

SOME ASPECTS OF GEARS LOAD CAPACITY INCREASING

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ABSTRACT:

There are many different materials of various types and characteristics used for gear production, depending on gear function procurement possibilities and available technology. The most used materials for gear box production are structural steel, heat-treatable steel and cementation steel. The effect of material quality and its properties on gears will be presented through calculation of gear load capacity, in cases when gears are made of cementation steel and heat-treatable steel. Besides requirements related to material quality there are also requirements posed for gears teeth quality. Choice of gear teeth quality, although has a large influence on load capacity, has to be related to costs, and also technical and technological production capacities. An influence of material quality and gear teeth quality presented in this paper will be analysed exclusively from gear load capacity aspect.

Key words: quality of materials, quality of gear teeth, gear load capacity.

1. AN INFLUENCE OF GEOMETRICAL CHARACTERISTICS

A simple one level gear train, which is defined with a center distance "a" and gear's ratio "i" can be realised kinematically with different basic parameters (m_n , β , z_1 , z_2 , x_1 , x_2) in domain of previously defined boundary values of diametral pitch m_n , deviation of gear ratio $\Delta_{i_{max}}$ i $\Delta_{i_{min}}$, an angle of slope of tooth curve β_{max} i β_{min} and a profile displacement factor x_{max} i x_{min} , being in a correlation dependance. With change in one or more basic parameters several other parameters, which are in correlation, must be changed automatically.

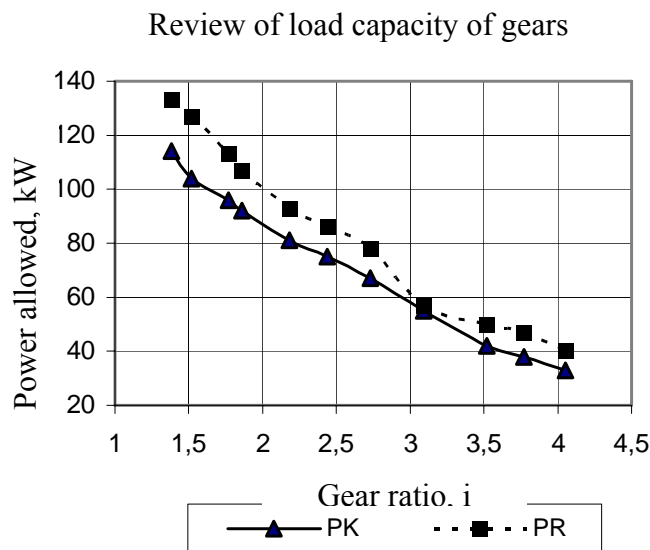


Figure 1. An illustrative review of gears load capacity

Figure 1 shows load capacity increasing (power) of existing gear-box (type MRZ-Krivaja) P_K and load capacity of optimized gear-box (MR-250) P_R , with a programme application „ZAROP“ [1], for optimal ratio of geometrical parameters, for previously selected function-load capacity increasing. During optimization of parameters as center distance, diameter pitch and gear width were not changed.

2. AN INFLUENCE OF MATERIAL CHARACTERISTICS

For gears manufacture, in depending of function, purchase possibility and available technology, there are many different materials with also different characteristics in use. For gear boxes with general purpose the most used materials are structural steel, heat-treatable steel and cementation steel.

Materials and its characteristics are very important and with great influence for construction of gears, and that conclusion is proved through gears load capacity calculation which are made of heat-treatable steel (Č.4732) and cementation steel (Č.4320), [3,6].

Gears load capacity calculation is done for arbitrary gears with characteristics showed in Table 1.

Table 1. Characteristics of analyzed gears

Center distance	$a = 160$ mm;	Correction factor of driver g.	$x_1 = 0,402$;
Number of teeth of driver g.	$z_1 = 19$;	Correction factor of driven g.	$x_2 = 0,301$;
Number of teeth of driven g.	$z_2 = 49$;	Num. of revolution of driver g.	$n = 289\text{min}^{-1}$
Helix angle	$\beta = 13^\circ$;	Cog quality	IT 5; 6; 7; 8; 9;
Gear width	$b = 64$ mm;	Safety factor of tooth face	$S_{Hmin} = 1,1$;
		Safety factor of tooth fillet	$S_{Fmin} = 1,75$;

Values of safety factors are estimated according to recommendations [2] related to industrial gear boxes. Calculation of load capacity is made by computer programme GEAR PACK CX 3.1. [1], for different cog qualities, and same value of safety factors. Calculation results are shown in Figure 2.

It is very significant from Figure 2 that an appropriate selection of material has a large influence on load capacity of a gear. The largest efficiency can be achieved by using of cementation steel, and it has to be used for expressive load capacity demands, in according to modern conceptions of gear box design of gear manufacturers all over the world.

It is negligible gain with using C/P according to P/P and it is very inquiring to applicate a material for cementation in production of gear z_1 because of technological requests, which are mentioned above.

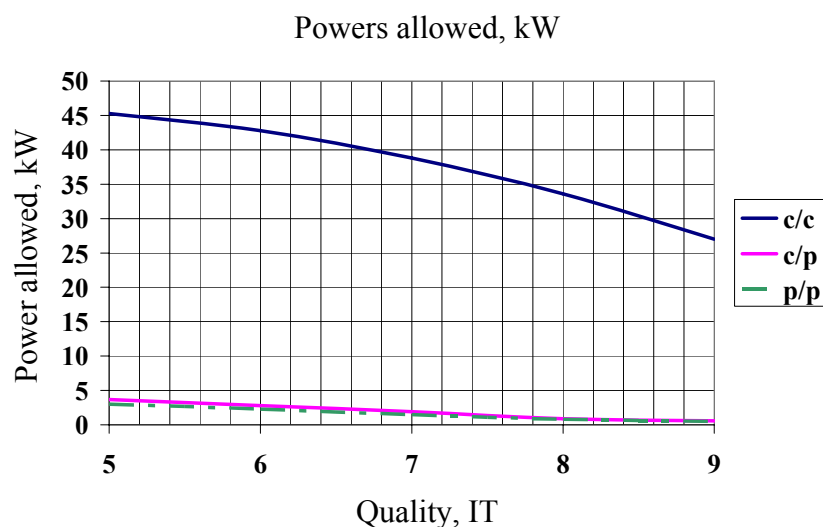


Figure 2. Powers allowed for cogged wheels for gear material and cog quality

3. AN INFLUENCE OF COG QUALITY TO GEARS LOAD CAPACITY

During gear box design, it has to be beared in mind that cog quality selection, with large influence to load capacity of gears, must be connected to costs and technological production possibilities. Cog quality will be appointed through aspects of gear load capacities.

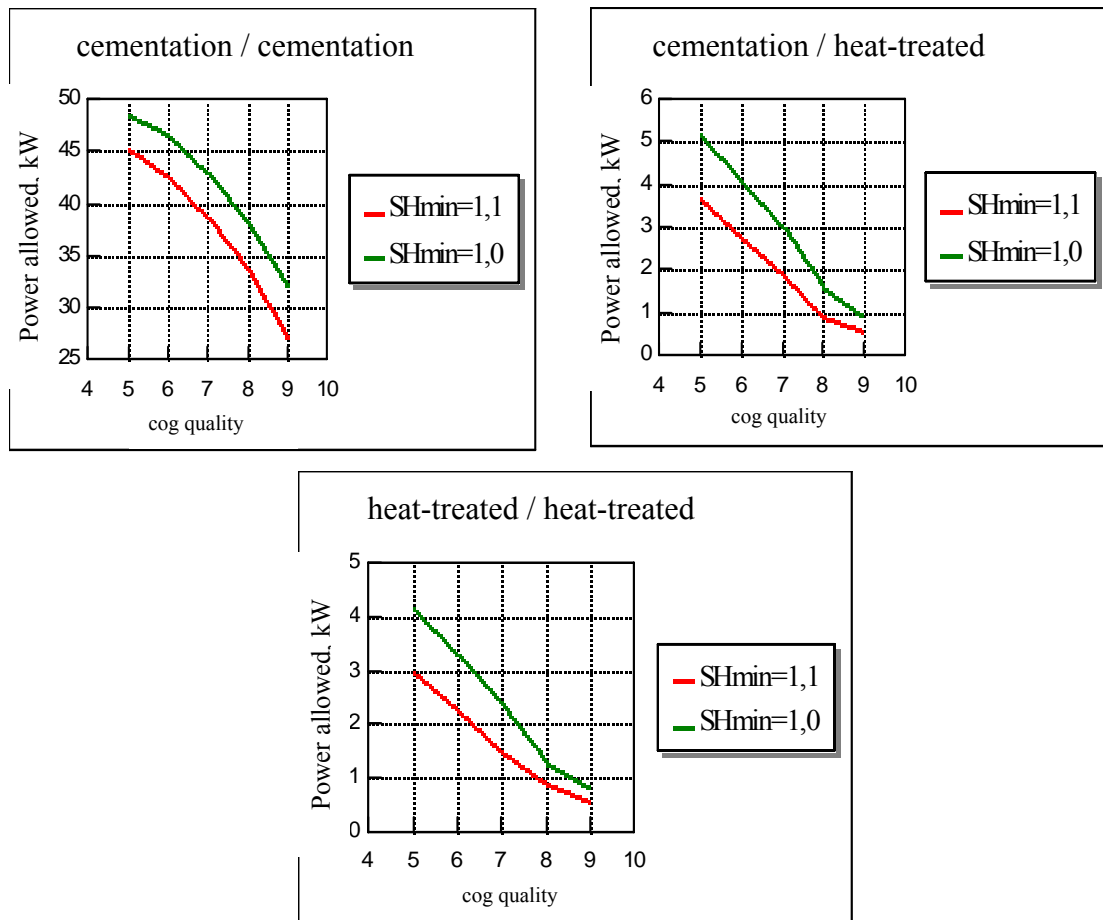


Figure 3. Load capacities for cogged wheels for different gear materials and cog qualities

Load capacity calculation is made using softwer programme [1] for gears with same basic parameters, width and number of revolution, as in Chapter 2, but with use of other safety factors for face and fillet of cog: $S_{Hmin}=1,1$ i $S_{Fmin}=1,0$. Load capacity calculation is made for different materials. It can be noticed from Figure 3 that there is a large influence of cog quality, [4,5].

Total review of load capacities for different material qualities and cog qualities is shown in Table 2.

Table 2. Load capacities for different qualities and material groups

	Gear material		Load capacity (kW)		Ratio P_5/P_9 (%)
	Z_1	Z_2	P_5	P_9	
C/C	Cementation steel	Cementation steel	45,3	27	170
C/P	Cementation steel	Heat-treatable steel	3,7	0,6	600
P/P	Heat-treatable steel	Heat-treatable steel	3,0	0,6	500

Load capacity increase due to cog quality increase is the most expressed proportionally for material "C/P" (600 %). Proportional load capacity increase from 170 % to 600 % bring some benefits. It means that a rational construction approach, quantity decrease of design material and build-in space may be achieved. It means that investments for technological and control equipment are justified.

4. CONCLUSIONS

For same characteristics, center distance "a", gear ratio "i", gear width "b", material, cog quality, safety factor and number of revolutions of driver gear, gears, which are defined using optimisation method of basic parameters, has powers allowed up to 30% greater than usually, except for case with same values, Figure 1.

During an analyse of given results related to material quality and cog quality influence on gear load capacity it can be concluded that the best material for use is cementation steel, while the largest increase of load capacity for different qualities can be obtained from combination cementation steel /heat-treatable steel (approx. 600 %).

According to total observations and absolute values, including load capacity increasing results related to material quality and cog production quality, the most acceptable situation is for combination where gears are made of cementation steel (c/c). That combination gives load capacity increase, regarding to cog quality, up to 500 %.

This results are good indications for making decisions for technological equipment investments, as equipment for thermal treatments and equipment for gear cogs polishing.

5. REFERENCES

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