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PIPELINE FITTINGS AND COMPLEMENTARY PRODUCTS

COMPUTER TECHNOLOGY FOR VALVE AND ACCESSORY DESIGNERS AND MANUFACTURERS

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The foundation of commercial success of industrial enterprises, including those manufacturing valves and accessories, is constant updating of their products.

The valve and accessory development process can be considered effective only if it makes possible rapid translation of designer's ideas into real products. Here comes computer technology to the aid of valve and accessory designers and manufacturers as it helps minimize the preparation time for manufacture of new products.

The SolidWorks system is designed to solve most of the problems facing engineers in all stages of creation of complex engineering articles. A flexible structure of the system, which includes an array of functional modules from supporting manufacturers and a basic core of CAD (computer-aided design) program, is the SolidWorks module designed to create computer models of solid bodies and to produce design documents in Microsoft Windows. It helps work out optimum solution to specific problems facing designers, engineers, and manufacturers, and also helps reduce cost substantially at every operation point.

The SolidWorks-created three-dimensional model of the valve being designed, which is displayed on a monitor screen, allows developers to determine whether it is amenable to assembly and suitable for accessing various elements of the structure, to monitor, and to show the intercrossing of the parts. This helps detect and eliminate errors right in the early stages of designing, promptly make necessary changes, and finally avoid attendant expenditures. This also allows calculation of the mass-inertia characteristics (volume, mass, surface area, moment of inertia, coordinates of the mass center, etc.) of the parts and assemblies.

In order to check shifting (translocation) of parts in the assembly or to demonstrate the assembling process itself, the SolidWorks Animator module is used. The SolidWorks Piping module is designed to create spatial images of complicated (irregularly shaped) pipes.

The PhotoWorks module can be used to get realistic scan patterns (half-tone graphic images) of redesigned items of valve systems (Fig. 1) and their computer models (Fig. 2).

The parametricity and the presence in the SolidWorks module of associative links between the parts significantly simplify work: if the design of one part is changed, all the associated elements in the assembly automatically shift or even change their geometry. It may be possible to simplify large assemblages by replacing their complicated parts by models roughly replicating their shape.

The tool for preparation of design documents by SolidWorks includes a wide array of devices that can help create drawings of any complexity on the basis of the existing three-dimensional geometric models of the solid bodies. The term "two-directional associativity" describes a very easily comprehensible situation: the models of the parts and assemblages and the drawings based on them are fully interrelated. A drawing exactly matching the geometry of the model can be produced at any moment.

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Fig. 1. Valve image obtained by computer simulation.

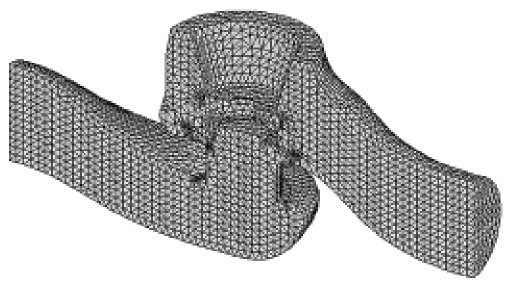

Fig. 2. Model of the flow section of the valve.

When a part is modeled, for instance by changing its parameters or by adding or removing its elements, the drawing is updated immediately upon opening up of the pertinent file. The file for the part will also be updated likewise if some dimensions are changed in the file for the drawing of the part. Similar operations are performed for the assemblages as well.

The CosmosWorks module, which is deeply integrated in the SolidWorks CAE (computer-aided engineering) system, makes possible engineering analysis of the designs.

After the model of the part is created in the SolidWorks module, it is perhaps necessary to answer the following questions:

– will it fail?

– how will it be deformed?

– is it possible to use a smaller volume of material without an adverse effect on its operational characteristics?

If there are no analysis tools, the answer to these questions can be obtained only by implementing all the costly and time-consuming stages of the cycle (process) of development of the new article:

1. Construction of a CAD model of the part in the automated design system (ADS).
2. Construction of a full-scale prototype.
3. Production tests of the prototype.
4. Appraisal of the production test data.
5. Making changes in the CAD model based on the production test data.

This process (cycle) is repeated until an acceptable solution is found. The analysis allows the developer to reduce costs by testing the model on a computer rather than in the process of costly production tests, to shorten the time required for putting the new types of valves in the market by reducing the number of product development cycles, and to optimize the design by quickly simulating several versions before taking the final decision and by having a longer time for their appraisal.

The finite-element method, which regards a complex problem as being comprised of several simple problems, is the foundation of any engineering analysis. In this method, the computer model of the part or of the assemblage is broken up into individual geometric primitives, i.e., into finite elements in the form of a network. The elements have common points termed nodes. The behavior of these elements is well known in any probable scenario involving use of supports and application of loads. The movement of any node is fully described by motions (shifts) in three directions (degrees of freedom).

The CosmosWorks module composes equations that govern the behavior of each element and that take account of its link with other elements. These equations correlate the shifts and the known properties of the materials, limitations, and loads. Thereafter, the program creates, on the basis of these equations, a large system of algebraic equations. This crucial program detects the shifts in the direction of the axes X, Y, and Z at each node. Using shifts, the program calculates the loads (stresses) operating in different directions as well as the corresponding strains.

Such elements as shells formed by triangles and rectangles for thin-walled sheet articles, tetrahedra for three-dimensional solid bodies, and various linear elements, including beams, flexible braces, springs, etc., are maintained (supported). The density (number of elements) of the network can be changed for the model as a whole or locally for specific points.

The functional potentials of the CosmosWorks module encompass such types of analysis of parts and assemblages as analysis of stresses, strains (deformations), shifts, thermal stress, etc.; frequency analysis (by the normal wave method) and analysis of longitudinal flexure; analysis of heat exchange (conduction, convection, and radiation); p- and h-adaptive analysis; analysis of the contacts in the assemblages with friction and large shifts, tension or shrinkage fitting, resistance of the thermal contact, loads (gravitational, centrifugal, torsional, distance, supporting, and with rigid connection), resonance (inherent) frequencies, nonlinear static and dynamic stresses; dynamic analysis of the response of the support, and so on.

In developing a new valve system, especially control valves, hydraulic tests of their operating (cutoff-throttling mechanisms) devices are performed to determine the certified value of the coefficient of maximum flow capacity K_v, for which a prototype of the article has to be made. The CAE module FloWorks can be used to determine this coefficient right in the early stage by computer simulation of the flow section of the valve (Fig. 2).

The CosmosMotion module can be used to simulate the operation of the mechanisms of the valve as a visual prototype. This considerably shortens the production time and the design process by reducing costly repetitive design alteration operations. The calculated loads (forces) of motion are automatically transmitted to the CosmosWorks module for further analysis.

The results of all analyses are presented in a suitable form (graphs, tables, diagrams, lists, etc.). The results of the stressed-strained state of the valve body loaded with excess internal pressure, as in real hydraulic strength tests, are presented in an intuitively comprehensible colored graphical form, which makes their interpretation easier, and can be shown in an animated form.

Casting is widely used for making parts of valves and accessories: bodies, flanges, covers, handwheels of manual doubling machines and drives, etc. All these parts have complex spatial shapes and can be produced only by casting from various steels and alloys.

Casting process is efficient and inexpensive. At the same time, for cast parts, the characteristic features are reduced strength, differing mechanical properties in different sections of the cast parts, tendency for flaw and stress formation, etc. The quality of the cast piece depends on the casting technology and design of the parts.

For making parts having cavities (chambers), such as valve body, casting technique based on fusible models is used. The models are made from easily fusible materials (paraffin, stearin, wax, rosin, plastics, etc.) by casting at 3–5 MPa pressure in a metallic pressure (injection) mold. The precision of the dimensions in this case is ±1%. The models are joined into blocks, coated with a thin layer of a refractory material (quartz powder with ethyl silicate or liquid glass), and molded into single-piece (nondetachable) sand molds, which are tempered at 850–900°C, as a result of which the models can be withdrawn without residues. The cavities formed are filled with metal at a normal or 0.2–0.3 MPa pressure.

For making easily fusible models, steel pressure molds (dies), which need much labor and time to design and make and are therefore costly, are required. Because of this, only their mass-scale series production is economically viable.

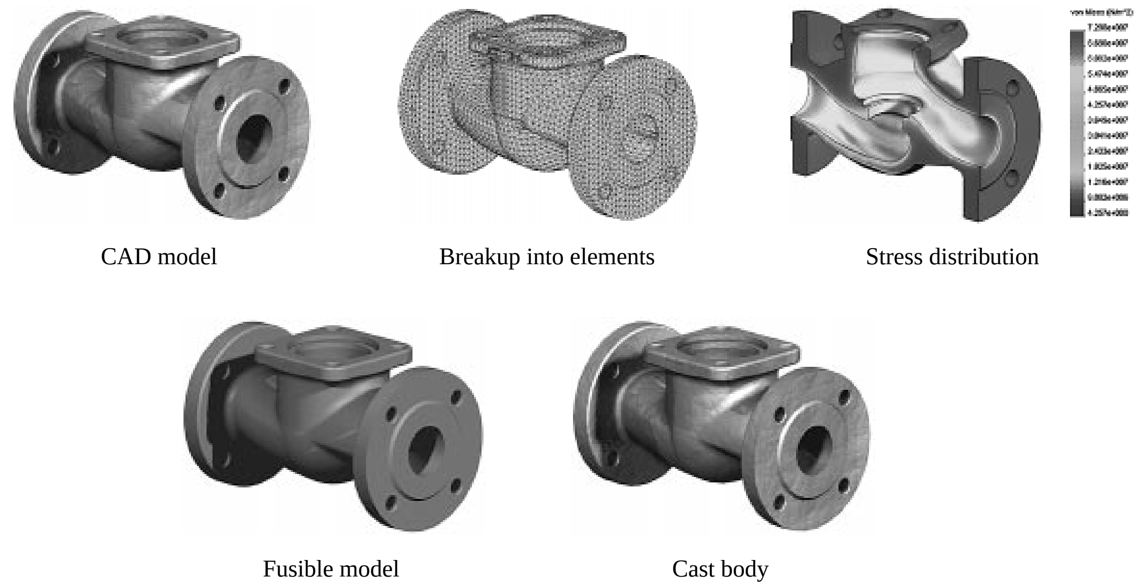

Fig. 3. Life cycle of creation of cast body of the designed valve.

High precision of dimensions (±2 %) and low surface roughness make subsequent machining unnecessary in most cases. For making valve bodies, only the adjoined surfaces, such as sealing surfaces of flanges, holes for fasteners, places of seat mounting, etc., are submitted to machining. The processes for making cast valve body are illustrated in Fig. 3.

In addition to the above-described method, there is a relatively new method for getting fusible models, namely, *stereolithography*. In this method, the fusible model is obtained on the basis of the geometry of the CAD model of the part by layer-by-layer hardening of the liquid photopolymer under the action of scanning laser beam.

A major advantage of this method is the possibility for making in the shortest time (1–2 days) an easily fusible model for subsequent creation around it a metallic part by casting in sand molds without making metallic pressure molds (dies). The method is indispensable for meeting single (nonrepeat) orders or when a prototype of the article (valve) is to be made quickly for full-scale tests as well as for improving the technical effectiveness, checking the scope of assembling, appraisal of the external look, and market research at minimum cost and risk.

The cost and time for making the prototype of the redesigned article can be reduced as well by applying the new technology of rapid construction of metal-polymer pressure (injection) molds for series pressure (injection) molding of fusible models from standard plastic materials.

The technology consists in the following. The obtained model of the required part in the stereolithographic device is filled with a metal-polymer composite. A parting line is formed. The metal-polymer composite mold is placed in a furnace for gas removal and curing (hardening). Further, the mold is separated (detached), the fusible model is removed, and the obtained pressure (injection) mold is submitted to final heat treatment. After this, the injection mold is ready for series molding under pressure from standard plastic materials of the fusible models in an industrial-scale automatic thermosoftening machine. In general, the process takes on the average 10 days ignoring the time taken for designing the CAD model of the part and for making the model by the stereolithographic method.

The merits of automated designing systems, such as SolidWorks, are quite obvious. However, even now many design and production organizations continue to use manual labor of designers and draftsmen and use computers merely for producing drawings generally in the AutoCAD program of the Autodesk Company. Yet, automated designing programs and technologies for quick prototyping and manufacture of equipment are increasingly becoming an obvious phenomenon among domestic valve system designers and manufacturers. Therefore, switch to them is just a matter of time.