Systematic Gearbox Sizing and Verification

Calculation of machine elements such as gears, shafts, bearings and shaft-hub connections must, more and more, be carried out faster and in even larger numbers, entirely comprehensible and, at the same time, be better documented. The design engineer must “sell” them against internal resistance and to external customers; results, calculation models and assumptions should be presented in a clear and comprehensive way. Although the time pressure increases, the susceptibility to errors during the exchange of data between individual calculations, calculation and CAD platforms must not increase during the whole project term. Customer wishes for changes involving alteration of the constructive implementation of a task are on the order of the day, and multiple calculation steps with reworked assumptions are requested. These increasing demands require a calculation tool which permits, time and again, a quick, sure and still comprehensive sizing of multiple stage drive trains. The graphic, tabular and textual display of the results is of the utmost importance because the designer must have the report writing task simplified and the propositions presented to the customer in a user-friendly way. Through a combination of the KISSsoft machine element design software and the KISSsys system software, the calculation engineer has at his/her disposal a tool that, within the team, solves the stipulated tasks with the required degree of detail in a timely and verifiable way.

The task designation

Classes of machine element software

The classic design of machine elements based on formulae, especially for gearbox construction, not always represents the state-of-the-art of technology. Numerical approaches are selectively used only, because the field experience and measurements integrated in the formula structures allow a swift and accurate component sizing without having to fall back on the time-consuming numerical models. The extensive standardization effort, especially those of the DIN Standards, of world-wide recognition, can be relatively well reflected in the software; however, the market for such software solutions is limited and competition is fierce. The software packages offered can be roughly classified in three categories:

I. Software for the verification of a given / already designed machine element: - the first degree of complexity- for a calculation software, the checking of a given machine element according to the standards (e. g. a feather key connection). The number of the
commercial solutions available is considerable and a good dozen products share this market.

II. **Expert system for the sizing and optimization of machine elements:** - the second degree of complexity- since software is supposed to help the manufacturer already at the sizing stage, verification alone is mostly not of much help. Here is where expert systems with their most sought-after functionalities, offer the user solutions to a given problem – e. g. the design of a machine element. Only few products consistently cover this customers' need; however, only the fewest packages offer sizing and look-up functions.

III. **Systems approaches to the analysis of complete systems:** - the third degree of complexity- software packages that deal with the whole system and power trains instead of resolving separate calculations only. The author only knows of three commercial solutions in the field of machine elements / gearboxes, world-wide. Following, one of these systems will be described.

Interestingly, the number of solutions combining the advantages of all three classes is very small; one (the only one?) is described here.

KISSsoft’s machine element design software is conceived to support the user in the sizing, optimization as well as in the verification stages. It covers the entire calculation process, from problem definition down to documentation and, therefore, can be considered as an expert system (category II, above).

Especially the toothing calculation - the most extensive calculation in KISSsoft- cannot be reduced to a proof of strength (as it would have been according to the first degree of complexity); admittedly, this proof is surely necessary and is explicitly asked for, however, it only constitutes a single step in the entire toothing calculation process. The toothing calculation must be understood as a process that, starting at a load determination, looks for an optimum toothing solution, analyses it and produces extensive documentation for the production, quality control and certification.

![Figure 1.1-1 Toothing Calculation Methodology](image)

This process is integrated in the individual KISSsoft calculations. However, KISSsoft looks at individual machine elements in every case without their interaction.

**From the expert system to the system approach**

Therefore, the goal is to offer tools for the analysis of complete systems. However, the constraint that the tool be also suitable for the sizing and verification of individual machine elements should be included, which is not always the necessary or desired purpose of the whole system. Therefore, the user asks for a system software (class III) without having to give up the advantages of the simple calculation software (class I) and of the expert tool (class II).
KISSsoft AG has solved this task definition in a unique way:
- KISSsoft’s machine element design software covers not only the simple verification but also the sizing and optimization costly procedures
- the user can determine the number of KISSsoft visible windows, thus configuring the software according to the particular needs
- with it, KISSsoft can be configured and used as a class I or II software
- KISSsys groups together in a system any number of KISSsoft calculations and, together with KISSsoft, constitutes a class III software solution
- time and again, the user may go back to its trusted KISSsoft calculations, thus minimizing the effort of switching from an expert system to a system solution.

Figure 1.2-1 KISSsoft simple Toothing Calculation Configuration, e. g., for Toothing Verification. It exactly requires three Data Entry Windows only (Tabs: Basis Data, Reference Profile and Tolerances, marked in Red). With this, it corresponds to a Class I Software.
Figure 1.2-2 KISSsoft Expert Configuration, for Sizing and Optimizing. Furthermore, other Calculations (additional Tabs marked in Red), several Graphics are displayed and additional Sizing Functions as separate Windows are activated. With this, it corresponds to a Class II Software

I.e., KISSsoft, as design software for individual machine elements can be used either as a stand-alone solution OR in connection with the KISSsys system add-on. This basic approach, although it combines the advantages of all approaches and offers the user a maximum of flexibility, was hardly ever implemented in the design of machine elements. This circumstance explains the success of the “KISSsoft + KISSsys” tandem.

Figure 1.2-3 KISSsoft and KISSsys Interaction illustrating a System of separate Calculations.
The additional cost of modelling

Characteristically, the operating effort increases from software class I to software class III. Of course, the power flow modelling in KISSsys also takes time and a learning effort. Should or could this not be afforded, there are application libraries offering solutions for standard gearboxes. I.e., not only the modelling software has to be bought but then also the ready-made calculation models must be fed with data for the toothing, shafts and bearings. These instant models were produced on direct feedback from customers and are offered or made available together with the proposed software.

The report therefore deals not only with any desirable power drive modelling in KISSsys but also with the application of ready-made calculation models for standard cases.

KISSsys basic Approach

Machine element design in KISSsoft

The KISSsoft design program was specifically developed for engineers and designers. It simplifies and accelerates the sizing and verification of machine elements under the application of valid standards like ISO, DIN, AGMA, etc.. The construction process becomes essentially more efficient, particularly by considering most different design variants. KISSsoft’s versatility is used in the most different areas, such as, industry transmission mechanisms, energy production, car manufacturing, printing and textile machinery, precision mechanics, etc.

Standard packages for various areas form the basis of the extensive software. Expert add-ons to the standard packages expand the system there where you need it. Refined sizing and optimization algorithms and most different interfaces to CAD platforms simplify the entire manufacturing process and guarantee obtaining the required component safety.

The entire design program is modularly built, i.e., a customer can really acquire exactly as many KISSsoft modules as needed.
KISSsoft performs the analysis of the following machine elements:
- spur gears: outer and inner toothings, herringbone toothings, planetary sets, gear trains, pinion / rack sets, individual gears,
- bevel gears, worms and worm gears, bevel face gears,
- shafts, axles, beams,
- rolling bearings, hydrodynamic axial and radial journal bearings,
- screws, bolts, pins, glued, soldered and welded joints,
- feather keys, splines, serrations, polygonal shafts, cylindrical and taper interference fits
- springs: Belleville, extension and compression springs, torsion rods and springs,
- Tolerance analysis, hardness conversion, local tension evaluation, Hertzian stress,

The calculations follow conventional Standards (DIN, ISO, AGMA,...), Guidelines (VDI, FKM,...), literature (Niemann, Winter, Haibach,...) as well as own methods. Approximately 1100 installations world-wide confirm the practical suitability of KISSsoft.

**Concatenation of several KISSsoft calculations in KISSsys**

With KISSsys, a software commercially available since three years, the power flow in the power trains can be calculated and linked to a strength calculation of the power train’s machine elements. It is thus possible to parameterize entire gearboxes / power trains and analyse them concerning strength and life time. Among other things, KISSsys allows the user to quickly carry out elaborate parameter studies of entire gearboxes / power trains and efficiently compare different design variants. KISSsys uses KISSsoft for the strength and lifetime calculation of the various machine elements. KISSsoft is a CAE software for a fast and secure sizing, optimization and verification of machine elements such as gear wheels, shafts, bearings, screws, shaft-hub connections and springs. KISSsoft is aimed at the user in the transmission construction area and is well known for its varied optimization possibilities. The use of KISSsoft in the wind energy area, for instance, is described in [6]. KISSsys, as system add-on to KISSsoft offers following features:

**Kinematics Calculation:**
- power flow / speed with spur, bevel, worms and face gear stages,
- modelling of rotational mechanisms (planetary, Ravigneaux, Wolfrom,...),
- differentials, (with bevel or spur gears), chain and belt transmissions,
- couplings can be activated and deactivated, slippage taken into account,
• outer loads applied to the system taken into account.

**Integrated strength and lifetime calculation:**
• to do this, KISSsys accesses KISSsoft,
• bearing stiffness, transmission error, profile modification, efficiencies.

**3D-models:**
• automatic 3D-display (based upon the data defined in KISSsoft),
• 3D-model export to CAD platforms, mechanism housing import, (-step / -iges),
• checking for collisions.

**Special features:**
• calculations with load spectra for all machine elements in the model,
• different mechanisms variants in the same model,
• automatic documentation (proof of strength) for the entire mechanism,
• integrated programming language for implementation of special functions.

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![Figure 2.2-1 KISSsys Environment with Tree-structure, Kinematics, 3D Display Menus, Tables and Dialogs.](image)

**The calculation procedure sequence in KISSsys**

The KISSsys strength calculation procedure is displayed in Fig. 2.3-1.
Figure 2.3-1 KISSsys Calculation Schematic.

The calculation model allows the calculation
- with a nominal load,
- with a load spectra
- with a single load from the load spectra
Results are either directly displayed in KISSsys in tabular form or can, for instance, be exported to Excel as text. Safeties, lifetimes, as well as individual damages will be identified. The essential basic functionality is that KISSsys calculates all forces, torques and meshing powers from the kinematics and passes over these loading data as input to KISSsoft. Afterwards, the individual KISSsoft calculations are carried out and the obtained results exported back to KISSsys for the purpose of being clearly presented.

Global variables, i.e. settings valid for all KISSsoft calculations, for example, lubricant temperature (used in all gear and bearing calculations) can be centrally input from a table, see Fig. 2.3-2 Settings.

![Figure 2.3-2 Calculation Parameter Entries.](image)

### Creating your own KISSsys Models

#### Model creation procedure

Creating a calculation model in KISSsys involves following steps:

1. Planning the model, defining system boundaries
2. Defining machine elements such as shafts, bearings, gear wheels and connections to be considered in the model
3. Interconnecting machine elements to show the power flow
4. Linking machine elements to the corresponding KISSsoft calculations
5. Summarizing display of results and input data into tables
6. Programming user-specific functions by means of the integrated programming language
7. Testing the calculation model

Establishing your own models implies an introductory training, especially when more complex drive trains are to be modelled. Time taken for modelling depends upon the user's experience; practice shows that the time effort will drop with the experience. All machine elements, their connections, the appropriate KISSsoft calculations as well as tables for displaying the data, will be shown in the form of a tree-structured architecture. The elements used, are copied / input from / to a library.
Tooothing, shaft geometry or bearing data, are defined as usual in KISSsoft. The schematic display results from the machine element disposition and the interconnections within the tree-structured architecture and shows also the power flow.

Experienced users can either create their own libraries or expand existing ones. This permits accelerating the modelling procedure.

**Example: tractor gearboxes**

Imagine a tractor gearbox with approximately 300 possible kinematic conditions and ten load cases. Then, for about 50 components, approximately 3000 calculations must be carried out and dealt with. In a calculation, how can it be guaranteed that the loads are correctly handed over from a component to the next? When modifying single components, how can it be guaranteed that, all other affected elements will also be recalculated? How could such a task be managed in case of using individual calculations?

In KISSsys, these many load cases and calculations are handled for single components so that all calculations can be simultaneously controlled. Naturally, a calculation of a tractor gearbox especially with the application of load spectrum, needs time; the calculation time of such a
project can definitely amount to an hour. However, the advantage is that it can clearly summarize in tables all lifetimes and safety factors. The results can also be exported to Excel where they could be graphically displayed and evaluated in detail. Any desired load spectrum can be calculated, should they be based upon measurements, synthetically or as test stand spectra values. Under application of these spectra, the user can run virtual tests and compare the calculation results with his/her experience.

Figure 3.2-1 KISSsys Models of a Tractor Gearbox. Above right: the complex Kinematics
Example: crane gearboxes

A German gearbox manufacturer, with development and production located in China, uses the services of KISSsoft Inc to enhance sizing in the development of a crane gearbox. Upon consultations and, following the customer requirements, the gearbox is modelled in KISSsys and, once this task is finished, the user can take the data directly from KISSsoft Inc. (sending a KISSsys model per e-mail presents no problem due to the data file small size, <1 MB).

The complex kinematics of this type of industrial gearbox, having two power inputs, allowing for the independent control of both outputs. During the gearbox sizing, different boundary conditions concerning shaft distances and tool selection are to be observed. The use of the KISSsys model permits a fast calculation of various occurring load cases. The 3D display allows a continuous checking for collisions that could easily occur on account of the scarce space available. Another advantage appeared just after conclusion of the project. Due to manufacturing requirements, the toothing had anyhow to be modified after the construction was finished. The checking of this modification ought to take place within half a day. This was absolutely no problem since the calculation could be quickly reloaded, the modified toothing data introduced, the calculation repeated and automatically documented within minutes. The fact of having all components (not only toothings but also shafts and bearings) affected by the modification in a single file helps managing and permits a swift access to the calculations. In the meantime, the gearbox is finished and the customer confident of the KISSsys application.
Figure 3.3-1 KISSsys Gearbox Sizing Model.

Figure 3.3-2 Left: The Crane Gearbox is manufactured in China by a German Gearbox Manufacturer for the local Market. Right: KISSsys 3D Gearbox Representation.

**KISSsys Model Libraries**

**Advantages**

The creation of calculation models in KISSsys requires a certain time and demands a systematic learning of the software. Users who cannot, or do not wish to invest this time, have the possibility of working with ready-made models. The number of stages, shafts and bearings as well as the gearbox kinematics are then pre-determined. The user can then quickly input tothing data and shaft geometries as well as the matching bearing types. The completion of the calculation model is then quickly finished and the gearbox, in its entirety, available for the calculation.
Industrial gearbox library

With the new GPK product based on KISSsys, the designer has a tool at its disposal permitting the calculation of complete industrial gearboxes. Instead of working with several separate calculations, the entire gearbox is considered as a unit and the calculation takes place simultaneously for all gears, shafts and bearings. With it, calculation and manufacturing will be more narrowly brought together, thus minimizing the time-consuming and error-prone exchange of data. The integrated estimate of costs allows the calculation engineer to keep an eye on the costs and the extensive reporting functions ensure that the work can be quickly documented according to the established quality guidelines.

The GPK gearbox calculation package also constitutes a valuable help for sales support: in case of customer special requirements, existing gearboxes can be recalculated and reports produced within minutes. With it, the sales force is in a position to answer customer inquiries of technical nature in real time and precisely documented. All calculations are based on the acknowledged and well widespread KISSsoft software and in accordance with the current DIN/ISO/AGMA Standards. This guarantees that the calculations produced with the GPK gearbox calculation package will be immediately accepted by both internal and external customers. At the moment, with the GPK gearbox calculation package, you can calculate multi-stage spur and bevel-spur gearboxes; further types will follow.

The advantages of using the GPK gearbox library are in particular:

- **Cost-efficient manufacturing:** in GPK, the cost of the gearbox (without casing) is estimated simultaneously with the sizing calculation. It is also possible to store in GPK manufacturing empirically established values / information to kilo prices for toothings, shafts and pinion shafts.

![Figure 4.2-1 Left: Five stage helical gearbox. Right: Bevel-helical gearbox.](image)

![Figure 4.2-2 Left: Costs Factors Input. Right: Global Settings](image)
• **Complete gearbox calculation within minutes**: verification of an existing gearbox with modified parameters or new load values, takes only a couple of minutes - start KISSsys, load gearbox file, modify toothing or load data, carry out the calculation and documentation printout.

• **Prompt and accurate reaction to offer enquiries**: on the everyday business, customers expect that the gearbox manufacturer would be able to quickly give information about the approximate size and weight of a gearbox. With GPK it is also possible the quick sizing of entire gearboxes and estimate the resultant weight and main dimensions (without casing).

• **Automatic documentation generation**: KISSsys takes on the production of the calculation reports. The user can choose, whether to have a summary of the calculation (e.g., for their customers or as cover sheet to the project document), or whether a complete report should be produced. The latter documents all calculations in a more detailed way and thus guarantees that the work will be quickly, precisely and comprehensively documented.

![Figure 4.2-3 Left: Summary Report. Right: More comprehensive and detailed Calculation Report.](image)

• **Intuitive graphics and a clear presentation of results**: GPK permits an impressive presentation of the calculations; already in the sizing stage, all participants can have an idea of the design. As a result, the calculation engineer’s work gains in credibility and will be more comprehensible also for non-experts.

![Figure 4.2-4 Clear Graphics on the Collision Checking and Documentation](image)
• **Simplified data management**: instead of having, like until now, to manage e. g., a four-stage gearbox with five shafts and bearings, as well as four toothing calculations (resulting in some 20 separate calculation files), with GPK there is only one single file. This is much more clear and the designer must not anymore lose time on which file belongs to which development condition of the design.

• **Work as in KISSsoft**: GPK falls back on KISSsoft for the calculations and data input. Consequently, it is secured that the user quickly finds the way around in GPK. Existing KISSsoft files can be directly called so that, for example, entire gearboxes can be assembled in GPK from existing single part KISSsoft files. GPK data can also be stored as KISSsoft files.

• **Direct transfer of the data to your CAD platform**: after gearbox sizing or verification, the user exports the 3D data as a -step file and can directly read it again in the CAD system.

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**Wind turbine gearbox library**

The current guidelines issued by the German Lloyd or the Det Norske Veritas are to be observed when sizing and verifying wind turbine gearboxes. On the other hand, these refer to valid Standards such as AGMA 6006, DIN 743, DIN ISO 281 or AGMA 6123, covering the calculation of toothing, shafts, bearings and coupling elements. Knowledge of these directives and standards, experience in implementing the calculations as well as understanding of the physical processes in a wind turbine, are prerequisites for the sizing and verification of gearboxes according to the state-of-the-art technology. This must be observed by all involved parties such as gearbox suppliers, installation manufacturers and certification experts. With it, there is the demand for a praxis-oriented and up-to-date software tool, with which the necessary calculations could be surely executed and permitting the data exchange between the companies involved.

Within the framework of several engineering projects and many-sided customer wishes, a library was created with the most frequently used wind turbine gearbox types. It allows the users to quickly find their way in the complex calculation world of wind turbine gearboxes. The models can be adapted by the users to their specific manufacturing data and are usable by both gearbox users (wind turbine manufacturers), as well as by builder (gearbox designers). In addition, they facilitate the gearbox-specific data exchange among component suppliers, gearbox- and installation manufacturers and certification experts. The models were produced in cooperation with installation manufacturers; this and the user-oriented documentation, guarantee their practical suitability.
Figure 4.3-1 Wind Turbine Gearbox Library: Above left, one Planet Stage, two Spur Gear Stages. Above right: two Planet Stages, one Spur Gear Stage. Below left: Differential Gearbox with three Planet Stages, one Spur Gear Stage. Below right: Planet Stage with one fixed Planet, one Spur Gear Stage.

Export to CAD

**KISSsoft export to CAD**

The KISSsoft modules for the calculation of toothed wheels have built-in interfaces to the most common CAD platforms, (such as SolidWorks, SolidEdge, ProE, UG NX3/4, Catia SolidDesigner and Inventor). Thus, at the pressing of a button, the calculated gear wheels done in KISSsoft from the gear tooth profile can be generated and displayed in the CAD platform. With this, the costly manual parameter input or transfer is eliminated. Following gear geometries are supported:

- Inner and outer spur gears.
- Inner and outer helical gears.
- Worm gear sets.
- Worms
- Bevel spur gears.

The manufacturing of toothed wheels can take place in several ways. A gear can be generated for an existing construction or, simply, as a new part. Toothed wheels are generated by Polylines or by arc of circle approximation. KISSsoft interfaces are available in German, English, French, Italian and Spanish. The exact tooth profile is generated by manufacturing simulation. On this basis, spur, helical as well as inner toothings are generated in the CAD platform. In addition, it is possible to place several toothings on already existing shafts. The admissible form deviation is implemented in the KISSsoft calculation and is also taken into account in the 3D display. The production and the calculation data are directly attached to the
tooth profile. With it, the user can also immediately pass all relevant production data onto the drawing. Through selecting of a tooth in the CAD, one can comfortably go back into the calculation, where the required alterations can be performed. This function guarantees that, from the wheel sizing down to the production, one can fall back on all necessary information without any loss of data.

Neutral interfaces in 2D and 3D formats complete the CAD-specific export functions.

Figure 5.1-1 Gear geometry direct Export to various CAD Platforms, as 3D-model or for the 2D-drawing including gearing data.

**KISSsys export to CAD**

For required space evaluation, collision tests and a quick CAD model preparation, for instance, at the offer stage as well as for the presentation of the constructive solution to the customer, a KISSsys model may be directly exported to a CAD platform by means of a neutral interface. Although, the model shows a simplified geometry, the main measurements however, are exact.

Figure 5.2-1 KISSsys exports a Model to a CAD Platform through a neutral Interface.
Outlook

KISSsoft’s further developments

New user interface
At present, KISSsoft’s user interface is being massively improved:

- Help function integrated in a browser.
- Project and file administration.
- Export possibilities for graphics and reports.
- Consistent use of symbols and formula symbols.
- Possibility of having several graphics simultaneously open.
- Possibility of blocking graphics for variant studies.
- Improvements in the toothing sizing.

Figure 6.1-1 KISSsoft’s new graphical User Interface.
Planet set calculation according to VDI 2737

Since some time, the VDI 2737 guidelines for a more economical sizing of planet sets are available to the industry. Following customers' requests, this calculation method is now being integrated in KISSsoft and will be available in the late summer.

Figure 6.1-2 Calculation Steps according to VDI 2737 (Linke, Baumann, Trempler Analysis of Planet Toothing Stress, DMK05).

Load distribution calculation for spur wheel toothings

The load distribution calculation for the synthesis of appropriate corrections is at present being developed in KISSsoft. Taken into account are bearing deformations / displacements, shaft deformations, meshing stiffness and tooth profile variations along the toothing width. The update is taking place step-by-step, four of the five steps are ready and the fifth is under completion.
Bearing calculation according to ISO 281-4

Particularly, our wind energy customers ask for a bearing lifetime calculation according to ISO 281, supplement 4. This calculation, takes into consideration the bearing inner structure and calculates how the load on the bearing is in itself distributed upon the individual rolling elements. That also implies the stress distribution along the rolling elements. Comparisons with a reference software showed that the already programmed KISSsoft calculation virtually delivers identical results.

Shaft calculation for statically overdetermined shafts

Contact pattern and bearing force calculations in statically overdetermined systems, require the possibility of calculating shaft systems. Especially, pilot bearings, idler wheels and differential casings must be taken into account. At the moment, we integrate an FEM solver for the calculation of coax shaft systems (up to ten overlaid shafts can be calculated). With it, translational and rotational bearing stiffnesses, as well as clearances, will be taken into account.
**KISSsys’ further developments**

In the first place, KISSsys profits from all KISSsoft developments. Specifically, KISSsys should be extended in the following areas.

**2D graphics**

The user normally avoids Excel for displaying the large quantity of results produced by KISSsys. This step should become superfluous, because the required easy generation of 2D graphics (bar charts and other) are, at present, being extensively developed in KISSsys.

**3D graphics**

Particularly for planet gear sets, the animation of the movement progress deserves special attention. Firstly, the animation stimulates attention and, secondly, it is also used to display the mechanism’s functionality. Further, it serves for checking rotation directions.

**Calculation with load spectra**

Shortly before concluding, the tasks are for an easy-to-use load collective calculation with KISSsys. This new production element allows the calculation of not only safety coefficients but also service lives. It does not restrict the included load collective scope. The function applies to both shiftable and non-shiftable driving stages.

**Improved user guidance**

Especially in practice, some basic points in establishing models showed room for improvement:

- Insertion of elements per “Drag of and Drop”.
- Insertion of comments to individual variables.
- Automatic copying and insertion of variable names and paths.
- User guidance for “Saving / Closing”, etc..

**Summary**

When building gearboxes, the engineer must simultaneously keep in mind the mechanism construction points of view as well as the mechanical strength of all components. Neither CAD systems, nor most of the software packages available in the area of designing machine elements, can approach this double role satisfactorily.

With KISSsys, the system add-on to KISSsoft, the individual machine elements are no more independently sized, but a whole system (gearbox, transmission), free of individual elements (shafts, bearings, toothings) is established and calculated. The primary sizing functions, like those already existing in KISSsoft, become thereby considerably more powerful: after optimizing an element (for instance, helix angle in a stage), all repercussions on the lifetime or strength of other machine elements (such as bearings, shaft-hub connections) affected by it, will immediately be shown.

Additionally, the checking of space requirements simultaneously with sizing calculations will be possible by importing casing 3D-data as –sat, -step or –iges files. This eliminates the costly and time-consuming CAD system checking of space requirements after every sizing calculation. CAD interfaces for the automatic preparation of drawings for the production of gears, including stamping dies, round up the cooperation with the currently available CAD systems.

Through this combination of sizing calculation and cooperation with the CAD system, the designer is given a CAE system that comes very close to the established requirements.
This system-based approach, besides the interconnection between sizing calculation and CAD system, offers further advantages such as, for example:

Due to the parametric construction of the whole gearbox model, changes can be easily introduced and compared, for example, regarding costs, dimensions, space requirements or efficiencies. Through an integrated programming language, it is possible to automatically carry out sensitivity analyses that permit to clarify whether a construction with the established assumptions will be prone to calculation errors.

Since KISSsys already includes, not only the kinematics, strength and space requirement calculations but also a freely programmable preparation of the results and reports, the use of further calculation and display tools (Excel, MathCAD,…) is, to a great extent unnecessary. The error-susceptible, unproductive costly and time-consuming exchange of data between the various calculation tools previously used by the gearbox designer originally is thus eliminated.

Since all concerned gearbox calculations are contained and managed in a unique file, it is thus guaranteed that all calculations will always be at the same status level. This also simplifies the exchange of data among the different project partners.

Ready-modelled and sized gearboxes can be stored on a server constituting a product database. The administrator mode permits the data to be protected by setting the files as read-only. This allows, for instance, sales and marketing access to the data to be able to swiftly answer customer-specific questions on the gearbox strength and lifespan.

With this system software, the work of the gearbox designer will be accelerated, simplified and less error-prone and, in the end, more interesting and satisfactory. This statement is confirmed by its success in the practice at the leading industry gearbox manufacturers. It turned out in several projects that, especially by executing variants and serial manufacturing, valuable time was saved by using a calculation model for the entire gearbox with the clear advantage of examining more variants in the same time.

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