gear data EXCHANGE

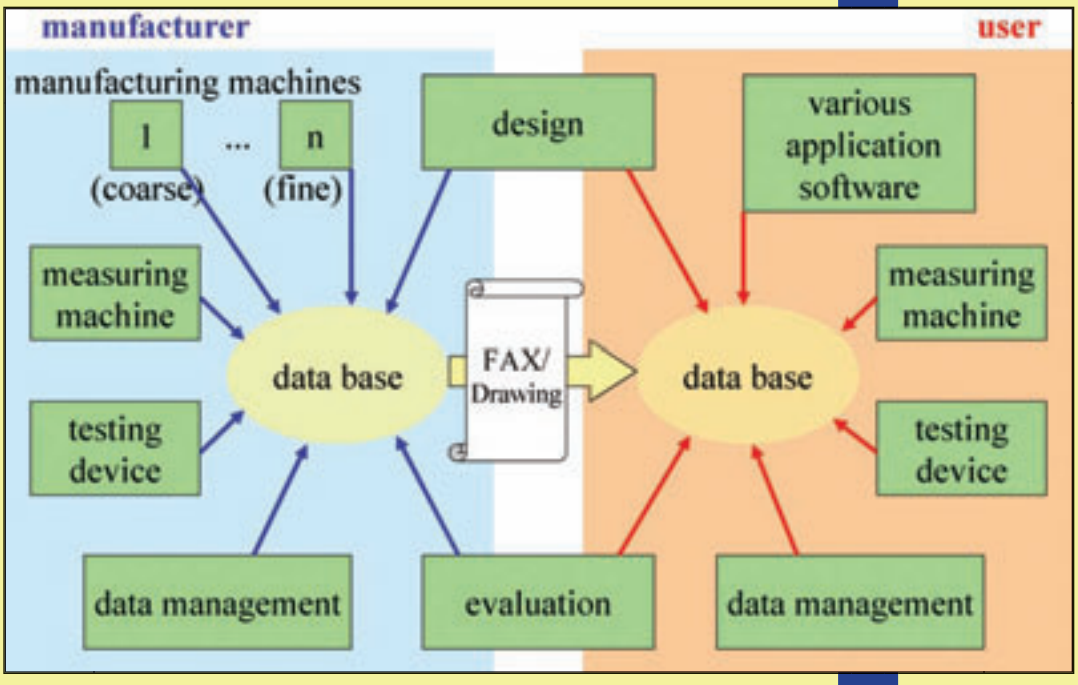

Figure 1—Data exchange between different companies.

Management Summary

The exchange of gear data between design, manufacturing and quality inspection operations is a unique, or individual, solution in many companies, with no conformance between suppliers or customers. So manifold errors or misunderstandings can result when the companies send to each other data sheets printed on paper—especially when they're faxed or when they're photocopies of photocopies of photocopies. Errors or misunderstandings can also result when the sheets are transmitted electronically using nonstandardized file formats.

To improve this situation, the Association of German Engineers (VDI) created a data exchange format for gears in conjunction with the Association for Electrical, Electronic & Information Technologies (VDE). This format allows for the electronic exchange of all geometric parameters for cylindrical gears.

format

by
Günther Gravel and Anke Günther

Introduction

VDI/VDE Technical Committee 3.61 "Measurements of gears and gearboxes" has defined a data exchange format for gears. This format appeared in Germany in September 2003 in a new guideline, supported by VDI and titled "Exchanging format for gearing data—Gear Data Exchange Format (GDE)." It contained the definition of a data format suitable for exchanging electronically all geometric parameters for cylindrical gears—including their modifications and tolerances—between design, manufacturing and quality inspection personnel. This format is based on Extensible Markup Language (XML). It can easily be integrated into most database applications and Internet environments.

The advantages of a coordinated, uniform (standardized) data exchange format are obvious. Additionally, the VDI committee constantly works on a systematic extension of this format, including with regard to gear cutting tools and other processes.

This paper gives, on the one hand, an overview of the GDE format and its specific content and provides a description of a practical application of this new development, which opens up new possibilities. Moreover, it reflects the format's current state of development and its new trends.

Motives and State of the Art

Information about a product today usually consists of large and complex amounts of data which describe the manufacturing process, machines, instruments, semi-finished products and materials involved, as well as the environmental conditions. Modern, highly specialized multi-step manufacturing processes, quality tests and statistical evaluations generally are based on different systems and data processing structures. Data exchange among the companies involved usually takes place through posting of drawings, by electronic mailing of scanned files, or via fax (see Fig. 1).

The data are then entered into a database system, usually by hand. Data transmission problems (arising, for example, in fax communication or during the scanning of model documents), errors made during entry of the data, and a limited readability or incorrect interpretation of drawings may lead to considerable misunderstandings and unnecessary delays.

Inside the companies, the situation is not much better. Data exchange between the individual systems usually takes place via specially developed, expensive conversion programs or, likewise, by time-consuming manual data transmission susceptible to errors. Progressive enterprises have a central data administration system at their disposal. They require defined interfaces through which the interconnected instruments communicate.

Requirements for a Uniform Data Format

With these problems in mind, VDI/VDE Technical Committee 3.61 "Measurement of gears and gearboxes" has specified a data exchange format for gears (GDE: Gear Data Exchange) which allows all data arising in the process of design, manufacture and quality testing to be described and exchanged. Several manufacturers of gears and measuring instruments, as well as members of research institutes, are cooperating to define the contents.

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Anke Günther

is a scientific assistant with the Bremen Institute of Industrial Technology and Applied Work Science (BIBA), a part of the University of Bremen, located in Bremen, Germany. An electrical engineer, she works in the institute's MAQ department (metrology, automation and quality science) developing software for measuring bevel gears. Günther is a member of several DIN and VDI work groups that develop guidelines for gear tolerancing and coordinate measurement, including the group developing VDI's gear data exchange format.

Figure 2—Representation of a GDE file in Internet Explorer.

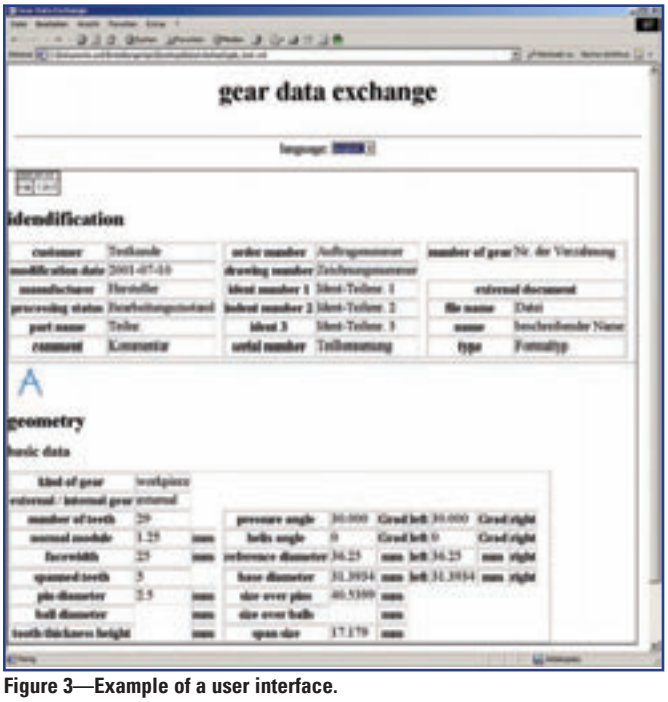

Figure 3—Example of a user interface.

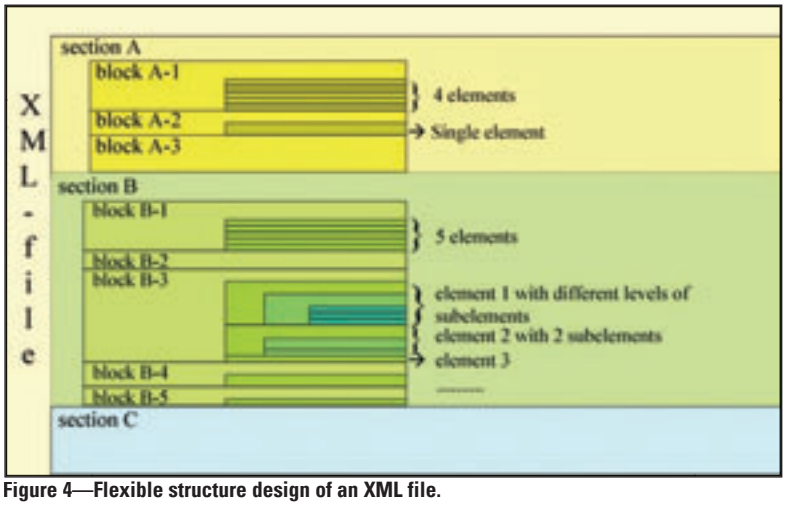

Figure 4—Flexible structure design of an XML file.

Likewise, the AGMA Data Exchange Protocol Committee is developing an information sheet on a system for digital storage and retrieval of gear metrology and related data for cylindrical gears. The committee is scheduled to publish its AGMA information sheet by the end of 2005. During its work, the committee reviewed the guideline on the VDI/VDE gear data exchange format. The AGMA format and its content are expected to undergo a formal ballot in which the committee members may comment.

In the VDI/VDE effort, broad agreement and acceptance are ensured by discussions among manufacturers of machine tools and cutting tools. The envisaged data format makes possible universal, rapid and—above all—safe communication between the different systems and databases. In addition, the format has a clear and extensible structure and may be mapped with readable ASCII characters. All users must, moreover, be given the possibility of representing their individual data in this format (Ref. 1).

When a new data format is designed, the essential questions are which structure is to be used for data description and which tools will make data processing possible. It is desirable and useful to fall back on established products which are widely used. They allow a wide spectrum of users to integrate the data format into their specific applications, with as little effort and outlay as possible. A modern data exchange format which meets these requirements and which is, moreover, suitable for Internet applications is XML.

Characteristics and Advantages of XML

The data format is based on the XML format, a format standardized throughout the world, which is especially well suited for Internet and database interfacing. XML has been developed on the basis of the application of, and the experience gained with, SGML (Standard Generalized Markup Language) and HTML (Hypertext Markup Language). Moreover, XML is a data-oriented format

and thus well suited for the description of complex data types. The structured data are filed as text files.

In addition to being easily readable (clearly structured ASCII text), the format has a structure which makes possible both flexible extension and easy description of user-specific sections. Integration into a database is usually easy, and utilization does not require a license. Meanwhile, it is yet another advantage that all operating systems commonly used are equipped with standard software tools with which the format can be read and processed (see Fig. 2).

A large number of suitable programs is available with which attractive data sheets or user interfaces can be designed to simplify data input. These aids make the direct processing of ASCII files superfluous. Figure 3 shows an example of an interface for data input.

The outward form of such an input interface can be individually designed by every user.

XML permits nesting of the data to any depth. The number of single elements per nesting level can be freely defined. Lacking elements and blank elements are possible (see Fig. 4).

The XML specification allows for separate management of the data structure definition and of the data set proper. The situation in practice will be as follows: VDI makes available a "complete" structure file (gde.dtd) without any data. This file is the definition file for all "valid" GDE data records. Taking this definition file as a basis, every user may design suitable GDE files which he may require to describe his data (see Fig. 5).

If the structure file is extended (by VDI or by user supplements), the data records of a previous structure file will be "valid" even at a later date.

Integration of the Exchange Formats

Another data model for the exchange of gear data is at present being developed, with the emphasis placed on the design of gearings (Ref. 2). This model is based on the CAD interface Step, and the aim is complete mapping of a gearing. Many modern programs for computation, simulation and construction are to be interconnected with its aid. The aspect of describing the gearings in relation to the shaft, which is also highly fascinating with regard to manufacture, inevitably leads to a highly complex data structure.

The GDE format, however, is to make fast and simple data exchange possible and is to support gear manufacture in particular. As the topics covered by the two formats supplement each other very well, there is close cooperation between the bodies concerned (see Fig. 6). After both formats have been introduced and established in the form of directives, it appears reasonable to combine in an ISO standard in the long run.

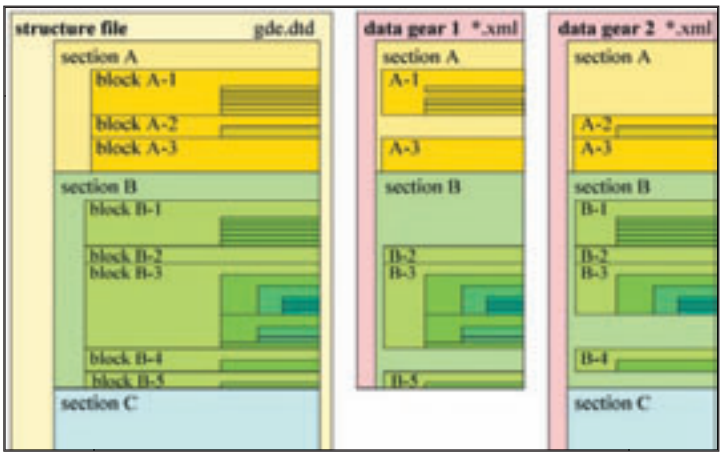

Figure 5—Separation of structure and data.

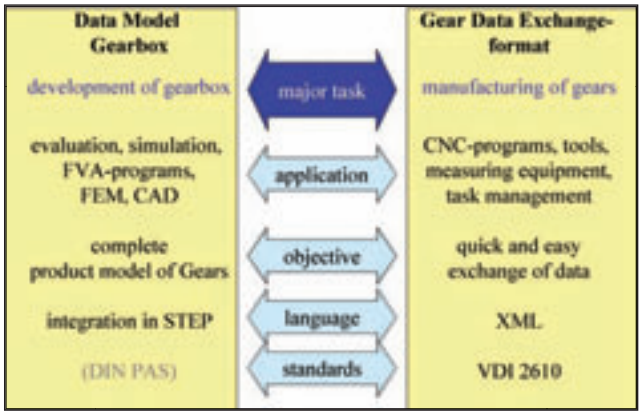

Figure 6—Integration of the data formats.

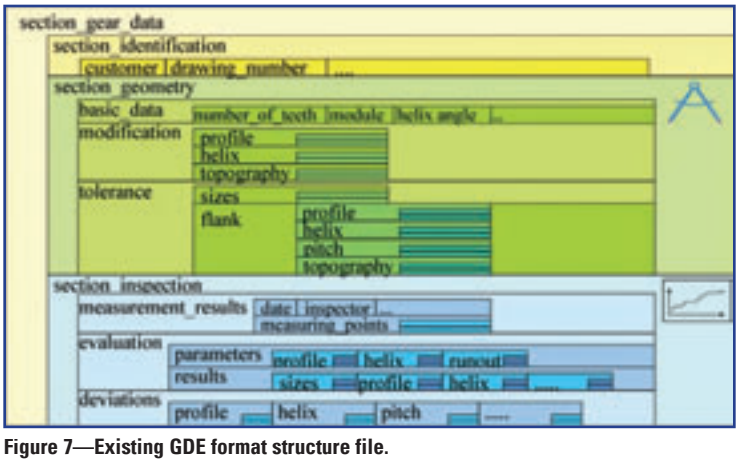

Figure 7—Existing GDE format structure file.

Structure

GDE currently covers all geometric characteristics of cylindrical gears,

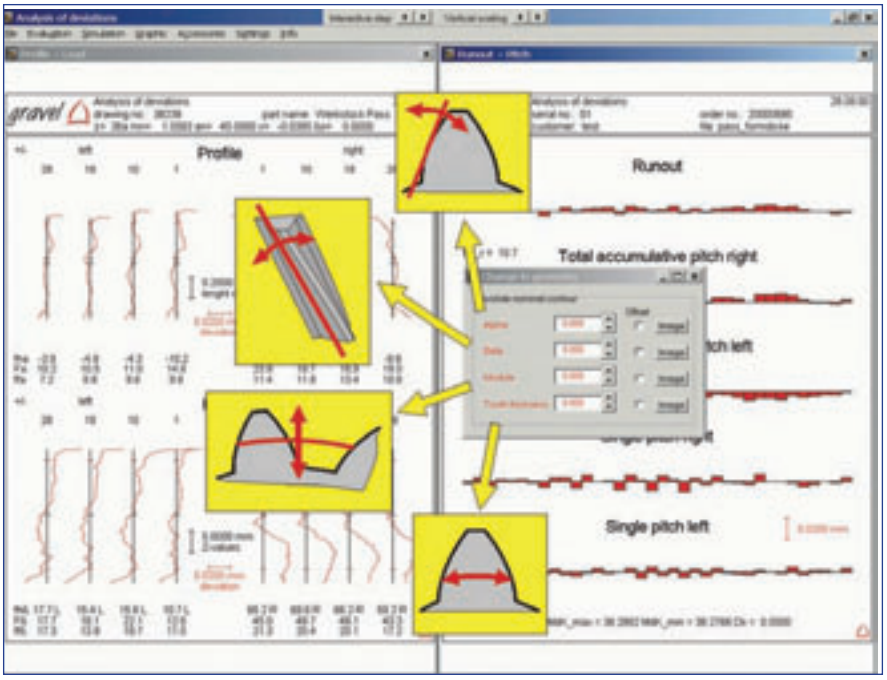

Figure 8—Program for the analysis of gear deviations.

including their modifications and tolerances. A large part of the measurement results has also been integrated (see Fig. 7). Still under preparation are sections describing bevel gears and splines and a section covering measurement and evaluation instructions for the automatic programming of gear measuring instruments. It has been planned to continue extending the areas already defined, in compliance with the users' requests, an essential prerequisite for this being compatibility, because constant adapting of existing interface programs must be avoided.

The identifiers of the individual keywords are stated in English. The directive will make available for the structure file a table with the German translations of the terms used. VDI/VDE Technical Committee 3.61 will be responsible for extensions of the GDE format in the future. Supplements proposed will be discussed at the committee meetings held every six months, and the programs will then be updated accordingly. Version numbers will be assigned to the different stages of development to ease management. Upward compatibility is to be guaranteed. VDI Guideline 2610 is currently available as a white paper (Ref. 3).

Example of Application

The following example demonstrates the possibilities and perspectives offered by a generally valid exchange format. An evaluation program for the analysis of errors arising in manufacture accesses the data of a measuring instrument and represents them (see Fig. 8). The effects of typical errors can then be simulated interactively and the real errors corrected. The correction values can be used in manufacture immediately and without further calculation. This powerful program consists of many tools for easy graphic comparision of measurements and for detection of systematic errors. Wearing of tools, hardening deformation or trends in production can be found with a click. The analysis program is now available with the GDE interface, so the program can be used with every gear measuring machine that supports the GDE format.

Summary

In summary, the utilization of a uniform exchange format allows software to be developed—independent of the measuring instrument and its interfaces—that can later be run to analyze and optimize production. The GDE interface will make additional developments possible in the future. Until now, these developments have not been feasible for purely economic reasons.

An earlier version of this paper was presented at two conferences: the International Conference on Gears, held March 13–15, 2002, in Munich, Germany, and Gear Measurement, held June 4–5, 2002, in Mannheim, Germany. The first presentation was published in VDI Report 1665, the conference's proceedings, by VDI Verlag GmbH. The second was published in VDI Report 1673. At both conferences, the version was written by Anke Günther, Frank Härtig and Günther Gravel. Härtig's contribution was a planned application of the gear data exchange format, but the application wasn't carried out as expected, so his contribution wasn't considered in the revised paper published here. This paper is republished with VDI's permission.

References

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3. Verein Deutscher Ingenieure/ Verband Der Elektrotechnik Elektronik Informationstechnik, VDI/VDE Guideline 2610, *Gear Data Exchange Format (GDE)*, September 2003.