THEORETICAL, SCIENTIFIC AND PRACTICAL ASPECTS OF THE BASIC STAGES OF CAD/CAM DESIGNING OF CENTRIFUGAL PUMPS

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Abstract Many theoretical and practical problems arise at different stages of the design/manufacturing process during development of a pump. The experience obtained in pump development proves that the quality of a pump depends on many factors, which should be satisfied to receive good results. At the same time, the theory of engineering design principles exists, which is applicable to designing various objects. The said theory can show the optimal way fulfil the task[1,2]. There is a great need in a special advanced pump designing theory which would include all the features required for this branch of industry. The described approach should also combine sufficiently high theoretical level with practice. The presented paper is an attempt to find on invariant abstract solution for certain procedures related to structural analysis and design of pump parts, groups of parts and assemblies.

چکیده در مراحل گوناگون فرایندهای طراحی و ساخت یک پمپ مسائل نظری و عملی زیادی مطرح می شود. تجربه نشان می دهد که کیفیت یک پمپ به عوامل پرشماری بستگی دارد که برای به دست آوردن نتایج مناسب باید مورد توجه قرار گیرند. برای این منظور و همچنین در طراحی انواع کالاهای دیگر از وجود اصول طراحی مهندسی می توان بهره جست. به کمک این نظریه می توان مناسب ترین راه حل مسأله را یافت [۱،۲]. دراین رهیافت باید همهٔ ویژگیهای طراحی یک پمپ با توجه به نظریه های پیشرفته و مسائل عملی مدنظر قرار داده شود. دراین مقاله سعی شده است که برای بعضی شیوه های مربوط به تحلیل سازه و طراحی قطعات پمپ، گروه قطعات و مونتاژ آن جوابی انتزاعی پیشنهاد شود.

INTRODUCTION

A brief sketch of our approach is as follows. We begin our investigation with the determination of the current status of the problem. Figure 1 shows the system space with the Objects, Structure and Knowledge taken as axes.

The specified point within the system space will be representative of the current status: the systematization of pump part drawings. Vectors, originating from the point, guide the development of the structural analysis of both an individual product and various groups of products.

We use another intellectual model as a theoretical basis for the formation of conceptuality along the Knowledge axis, so that pump building blocks could be created in the future.

Such an intellectual geometric model, called "Multistory", allows single out succesive examine level and identical positions of concrete acting managers. Each plane of the "Multistory" represents two-places tipe reiterated great number descriptions of "assembling objects" much more complicated conception of the mental activity.

To the right part of great number, that reflexes the lower plane of the "Multystory", we add the correlation system and the next, left part of great number. The adding of the left part of great number provides with the replacing the assembling objects on the more high plane, i.e. is the indication to the more complicated ideas from the simplest ones.

The expedient is in each plane of realize the concrete activities and concrete acting managers that select the left part of great number, the interaction the left and right parts of the results on the higher plane. This model ("Multi-

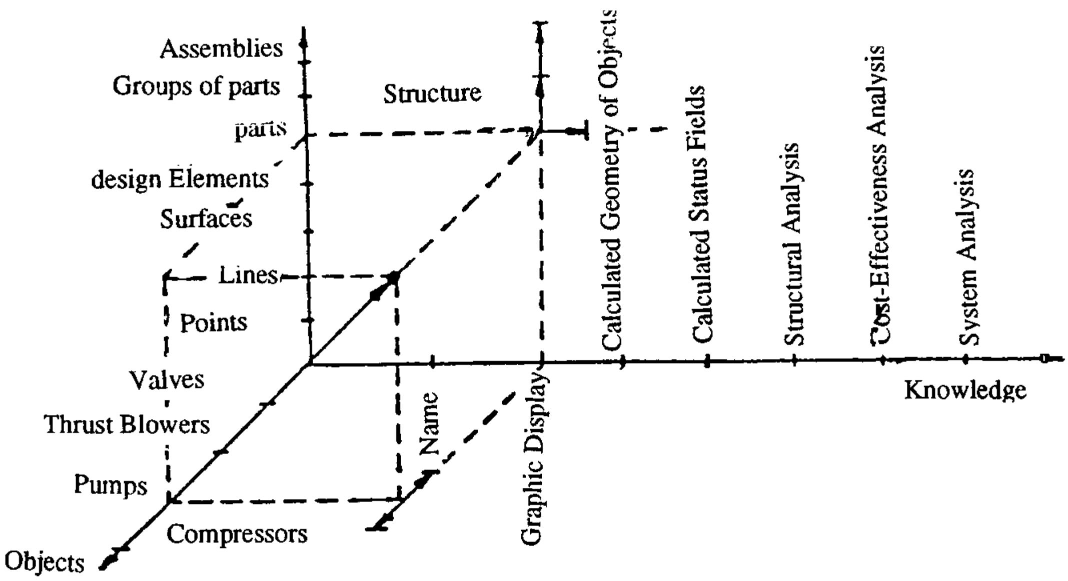

Figure 1. System space.

story") of the formation activities provides plan and to control of the quality of work of the manager, to train others, develop and cultivate one's talent.

STRUCTURAL ANALYSIS OF A CENTRIFUGAL PUMP

Structural analysis shows that a dynamic pump should be viewed as an engineering object of intricate shape, though it is a medium intricacy object as far as the structure is concerned. It makes good sense to consider the superposition of both the fluid passage element structure and the entire pump design.

Stuctural Design of Fluid Passage Elements

The analysis of forms of pump fluid passage structural elements made possible the determination of elementary

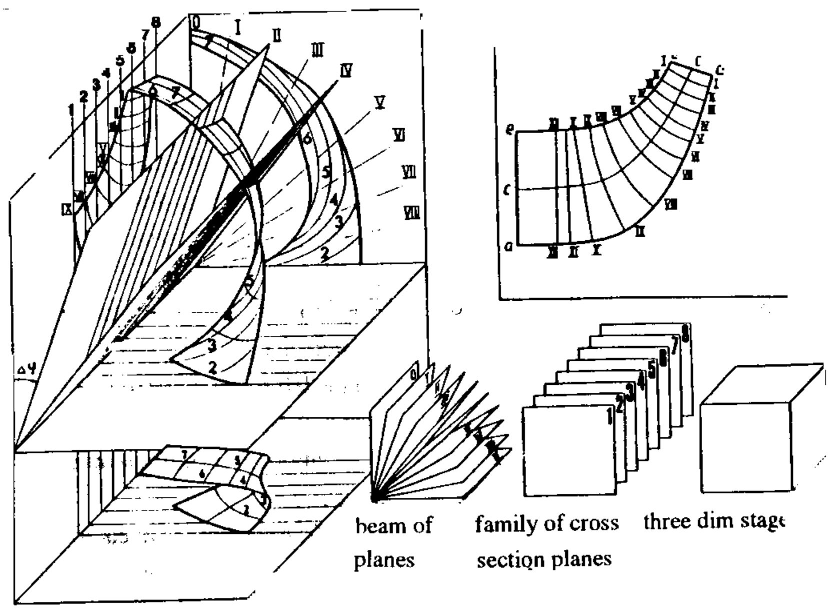

Figure 2. Forming blade for first stage inpeller.

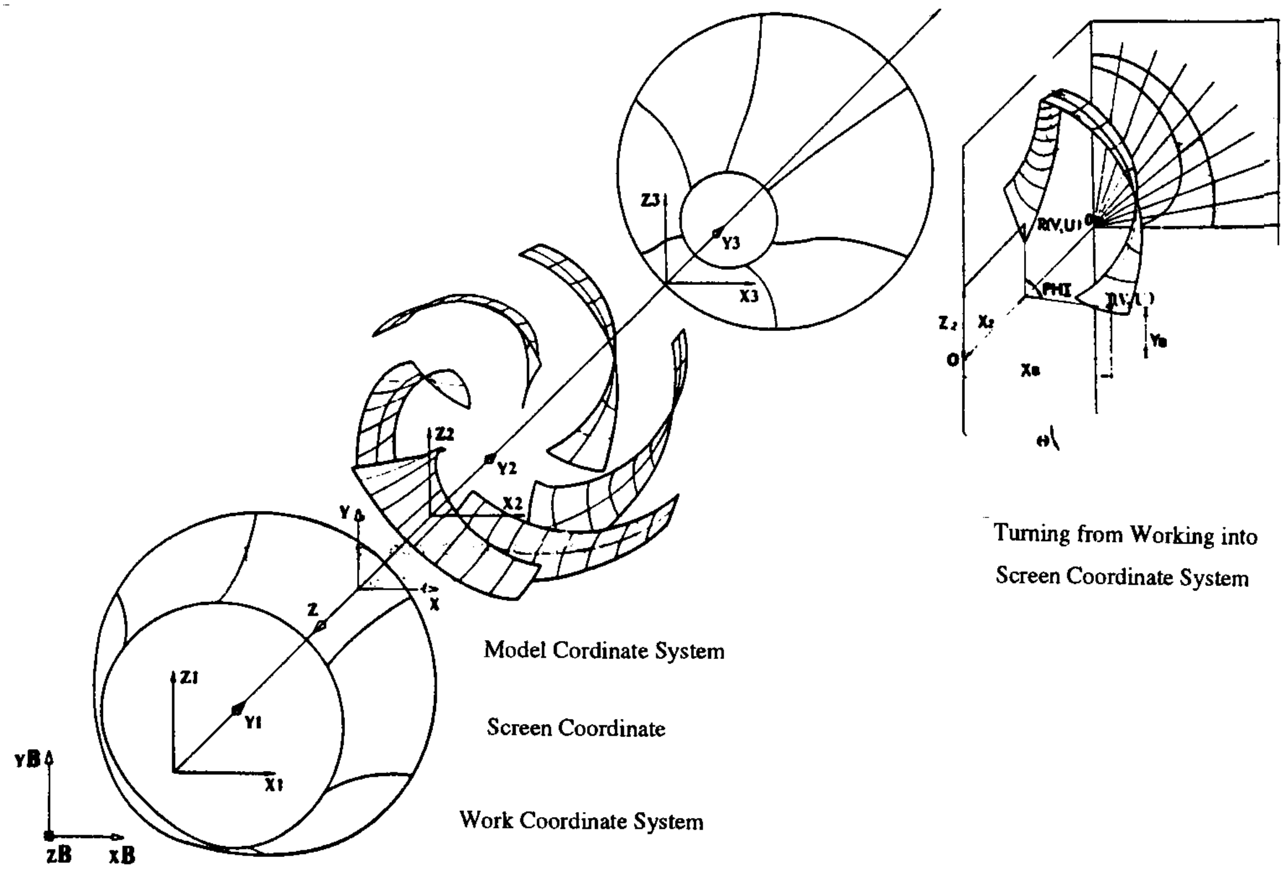

Figure 3. Inserting the blade system into interdisk space.

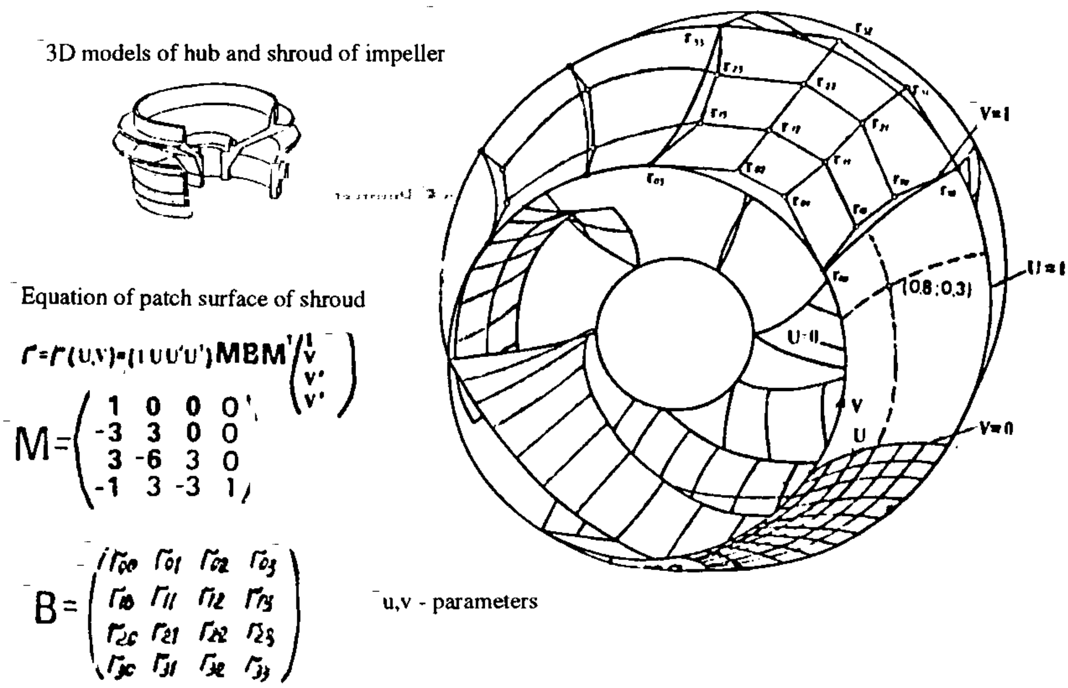

Figure 4. The process of receiving 3D model of pump impeller.

geometrical design procedures which facilitate the synthesis of a fluid passage.

Figure 2 presents the process of impeller vane formation by means of plane bunches with either integral or disintegral axis. The formed discrete technological structure of the surface consists of the so-called moded cuts 1, 2, 3, ..., 7, which serve to describe vane cross-section. The model cuts, made at various distances one from another are normal to the pump axis.

Figure 3 shows the stages of formation (by way of elementary shifting and turning) of both the main plate and the wear plates, as well as the six impeller vanes.

Figure 4 describes the result of the applied transformation as a system of vanes, which fit the space between the plates.

Stuctural Design of a Pump as a Whole

After the structure of the fluid passage elements has been formed, a model pump is developed to gradually become more and more complicated.

Despite the widening spectrum of capabilities of automatic input of pictures into a computer by way of such technical means as a scanner, a designer still has to form the structure of the object being developed. It is necessary to form structural units of the object and lead them to the form suitable for presenting in a computer with due regard to the goals of the designing stage.

1. Deciding Between Global and Local Coordinate Systems: Definition of the Main Axis of Assemblying. Figure 2 shows the global (x, y, z) and local (x_1, y_1, z_1 and x_2, y_2, z_2) axes of pump coordinate system and the directions of assembly generatrix.

2. Definition of the Base (Shoulder) Point, Characterizing theJoining Points of the Main Units and Sub- Assemblies.

After the main axes of the pump have been determined, the pump is divided into zones with regard to pump's analytical and organic structures.

Figure 5 demonstrates the results of such a division.

3. Inputting Pump Structure into Computer Memory.

After the coordinate systems have been chosen and the pump configuration divided into zones, they are input into computer memory. The described process is similar to that of assemblying a pump under real production conditions. The difference is in the stricter requirements imposed on

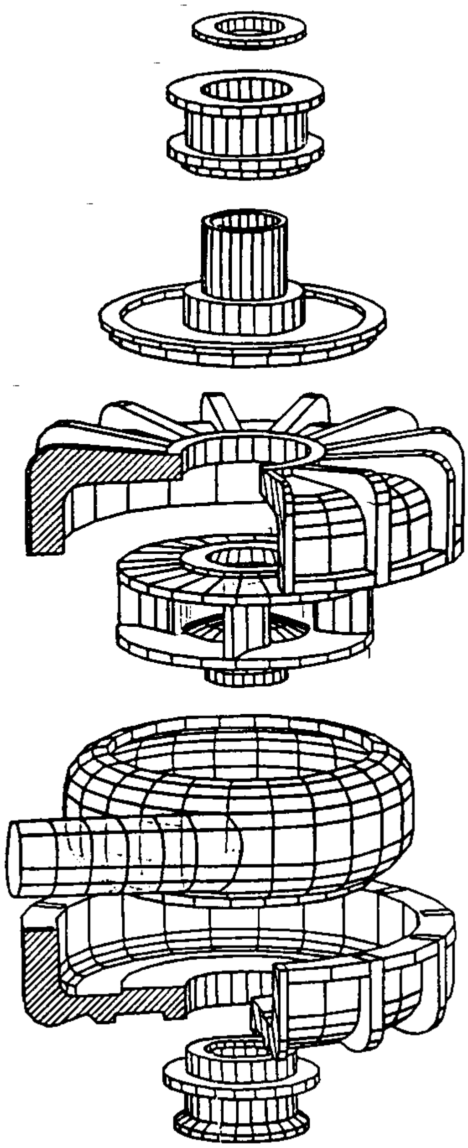

Figure 5. Pump structural divisions

computer assemblying in the points of part and unit ma ting.

Initially a model pump is determined in the form of a wire-frame. It should be the model of the exterior appearance of the pump as a whole. Then the wire-frame is defended in the course of further development of the internal structure of each sub-assembly with due regard to its specific features. Alongside with that, many interior parts and units of the pump (e.g., the pipe bunches) are presented separately to be inserted into the object at the mating points. Figure 6 shows an example of pump construction fully input into the memory of a computer system.

4. Checking the Computerized Assembly of the Object

for Correctness.

After the pump has been input into the memory of the computer, a complex check of the correctness of mutual geometric positioning of all of its structural elements is conducted Displaying or making solid copies of various sub-systems of the pump in different combinations makes possible the conduct of a cross-inspection of correctness of assemblying.

ADVANTAGES OF COMPUTER-ASSISTED PRESENTATION OF THREE-DIMENSIONAL ASSEMBLIES

Concentration of graphic information in a single drawing is believed to be the basic advantage of computer-assisted pump assemblying, as compared to manual assemblying. During manual designing it is impossible to locate (within the framework of a single assembly drawing of a technical system) all assemblies, sub-assemblies, groups and separate parts, since they become an unreadable mess of lines. Computer-assisted assembly provides for the task to be fulfilled due to electronic presentation of the drawing. Additional advantages are as follows:

Possibility to Provide Electronic Quality Check of Documentation

When automated assembly is used, the computer immediately points out all the mismatch points of units and parts because of the improper dimensions of certain structural elements.

Using a Computer Assembly Drawing as a Basic Model for the Version and Adaptive Engineering Design of a Series of Pumps and Boilers of Identical Structure.

If the base version of the boiler is stored in computer memory, there is no difficulty in carrying, out modernization by way of changing some of its structures

Improved Visual Presentability of the Appearance of a Boiler Instead of a Mock-Up as an Instrument for Modelling.

At present expensive mock-ups and scaled models are made of the computer three-dimensional presentation to ensure the final estimation of project quality, which facilitates obtaining any required sections and projections, changing the point of objects observation. The described presentation may supercede models and mock-ups in some cases.

Solving the Problems of Lay-Out and Changing the Drawing in a Dialogue Mode in Terms Suitable for a Practical Designer.

The computerized form of 3D presentation of an object enables a practical designer to work in an individually preferred manner, changing the form of boiler structural units in an interactive mode.

CONCLUSION

The paper reviews the approach adopted for the formation of centrifugal pump fluid passage elements. The described approach is based on the employment of applied methods of descriptive geometry. Transition to 3d designing of pump geometry provides basically new prospects for the rational combination of a three-dimensional geometrical moded and different types of strength, hydrodynamical, technological and other calculations.

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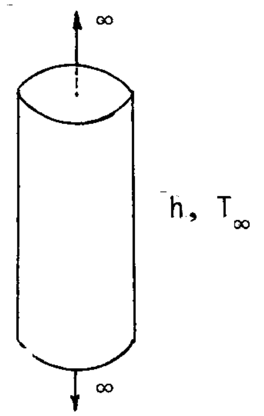

Figure 2. A schematic of an infinite cylinder.

to:

$$\alpha_m \left[\frac{\partial^2 T}{\partial r^2}+\frac{1}{r}\frac{\partial T}{\partial r}\right] \quad \frac{\partial T}{\partial t} \qquad (13)$$

Analytical solution of equation (13) consists of Bessel's functions and is available in reference [10]. The analytical and numerical solution is based on information listed in Table, 1 and corresponding results are compared in Figure 3.

It can be seen that the finite difference method of solution can be used to predict

Table 1. Inputs for the Tested Model of an Infinite Cylinder

Parameters	Values
Thermal diffusivity	2×10^{-6} m^2/s
Thermal conductivity	2 W/m.^{0}C
Heat transfer coefficient	30 W/m^2.^{0}C
Surrounding temperature	400 ^{0}C
Initial temperature	20 ^{0}C
Radius	10 cm

transient temperature distribution in the container in r direction with reasonable accuracy. Furthermore, this figure shows that any reduction in the node spacing results in higher accuracy of solution.

b) Finite cylinder, without porosity and heat generation sources.

This special case is shown in Figure 4.

Under this condition equation (3) is simplified to:

$$\alpha_m \frac{\partial^2 T}{\partial z^2}=\frac{\partial T}{\partial t} \qquad (14)$$

Transient temperature distribution within the cylinder is determined by solving equation (14), and with parameters given in Table 2. Comparison of the analytical and numerical

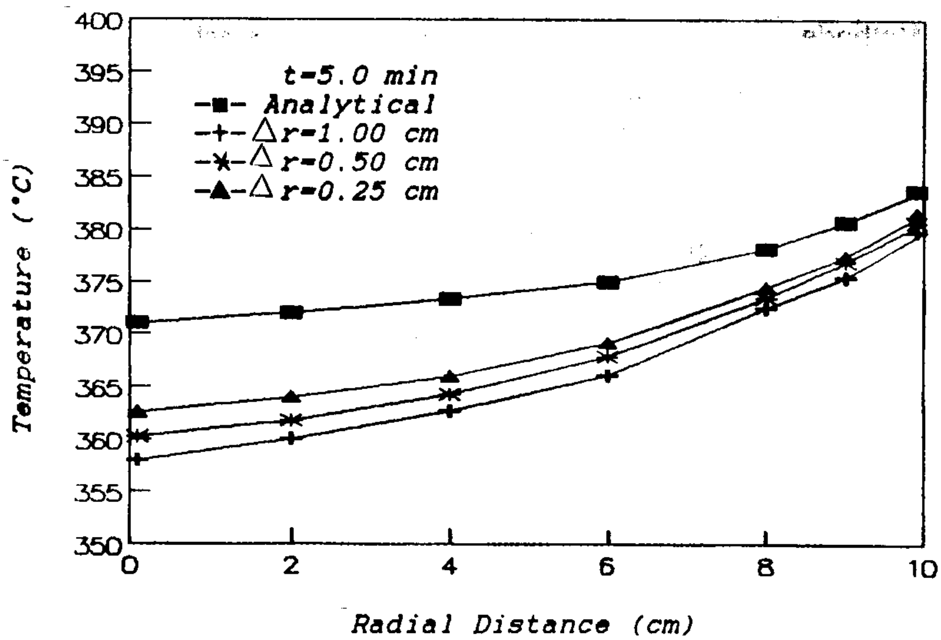

Figure 3. Comparison of numerical and analytical results in the case of infinite cylinder.