Determining value of K_a in regards to DIN 3990 and AGMA standards

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QUESTION

I'd like to know about the different approaches and factors considered while determining the value of K_a in regards to the DIN 3990 and AGMA standards.

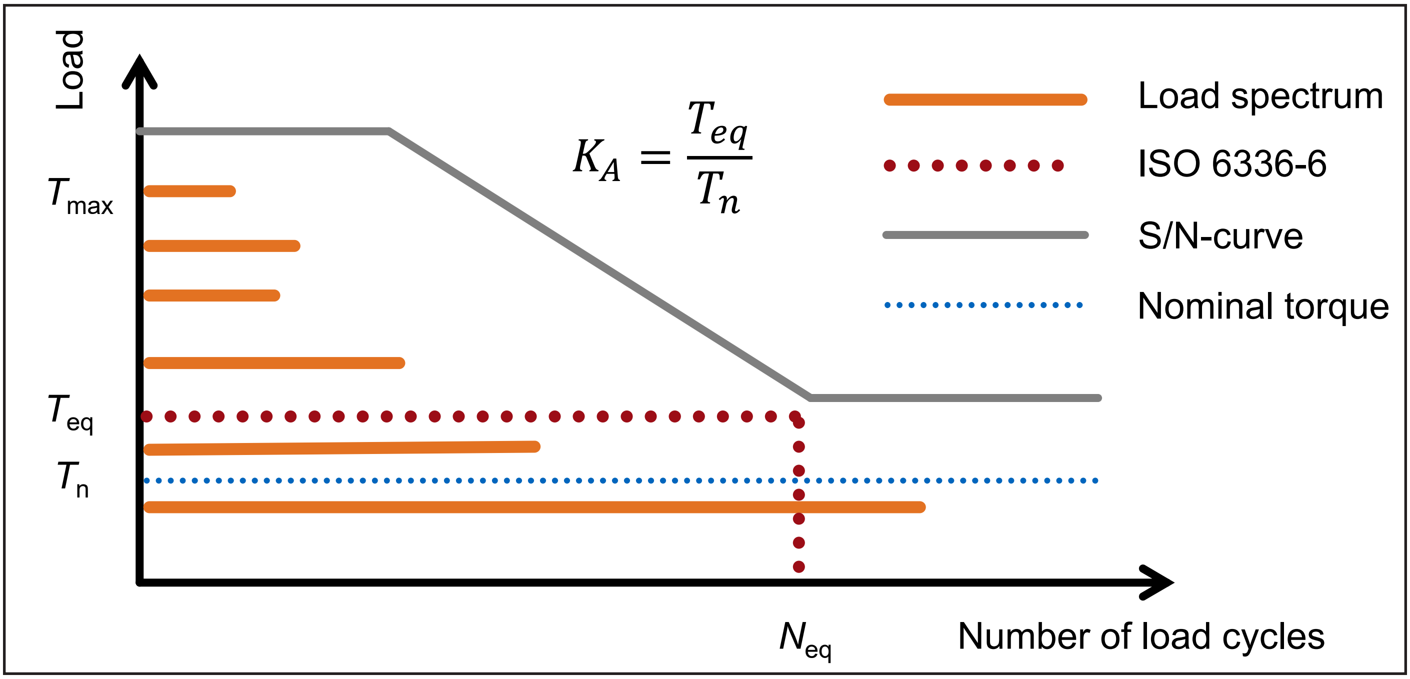
I saw a gear standard sheet in which they have considered K_a=2.0 while considering DIN 3990 standard, and K_a=2.5 considering AGMA Standards.

I also would like to know about the significance and basic approach while calculating K_a from Din 3990 and AGMA, and the difference between both calculations.

Expert response provided by Michael Hein, FZG, head of department/worm gears and bevel gears, fatigue life analysis: DIN 3990 as well as ISO 6336 define the application factor K_A as adjustment factor for the nominal load F_t to take into account all additional gear loads from external sources. AGMA 2101 uses the overload factor K_O instead. This factor K_O is also intended to make allowance for all externally applied loads in excess of the nominal tangential load, F_t, for a particular application.

AGMA 2101 only provides brief advice on how to establish reasonable overload factors for specific applications. According to the standard, all possible sources of overload — like system vibrations, acceleration torques, overspeeds, variations in system operation, etc. — should be considered. It is not stated if the overload factor K_O is supposed to be the ratio between the highest occurring load and the nominal load — or anything in between. There is also no clear indication if K_O is the same value for the calculation of the pitting load carrying capacity and tooth root load carrying capacity.

Application factors K_A, according to DIN 3990 and ISO 6336, can either be determined according to method A or method B, whereas method A is the more precise one. Method A uses load spectra which are determined by means of a careful measurement and a subsequent analysis of the measurement data, a comprehensive mathematical analysis of the system or on the basis of reliable operational experience in the field of application concerned. Based on this



load spectra, application factors for the calculation of pitting ($K_{H,A}$) and tooth root ($K_{F,A}$) load carrying capacity can be determined according to DIN 3990-6 and ISO 6336-6, Annex A. These factors are derived from a fatigue life analysis according Palmgren-Miner, with an equivalent torque T_{eq} that represents the applied load spectrum in one single load. Therefore, the slope of the S/N-curve of the considered material, as well as a failure mode-dependent load cycle limit $N_{L\,ref}$, has to be known. The equivalent torque T_{eq} is determined iteratively and is set in relation to the nominal torque T_n for the calculation of the load carrying capacity. The ratio T_{eq}/T_n then is the application factor K_A.

If no reliable data for a calculation of an application factor according to method A is available, DIN 3990 as well as ISO 6336 provide guideline values for K_A. These values are described in DIN 3990-6 and ISO 6336-6, Annex B, but will be moved to part 1 of ISO 6336 in the next revision. These empirical guideline values are dependent upon the working characteristics of the driving and driven machine, and are somewhere in the range of $1.0 \le K_A \le 2.25$. Other values may be used if agreed between purchaser and manufacturer.

The next revision of ISO 6336 will also include advice on how to determine application factors for calculation of tooth flank fracture ($K_{FF,A}$), scuffing ($K_{\vartheta,A}$) and micropitting ($K_{\lambda,A}$) load carrying capacity.

All in all, application factors K_A determined according to DIN 3990 / ISO 6336 can also be used as overload factors K_O for calculation of load carrying capacity, according to AGMA 2101 if no other reliable data is available. The main difference is that application factors K_A according to DIN 3990/ISO 6336 are based on the determination of an equivalent torque T_{eq}. This means that a gearbox loaded by $T_{eq} = K_A * T_n$ has theoretically the same lifetime as in real application with variable loads.

Depending on the used definition of the overload factor, K_O will be equal to or greater than the application factor K_A, $K_O \ge K_A$. If K_O is calculated as ratio between the maximum-occurring load and the nominal load $K_O = T_{max}/T_n$, the calculation will always be on the safe side — but may lead to unnecessarily large designs. If nothing better is known, it is recommended to use an application factor K_A calculated according to DIN 3990 or ISO 6336, instead of $K_O = T_{max}/T_n$ to avoid oversizing.

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