POWERS OF TRACTION RECTIFIER SUBSTATIONS OF DC ELECTRIC RAILWAYS 3kV

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Summary The article states main principles of dimensioning of traction supply stations of DC traction current system. It also provides detailed results of the traction rectifier substation Ostrava-Svinov load measurement. The measured values are subsequently used for calculation of characteristic coefficients, which make it possible to dimension rectifier groups.

Abstrakt V článku sú uvedené hlavné zásady pri dimenzovaní trakčných napájacích staníc jednosmernej trakčnej prúdovej sústavy. Ďalej ukázané niektoré výsledky merania zaťažení Trakčnej meniarne Ostrava-Svinov. Z nameraných hodnôt sú vypočítané charakteristické súčinitele, ktoré slúži pre dimenzovanie usmerňovačových skupín.

1. CALCULATION OF LOAD AND DETERMINATION OF NO- MINAL POWERS OF TRACTION RECTIFIER STATIONS

For dimensioning of electrical appliances of traction supply stations the permanent nominal power is deciding, which must admit certain overload and when real development of load arises, it must ensure that the maximum accepted value of warming will not be exceeded. Therefore for dimensioning are also important time loadings as follows:

- P_{2h} two hours loading i.e. the highest effective current in two hours,
- P_h one hour loading,
- $P_{15\,min}$ fifteen minutes loading,
- P_{5min} five minutes loading,
- P_{1min} one minutes loading.

Some of these values may be crucial for choice in the matter of type magnitude of electrical machines, rectifiers or appliances in the supply substation.

The only value that can be quite for certain determined in advance is I_a (middle arithmetic current), because it is determined by the total energy needed for traction including all additional needs and losses in the traction vehicles and in distribution nets.

If we denote:

- D_d middle daily transport (t.day^{-1})
- w_1 specific consumption of energy for traction, including all losses and side needs, measured in the supply station (W.h.t^{-1}.km^{-1})
- L length of the supplied section (km)
- P_a middle arithmetic power of the station (kW)
- A_d daily consumption of energy (kW.h.day^{-1})
- I_a middle arithmetic current (A)

it will be:

$$P_a = \frac{D_d.L.w_1}{24.1000} \quad , \tag{1}$$

$$A_d = 24.P_a = \frac{D_d.L.w_1}{1000} \quad , \tag{2}$$

$$I_a = \frac{P_a}{U}.1000 = \frac{D_d.L.w_1}{24.U} \quad . \tag{3}$$

Development and magnitude of supply station load are result of haphazard phenomenons, though, being conducted by certain patterns. These are relations between transportation work, relation between the middle power and density of traffic. From statistical probability it is then possible to determine characteristic values of nominal, effective and maximum loading, providing that according to statistical observations we derive probable mutual ratios of characteristic values to the basic value, which is the middle arithmetic P_a.

If we observe daily development of power of a traction rectifier station, we can suggest characteristic values of powers, which determine type power (magnitude) of machines and appliances. These are P_{max}, P_{2h}, P_{ef} a P_a.- fig.1.

For evaluation of relation between these powers we use proportional statistically verified coefficients:

c_s - coefficient of peak power

$$c_s = \frac{P_{max}}{P_a} \quad , \tag{4}$$

c_p - coefficient of overload

$$c_p = \frac{P_{max}}{P_{ef}} \quad , \tag{5}$$

c_a - coefficient of time utilisation of nominal power

$$c_a = \frac{T}{8760} \quad , \tag{6}$$

T - time of annual utilisation of nominal effective power.

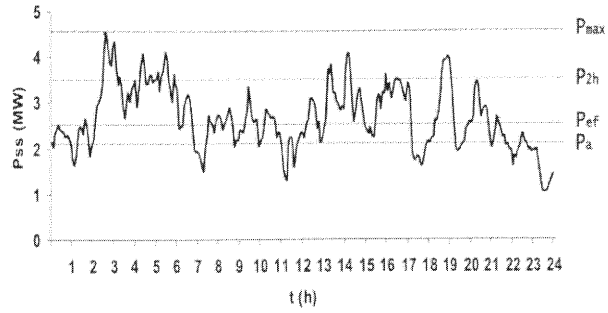

Fig. 1. Characteristic development of load in the supply station.
P_a middle arithmetic daily power, P_{ef} effective (quadratic) continuous power, P_{2h} two-hours power, P_{max} maximum (peak) power

2. MEASURING THE LOADS OF TRACTION RECTIFIER SUBSTATION

The measuring was done from Friday 21st February 2003 till Thursday 27th February 2003 in the traction rectifier substation Ostrava-Svinov.

When measuring in a traction rectifier substation it is necessary to measure on the input (22 kV) three-phase voltages and currents and on the output of the traction rectifier substation (3kV) direct current and voltage. For attaching measuring equipment are used measuring transformers of MTP current and MTN voltage on the AC side of the traction supplying substation and voltage bleeder and shunt attached through optoelectronic converter on DC side of the traction supplying substation.

The following figures and tables show examples of the measured and calculated values.

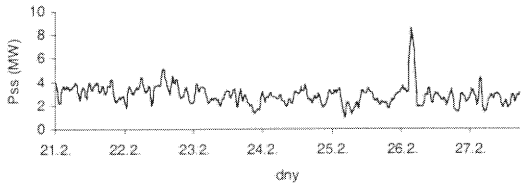

Fig.2. Diagram of P_h loading.

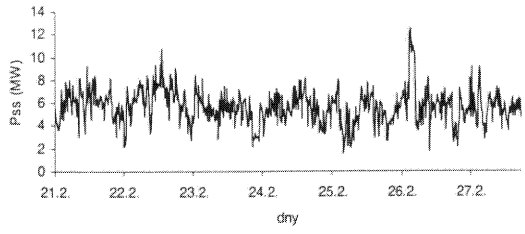

Fig. 3. Diagram of one-hour peaks of loading.

Tab. 1. Final statistic of powers.

Day	P_{max} MW	P_{1min} MW	P_{5min} MW	P_{15min} MW	P_{1h} MW	P_{2h} MW	P_{ef} MW	P_a MW
21.2.	9,24	6,73	5,42	5,14	4,21	3,93	3,35	3,06
22.2.	10,7	8,37	6,64	5,97	5,11	4,73	3,51	3,2
23.2.	8,44	6,54	5,21	4,54	3,86	3,62	2,80	2,50
24.2.	8,16	7,04	5,24	4,44	3,79	3,53	2,65	2,41
25.2.	8,13	6,17	4,49	4,09	3,52	3,36	2,58	2,30
26.2.	12,4	11,3	9,99	9,46	8,61	7,61	3,42	2,88
27.2.	9,17	7,07	5,35	5,20	4,30	3,39	2,58	2,30

Tab. 2. Count coefficient.

	Cs	Cp	Ca
21.2.	3,02	2,75	0,91
22.2.	4,78	3,07	0,64
23.2.	3,38	3,02	0,89
24.2.	3,38	3,08	0,91
25.2.	3,54	3,15	0,89
26.2.	4,33	3,66	0,84
27.2.	3,99	3,55	0,89

3. CONCLUSION

Development of load is characterised by great irregularities and great ranges of values. Also from measured time developments of current and power one of the basic characteristics of electrical traction is clear and that is great dynamics. From the daily development we can observe power peaks representing traffic peaks.

From the development of load several important values were derived, which are deciding for dimensioning of traction transformer substation.

From the development of powers we can gather that the maxim of one minute, five minutes, fifteen minutes, one hour as well as two hours power are substantially lower than the maxim of the instantaneous.

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