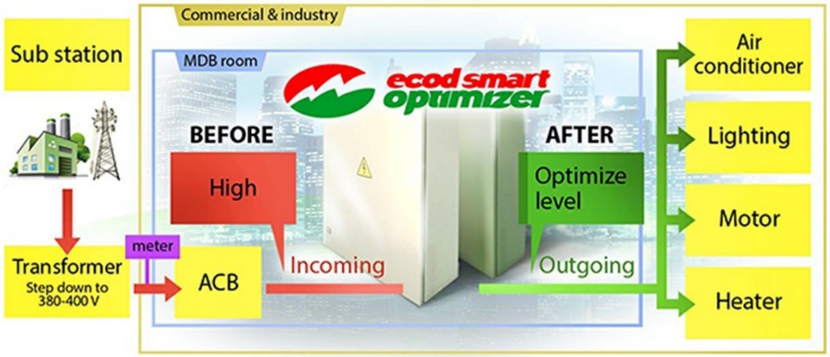
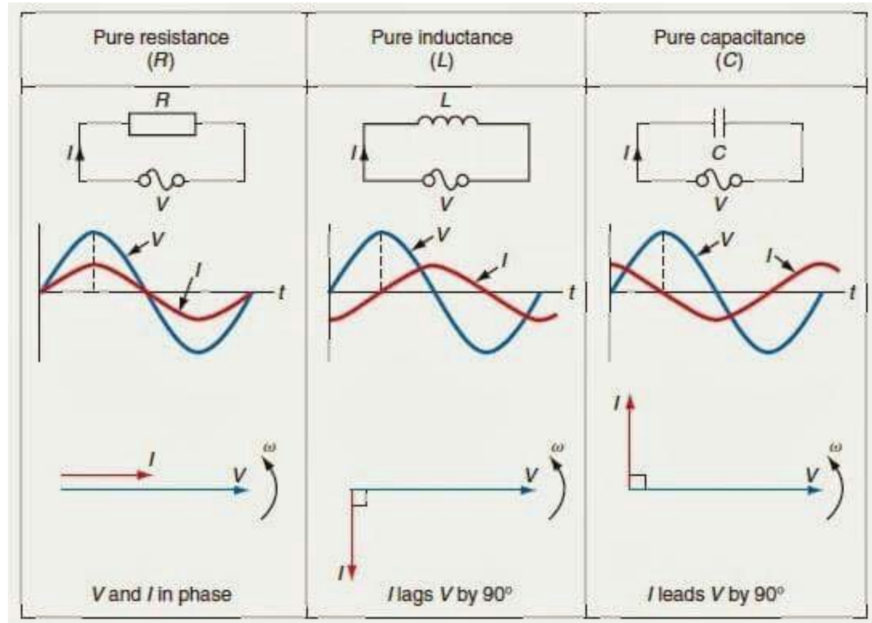
In most cases the necessary power is not constant but within tolerance range.

We are saving energy by keeping the customer's power at the minimum of the tolerance range.





1. 2.

1. **RESISTIVE LOAD** – KW Power (P) =Volt*Amp = V*I, reducing V (Volt) will reduce I (Amp), resulting in P (Power) reduction.

   Ohm's law: I=U/R

2. **INDUCTIVE LOAD** – KVA Power (P) =(Volt*Amp)/Power Factor = (V*I)/ Power Factor, In most cases, asynchronous motors operating with a load less than the nominal power. It is known that if the engines are working below 75% of their nominal capacity, if it is impossible to replace them smaller motor to reduce losses recommended lowering the supply voltage to 0.9 from the nominal.

Modifying supplied voltage

Typically, asynchronous motors are designed so that at nominal mode of loaded they have an **efficiency and cos φ1 (Power Factor)** close to the maximum. In addition, the maximum efficiency is achieved when permanent losses are mechanical and in steel are equal to variable losses in the windings. Therefore, the **effect of voltage variation is ambiguous and depends on the load on the motor shaft.**

By voltage increases, the magnetic flux increases and, consequently, the no-load current and magnetic losses in the magnetic core steel increase. As a result, the **efficiency and cos φ1 (Power Factor)** of the engine are reduced. **The maximum torque of the motor changes in proportion to the square of the voltage.**

In case of loaded of asynchronous motors - **lower 75%**, there is no threat to impaired operation stability, voltage reduction may be favorable, as the magnetic flux, the no-load current and magnetic losses in the magnetic core steel decrease in proportion to the **efficiency and cos φ1 (Power Factor)** may increase.

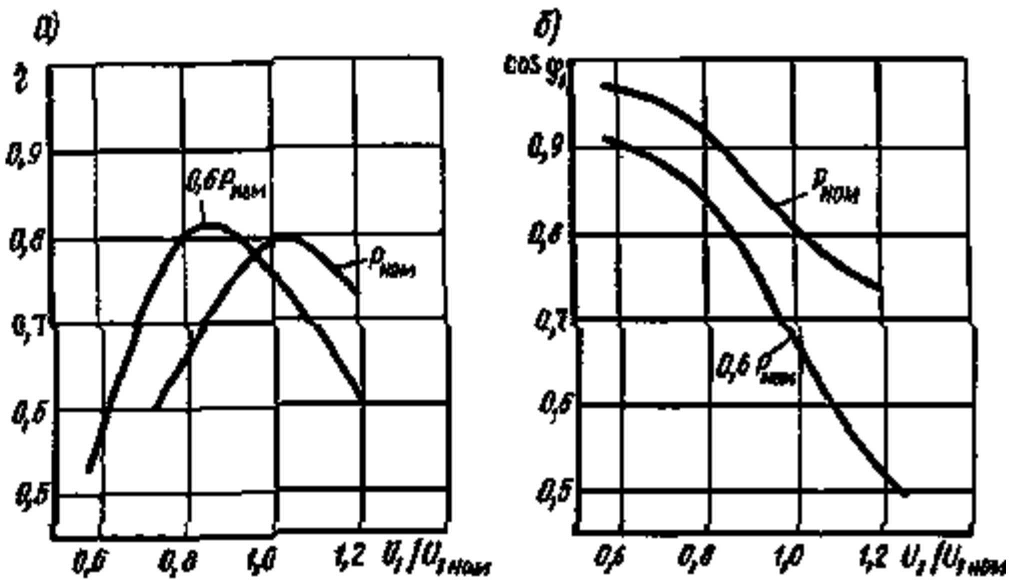


Fig. 4.72. Dependencies of efficiency and cos φ1(Power Factor) of the induction motor on the supply voltage.

In fig. 4.72, **(a)** shows the curves of the dependence of the efficiency on the mains voltage for two values of the engine power **P = P nom** and **0.6 P nom**. Each load corresponds to the optimal voltage at which the constant losses are equal to variables. The smaller the load, the lower the optimal voltage value. The motor power factor at loads less than nominal may also increase with decreasing voltage and there is a voltage for each load at which the power factor has a maximum **(Fig. 4.72 b)**. Thus, it is desirable to reduce the supply voltage at partial loads so that the **efficiency and cos φ1 (Power Factor)** are maintained at a high level.

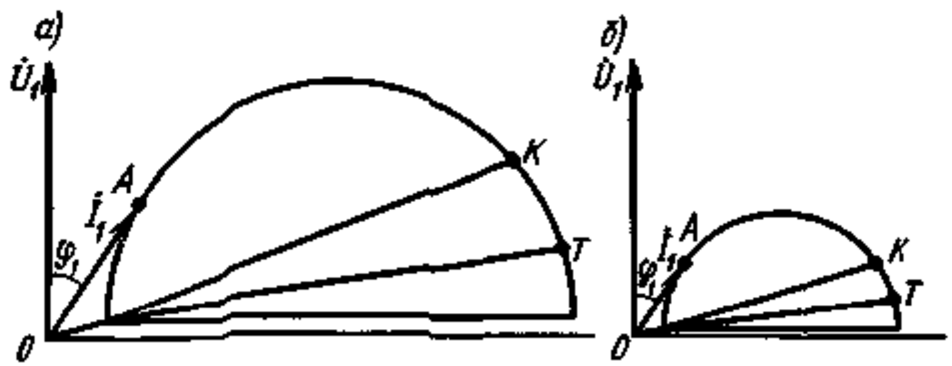


Fig. 4.73. Pie charts of an induction motor at rated and under voltage

In fig. Figure 4.73 shows motor pie charts at nominal voltages and loads (a) and at reduced voltages and part loads (b). When the voltage drops, the no-load current and the diameter of the currents are reduced. In both cases, the **cos φ1 (Power Factor)** value is close to the maximum, since the current vector **I1** is located tangentially to the circumference of the currents. If the engine is operated for a long time with loads less than **0.5 P nom**, it is usually advantageous to have a voltage regulating device (for example, a transformer with regulation under load). In the simplest case, the phase voltage of the motor can be changed by switching its windings from connection Δ (at nominal load) to Y (at low load).

Tests of asynchronous motor with different loaded and different supplying of voltage

Loaded Power = Nominal Power

U, V	*I, A*	*P, KW*	*Q,* KVAr	*S, KVA*	*Cos φ, Power Factor*
440	4,43	2,25	2,54	3,4	0,66
400	4,2	2,1	2,1	2,91	0,72
390	4,2	2,1	1,91	2,84	0,74
380	4,3	2,1	1,91	2,84	0,74
370	4,35	2,1	1,82	2,78	0,75
360	4,35	2,1	1,69	2,7	0,78
350	4,45	2,1	1,68	2,65	0,78
330	4,65	2,1	1,68	2,66	0,78
300	4,95	2,175	2,38	3,23	0,65
270	5,4	2,4	0,5	2,52	0,95

Loaded Power = 80% of Nominal Power

U, **V**	***I,*** ***A***	***P,*** ***KW***	***Q,*** **KVAr**	***S,*** ***KVA***	***Cos φ,*** ***Power Factor***
440	4,07	1,8	2,52	3,1	0,58
420	3,88	1,75	2,21	2,82	0,62
400	3,72	1,68	1,94	2,57	0,65
380	3,65	1,68	1,71	2,4	0,7
340	3,75	1,68	1,42	2,2	0,76
300	3,9	1,68	1,1	2,03	0,82
270	4,35	1,68	1,1	2,03	0,82

Loaded Power = 60% of Nominal Power

U, **V**	***I,*** ***A***	***P,*** ***KW***	***Q,*** **KVAr**	***S,*** ***KVA***	***Cos φ,*** ***Power Factor***
440	3,65	1,35	2,44	2,78	0,48
400	3,33	1,3	2	2,3	0,56
380	3,22	1,3	1,65	2,11	0,62
340	3,1	1,2	1,27	1,823	0,66
300	3,1	1,2	1,07	1,608	0,75
270	3,25	1,2	0,92	1,518	0,79
230	3,55	1,2	0,74	1,412	0,84