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CAD-3D – complex tool for product development

With construction examples from agricultural engineering

The higher efficiency of the CAD system shortens the complete construction process and offers more time for creativity. It offers faster solutions and a higher standard of agreement between everyone involved in the development process. It allows interim results to be discussed by team members in planning meetings with the help of visualisation tools and thus helps in creating new ideas and in the distribute of tasks. Computer-supported simulations will continue to expand. The economy of the system involves a niveau of high costs as well as efficiency. But investments in the system pay.

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Keywords

Product development, CAD, CAD-3D, 3D-modelling, EDM/PDM-systems, digital-mock-up

CAD-2D systems have been used since the late 60s. In those early days they offered suitable solutions for the then existing industrial processes.

Nowadays many CAD users are on the threshold of stepping-up to a 3D system. [1, 7]. The transition to modern 3D technology is being carried out by many firms in well-defined steps so that the proportion of 3D constructions is increased step-by-step inline with the increasing knowledge and experience of staff. Only a few companies working exclusively with the 3D technique. Most work with a combination of mainly CAD-2D systems and successive development of the 3D system with which the constructors become gradually acquainted. Globally seen – expressed in the number of instruments as well as operational hours – the construction departments of companies surveyed have been so equipped on average:

- around 1% with conventional drawing boards
- 78% with CAD-2D systems
- 21% with CAD-3D systems

Currently CAD-3D is most suitable for the modelling of complex components and component groups. Companies often begin with the introduction of 3D systems for the presentation of especially difficult geometries of selected component constructions.

In the next step, most 3D users utilise the advantages of 3D modelling mainly in the assembly of component groups or for the conducting of complicated calculations or analyses.

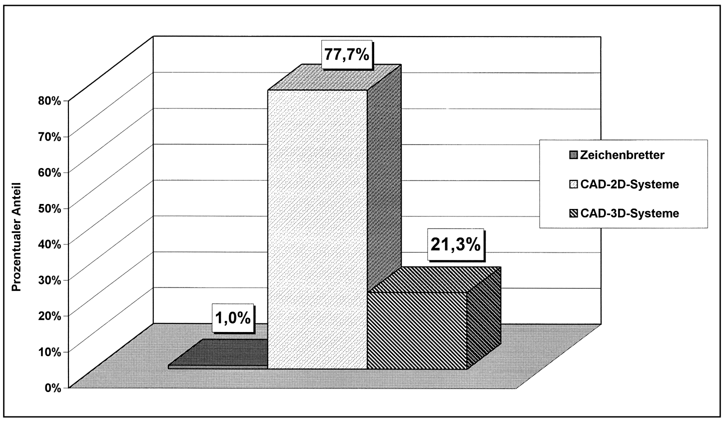

Fig. 1: Technical equipment

Certainly, an increase in product development productivity can be achieved through the gradual introduction of 3D systems. On the other hand, a loss of productivity threatens when there is a too abrupt change from 2D to 3D construction. The technology changeover must be thoroughly thought-out and prepared for. 2D constructors with indispensable product know-how must change their methods and accept new working approaches. Internal routines must be adjusted. There's hardly an entrepreneur that can afford a stagnation of product development, not to mention a drop in it, even when this is perhaps only fleeting. The changeover to modern technology misses its target as soon as it leads to losses. These occur the moment product development doesn't run smoothly. Where the transition from 2D construction to 3D modelling is gradual, then the risks are foreseeable. The CAD user must recognise that a volume modeller in comparison with a 2D system is basically completely another tool. In many cases, the development of a complete volume model takes longer than the geometrical definition with a two-dimensional system [1].

The process which runs from the emergence of a product idea through to the finished object is often long and intricate. It leads from the first sketch over drawings, assembled parts and the creation of a prototype through to the NC production of the compo-

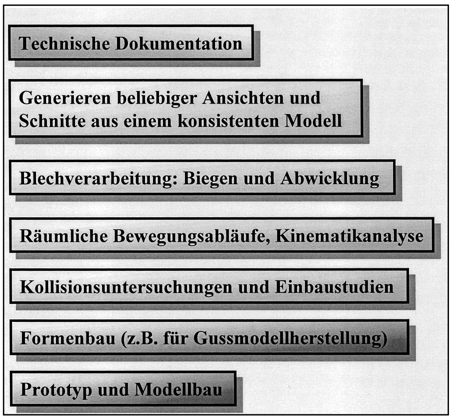

Fig. 2: Fields of usage for volume systems

nents and their assembly. Put simply, two worlds meet at this point. One is the world of the constructor who designs and measures the components with the CAD system. The other features the assemblers which have to translate the finished plan into practical reality. A practical CAD system must enable the constructor to sketch out the basic moves of the construction starting from the desired function, and to analyse the way it functions from a simple abstract model [3].

Further, a detailed rule book has to be created which tells the constructor which construction details such as screws, bored holes, tongue breadths or „freistich" forms he or she may include. This is why CAD and EDM systems should support the user with regard to these rules. Thus, e.g., construction limitations and regulations in the form of macros are able to be integrated or amalgamated into a utilisation programme with the help of features including suitable parameter lists.

With modern CAD/CAM systems these functions are supported by libraries in which information over the present machines, tools and materials are stored. Through this, the constructor can exclusively use the element or object which can also be produced with in-house machinery and tools. Thus, not only is the use of own-resources optimised but the manufacturing costs can be estimated with greater precision.

A part of the CAD system available today offers support in the development of cast metal and rolled metal parts in that information over the material to be used and manufacturing method is made available to the constructor during the modelling. Such know-how from the CAD systems is, however, not available with most production methods so far. Here, there's a great need for further development in the direction of knowledge processing.

Cost calculations

The costs to be expected for the developed product are a very important factor in all construction decisions. In most cases the link between modelling or drawing of a component and the calculation of manufacturing costs is missing in the construction procedure. Often this calculation is even carried out by another department. The costs of a component are, e.g., based upon the measurements of the material used, the tolerances and the type of surfaces, the numbers, the machines required for production, labour and running costs involved in the manufacture. Some of this data can be taken directly from the CAD model. In association with a databank in which are stored, e.g., known machine costs in production, a very exact estimate of the costs can be reached, especially in the case of construction alterations. Individual CAD systems offer so-called „Construction note books" which enable the constructor to record details of the product to be developed and to document decisions. Additionally, structuring and indexing are necessary to achieve a generally usable system. Engineers spend a great deal of their working time in reprocessing earlier results or seeking earlier information. The possibility given to the constructor enabling the accessing, the archiving and recalling of the total breadth of construction information offers substantial repayment in terms of construction efficiency and quality [3, 4].

Where 2D systems are applied the user can, when in doubt, „cheat" or simply leave details out. But a volume modeller demands complete and precise geometrical description. Additionally a volume modeller requires much more hardware capacity than a CAD-2D system. This aspect, however, increasingly reduces in importance in that the price of appropriate hardware platforms with similar performance capacity halves about every 18 months.

The main advantage of a volume model lies in the minimum danger of false interpretation. Additionally data produced once can be further processed for other applications without problem. Through appropriate planning and targeted training this technology allows processes to be substantially optimised.

In the 2D world, a drawing accompanies the complete production cycle and is repeatedly consulted for interpretation. With 3D, the volume model is the „product core". Here, drawings represent only one possible presentation platform. Different calculations can be directly carried out on the basis of the volume model to discover, for instance, the mass properties. And this model also allows much better appreciation of the overall appearance and functional potential of a product and allows it to be better understood by the developer. Mistakes can thus be recognised early on-screen, and not first with the prototype [3, 5, 7].

Data administration

Application of CAD-3D tools does, however, throw up a few questions with regard to data administration because there's a lot more data to handle compared with in the past. Further, the method must be exactly defined and documented in 3D construction so that different users can work on it independently. At the same time as 3D introduction it is crucial to recommend that standards for the development of a model, for the use of libraries, construction elements and for the identification of components, component groups and other parts be established because a standardised approach notably eases further-processing work and the re-utilisation of the model. Because much more calculation capacity is required for volume modelling than for 2D systems no savings should be made in hardware equipment because the more complex the component to be constructed, the more calculation capacity is required. Here, additional memory capacity (RAM) is often more important than increased processor performance. Often, however, poor productivity with the software can be traced to the network applied. Urgently recommended is testing with own product data the performance capacity of CAD software on different hardware platforms.

In the meantime, CAD systems can be expanded increasingly more easily and more

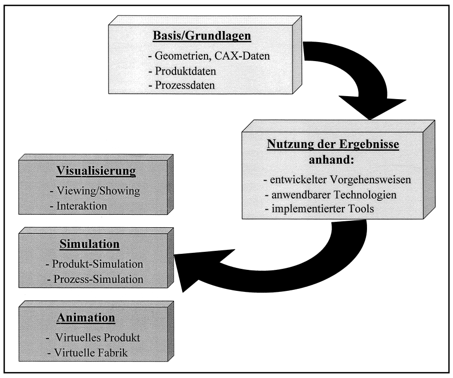

Fig. 3: Possibilities of CAD

comprehensively with additional applications in order, e.g., for a model-relevant calculation or simulation to be carried out. The technological possibilities develop very rapidly nowadays, and in a wide variety, so that a CAD supplier often cannot keep up to the desired extent with developments in additional functions. In such cases, the best solution is often to use specialised suppliers of additional programmes. An exact investigation of systems available regarding performance capacity and compatibility is always advisable, especially where software from different producers has to be brought in [4].

Training indispensable

The introduction of software systems does not have to take place in all departments simultaneously. This means that the integration of volume modelling, EDM/PDM system and Internet/Intranet solutions can be planned and realised at different times. Training is an exceptionally important theme when changing over to a CAD-3D system. The confident use by the user of new tools and ease with changed processes requires intensive preparation. Often, poor training causes many problems. It can drastically slow down economic performance in that it takes representatively longer before a user can work productively with a new system. The availability of a comprehensive and easy to understand online documentation as well as computer-supported training program is thus indispensable. Additional training opportunities can be realised from the manufacturer, dealer, adviser or from inhouse experts. Training and further education must have an important ranking in cost and time planning for the conversion to new CAD-3D software.

The Internet has substantially improved the possibility for communication of graphic information between engineers. Despite all the standards (e.g. IGES, DXF, STEP, VDAFS, SAT) which have developed in the last years, there still remain limitations in data exchange between different systems. The CAD suppliers are agreed in this target and have made notable advances in this direction. However, there is still special work to be done in the optimising of data interfaces.

Electronic product descriptions

The transition from the completion of a 2D drawing to 3D modelling requires, however, more than just starting the system and training the user. New development methods are necessary in that the routine up until now often obstructs successful introduction of this third generation system. Now, the age of complete electronic description through so-called Digital Mock-Up (DMU) has dawned. Already, DMU is described by specialists as the basis for future virtual product and process modelling. DMU is computer simulation of a complete product. It contains all required functionalities required for the support of development, manufacture and maintenance. DMU serves as basis for product and process development and supports communication and as well as decision processes from the first draft through maintenance to product recycling [2].

An input/output evaluation of DMU is only practical when the total production process is considered in that the responsibility for making the data available for the instances involved in the process moves. For instance, the engineering departments have to carry more responsibility for data. Thus, alongside the correct 3D geometric presentation all DMU-relevant variants must also now be introduced. The data that has to be prepared for this is an important component of the engineering department. The basis is the information and data available in the company on the product itself, such as CAD drawings or models as well as data for the production and assembly process. These are prepared and on the basis of project results altered in type and method by company staff so that they meet the demands of a DMU. The possibilities for use are on the other hand dependent on which target group is being aimed at with the application of the DMU and to which problem or task DMU will be applied.

To the possible aims belong, e.g., the visualisation of virtual products in an early planning phase and their publication, or the creation of an independent and worldwide platform for discussion over the draft. A further observation in the direction of product simulation, such as conducting a FEM calculation or other verifications of the product functionality or quality is inherent in the investigation affecting the evaluation of the manufacturability of the product

Application examples in practice

Three construction examples now follow from farm machinery to present examples of special characteristics and strategies of 3D modelling with its multiple possibilities, but also the demanding application methods.

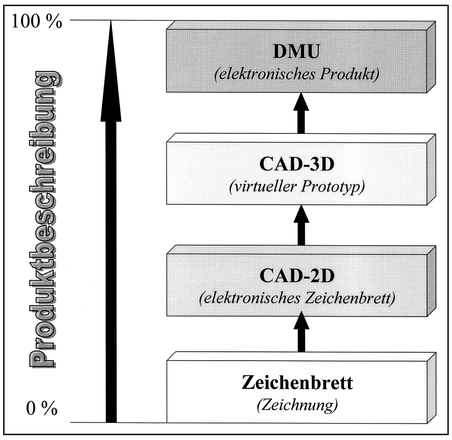

Fig. 4: Development from drawing-board to a virtual product

Development of large tractor by MALI Spezialfahrzeuge

This high performance large tractor is not only suitable for the cultivation of extremely large areas of land from around 1000 ha but has also at the same time enough flexibility for a range of task which up until now were reserved for the so-called self-propelled machines such as the fitting of a 9 m mower, silage harvesting equipment and other special implements. The first conception of the tractor was built only around a required minimum turning circle of 15 m and maximum axle measurements. The 3D modelling of the axles including tyres was therefore the first step. With this ground model, the extreme positions of the front axle were simulated at maximum steering angle of the wheels. This allowed the calculation of possible free room for the full frame which had not only to bear engine, transmission and axle connections but also front and rear hydraulic lifts.

Fig 5: Digital tractor model

The constructors used a parametric action CAD-3D system with which through changing of single parameters all possible variants of the tractor conception could be run through. At the same time, deformation analyses were carried out on 3D models of frame and cab so that the design of rigidity-relevant parts could be optimised as early as the draft phase. Also, the kinematics of the free-hanging front axle with hydropneumatic suspension was able to be established and inspected.

Summary: Only through the help of a CAD-3D system could the total product development of such a hi-tech product be brought to production stage in such a short time. It was used comprehensively in the product development and applying the system pays in much smaller alteration input and a dramatic reduction in the number of prototypes.

Construction example in specialist agricultural engineering

The task was the development and design with CAD-3D system of a vehicle trailer

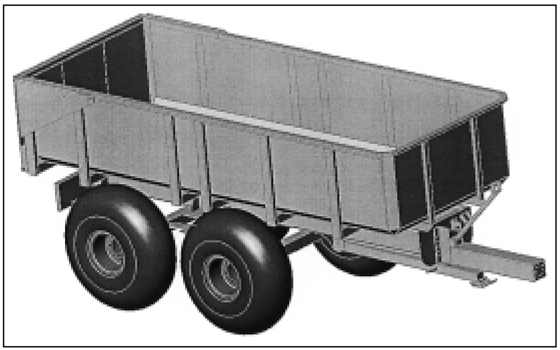

Fig. 6: Digital trailer-model

construction with moulded tipping container [6].

The company aim is to offer individual solutions in vehicle and special machinery construction for customers and this demands an open and component group oriented designing concept. With this it is possible to bring-together different sub component groups into a main component group and to assemble them as customer-oriented project. In this case, as part of a diploma paper, the CAD system Solid Works 99 was used. The planned vehicle trailer with moulded tipping container featured the main component groups:

- Chassis with frames
- Tipper form, and
- Height adjustable hitch shaft with hydraulic stand.

To begin with, a basic vehicle type was designed. Because of the parametric construction of the program different base measurements for the chassis frame could be subsequently modified and, through this, the ground form of the trailer defined according to customer information.

When the concept of the chassis frame is established, then appropriate tipper forms and sizes including a rear flap simulation fitting the design and introduced for the future use of the vehicle, can also be created. In every phase of the construction process the customer can observe reality-near 3D images and thus be informed about concrete details. In this way a precise and detailed job according to requirements is able to be achieved.

Component group drawings with number lists and exploded drawings additionally serve the illustration the assembly method and are used in the assembly as well as later during repair work.

Subsequently it can be established that a CAD-3D system helps in substantially improving the development of vehicle design according to customer wishes. The constructor can offer the customer a thought-through recommendation because, at a very early stage, a reality-near 3D presentation of an object is available. Alterations and design variations can be directly carried out on the concept model through substituting parameters. A detailed picture of the construction helps also in-house, however. The staff involves themselves rapidly and confidently in the product development decision process. But the important point is that the construction engineer can use the CAD system with confidence and can effectively exploit the multiple possibilities. Training and further education must have a high ranking in the utilisation of 3D software.

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