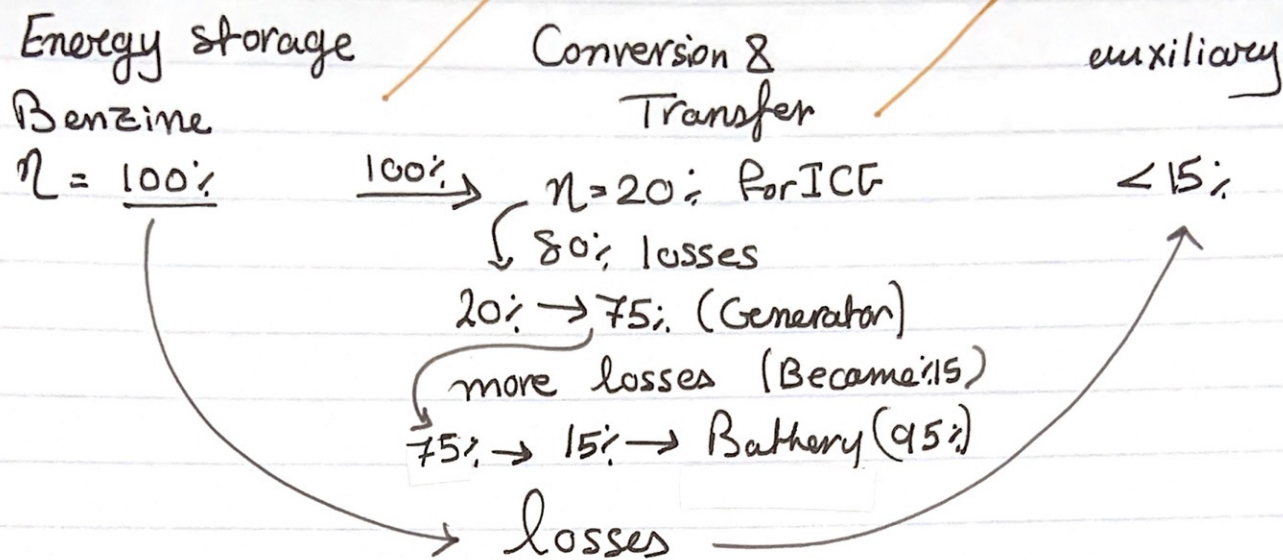
Charging System

$V_{Alt} < V_{batt}$ ← من البطارية الطاقة
 I from batt → Loads

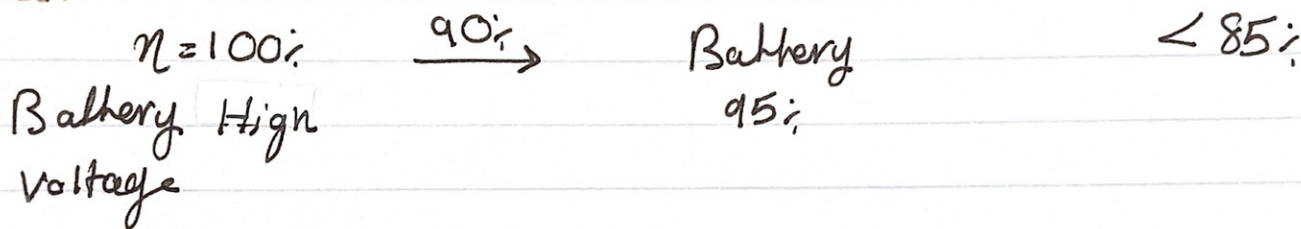
هو مصدر الطاقة → $V_{Alt} > V_{batt}$
 I from Alt → Loads & Batt

Efficiency of the energy conversion for the auxiliaries

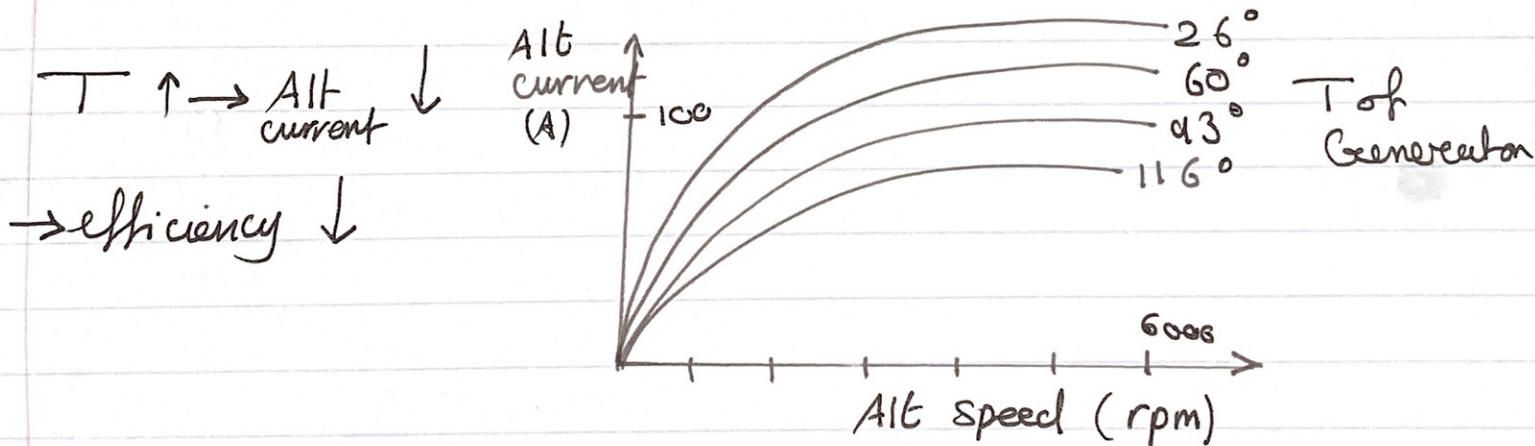
Conventional:



Electrical:



Alternator Current Output

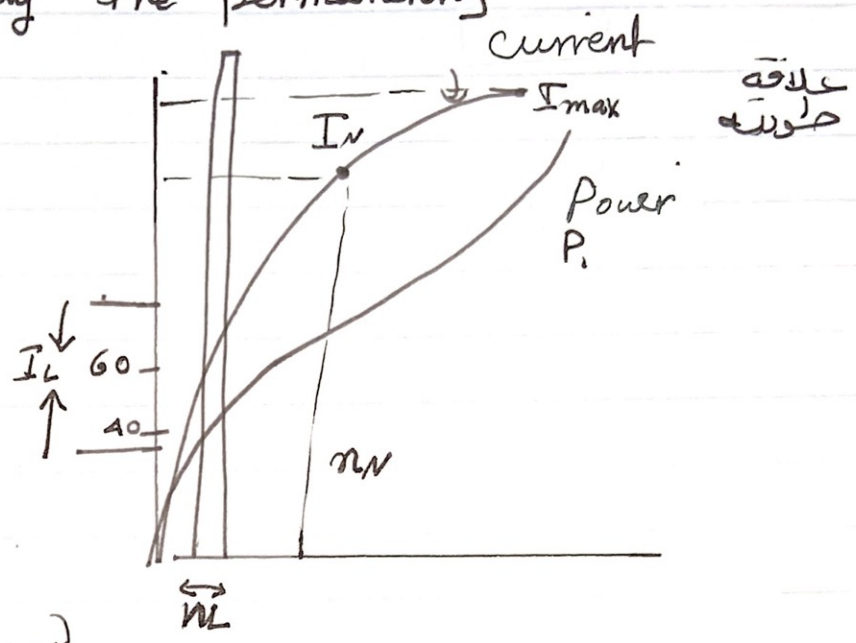


Alternator Current output

0-Ampere speed (n_0) → Speed at which the alternator reaches its nominal voltage with no electric current delivered

- Speed at engine idle (n_L), current at n_L (I_L) sufficient to supply the permanently active consumers

- Rated speed n_N
 ~ current I_N : full load current of the alternator
 $n_N = 6000 \text{ rpm}$
 $U_G = 13.5, T = 23^\circ\text{C}$



- Maximum Speed (n_{max})
 maximum current (I_{max})
 highest current that the alternator can generate
- P_i :- Max Power transferred from the engine alternator

Alternator cooling

- by integrated fan
- 120 - 140 A from Alternator if cooled
- due to cooling :-
- efficiency (10 - 25%)
- output at idle speed \uparrow
- Noise \downarrow
- Resistance to corrosion $\leftarrow \delta T$
- ~ ~ high temperature

higher efficiency
 \rightarrow less fuel consumption

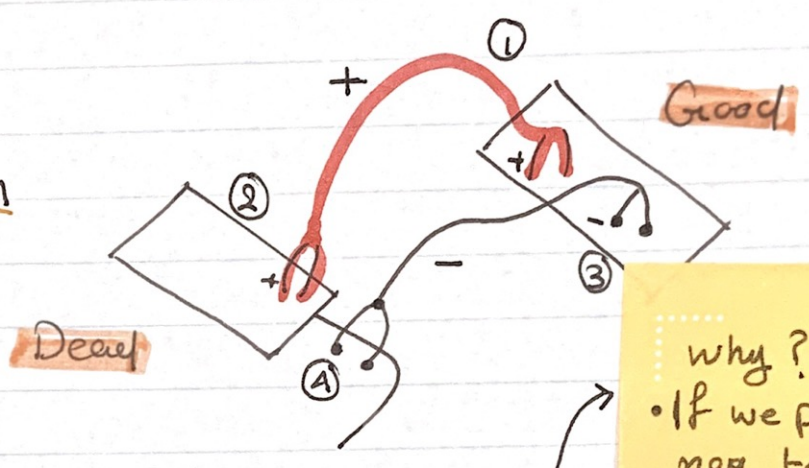
Electromagnetic Disturbances

- **load Dump pulse**: engine is running, battery is disconnected. It destroy the semiconductor circuits
- **Double battery**: happens during a jumpstart in which two 12V batteries in series are connected to the vehicle power harness

Jump start

Parallel connection

1. connect Red to Pos of good
2. connect Red to pos of dead
3. connect black to neg of good
4. " " " bare metal to dead
5. start Good & wait 2 min
6. " Dead & " " "
7. Disconnect 4 → 3 → 2 → 1
8. Drive for 10 min to charge the battery



why? safety
 • If we put neg to neg
 There will be a spark
 If H₂ exist it will turn into a big spark

Generator Selection

مستمر
 ممتد
 متقطع

- ↳ continuous loads = 180 watt
- ↳ Prolonged loads = 260 watt
- ↳ Intermittent loads = 1.7 kW (only 10% at same time)

$$P_{tot} = 180 + 260 + \frac{10}{100} \times 1700 = 180 + 260 + 170 = 610 \text{ watt}$$

$$I = \frac{610}{14} = 44A$$

Generator