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DEVELOPMENT OF THE UNIVERSAL THREAD-GRINDING MACHINE

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ABSTRACT
There are many available methods for the grinding of thread surfaces. Depending on whether the threads are used as joining elements or whether they are kinematic ones, the dominant requirement being the dimension or precision, they differ from each other by a significant measure. The geometric requirements basically influence the manufacturing process.
This lecture primarily deals with the development of concepts of thread-grinding machines for the manufacture of kinematic thread surfaces of high precision.
This problem is a real one because, according to present knowledge, no thread-grinding machine tool is commercially available suitable for the universal finishing of the newly developed worm gear drives (e.g. spiroid, globoid).
Most up-to-date CNC-controlled thread-grinding machines are suitable for manufacturing a given type of thread surface within a well-defined range of dimensions [3]. The target is to develop a thread-grinding machine suitable for universal adoption.
Keywords: thread grinding, thread grinding machine,

1. REVIEW OF THREAD SURFACES FROM THE POINT OF VIEW OF THREAD-GRINDING MACHINE

Previously mentioned thread surfaces with constant lead can be classified into three groups as:
1. thread surfaces for joining elements;
2. kinematic thread surfaces;
3. tool surfaces.

Additional types of thread surfaces are not discussed in detail here (eg worms of extrusion). Here the grinding of kinematic thread surfaces is discussed (cylindrical and conical worms, ball-thread spindles, feed spindles, etc). These require a high level of finishing precision. They are summed up in Figure 1.

1.1. Manufacturing problems of thread surfaces

The grinding of thread surfaces raises two basic problems: productivity (eg double conical and threaded grinding wheels etc) and precision (eg finger-like grinding tool etc).

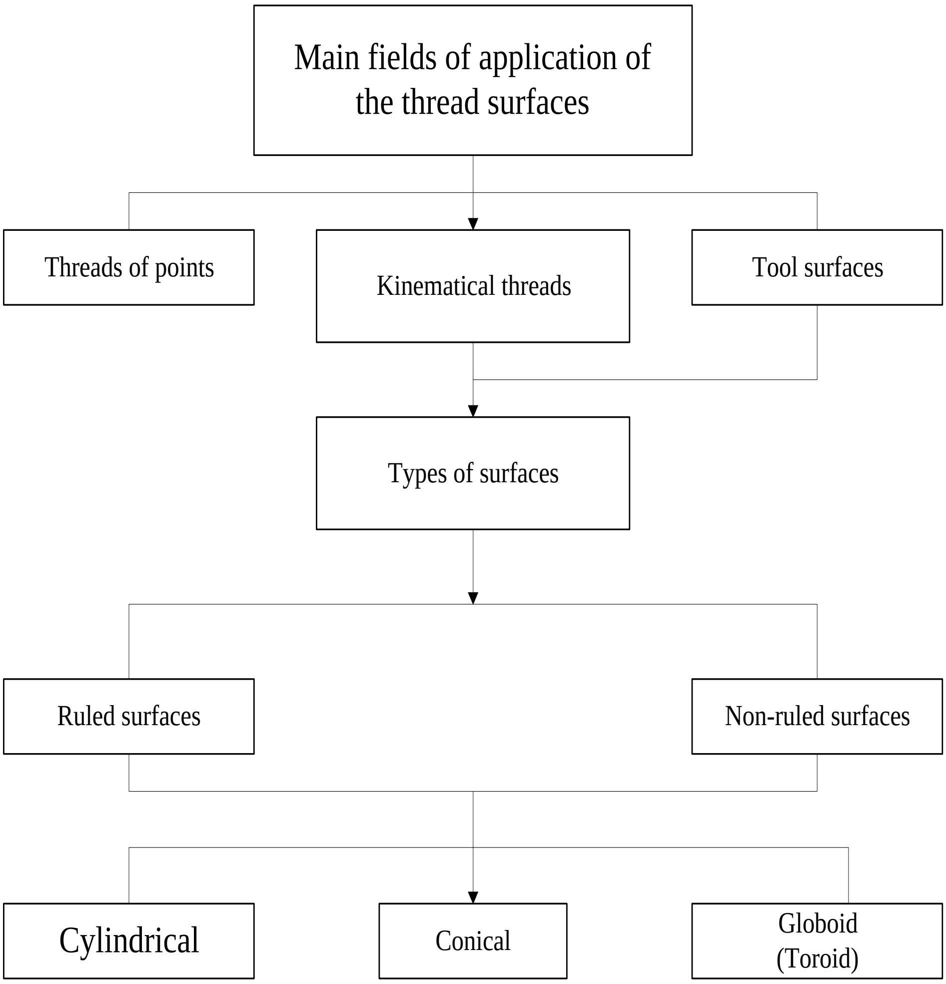

Figure 1. Summary of thread surfaces

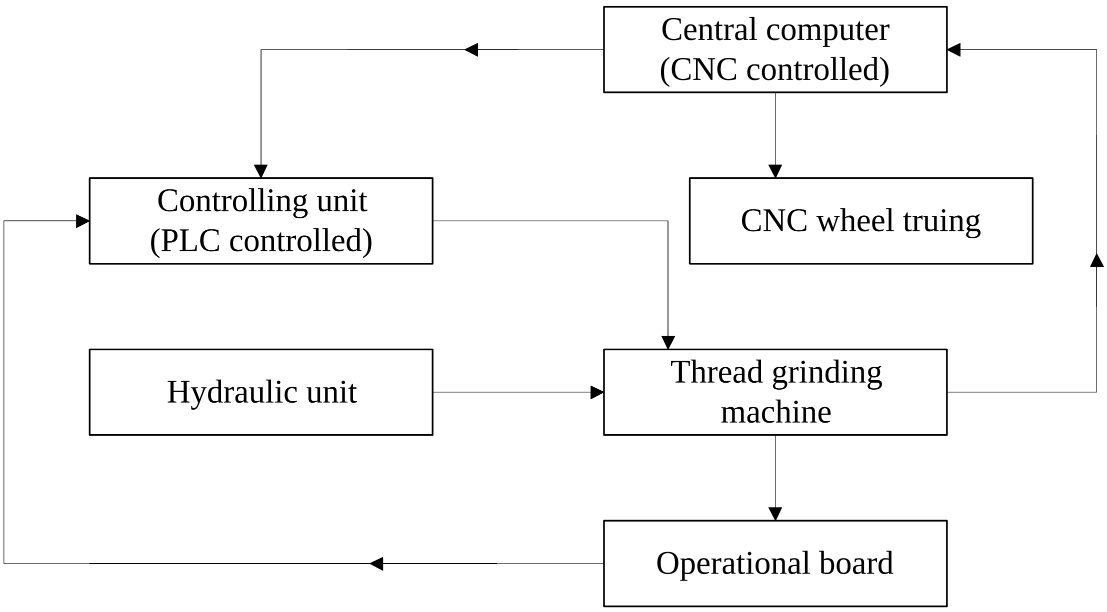

Figure 2. The structure developed

The two problems are not mutually exclusive, but they can be dealt with by the use of appropriate technology and machine tools.
The basic problem that arises when grinding thread surfaces is that the contact curve of the thread surface and a surface of rotation is a of the respective diameters or a ratio of them. (Naturally the given profile should be taken into consideration).
The problem is even more complicated in the case of a non-cylindrical surface, eg a conical (spiroid) worm that should be ground. In this case not only is the wear of grinding wheel manifested in a change in its diameter causing distortion of the thread surface (for constant profile), but the change in the conical worm diameter along its axis (change in lead angle) also requires changes of the grinding wheel profile from place to place. Here it should be noted that with the use of a conical grinding tool the distortions are reduced but then the productivity is significantly less; therefore this solution is mainly applied in manufacture of the tool (eg machining of the back surfaces of generating milling cutters) [2].
At the same time the tool necessary to produce the worm gear has to be manufactured. The grinding of the back and side surfaces of the hob cutter and the re-sharpening of its flank requires the solution of serious geometric problems too; otherwise, it has to be carried out on a machine tool. But traditional thread-grinding machine tools are not always suitable for exact manufacture of the tool. In the case of a conical worm hob, the grinding of the back of the side (or the back) surface with the necessary constant, lead, the problem is more complicated because its teeth are positioned over a conical surface [1, 3, 6].
For the machining of a back surface generated by radial back-machining, it is most advantageous the use a CNC-equipped grinding machine connected to a wheel control appliance; when continuous wheel control is not used, the wheel can be optimized on the back surfaces of the teeth on the hob as part-surfaces of the domain of conical surfaces [1].

1.2. Requirements of the thread-grinding machine

Regarding control requirements there is expense involved both in the employment of the number of controlled shafts and in the expense of introducing control itself, which is increasingly progressive (eg the cost of controlling a five-shaft system can be much more than the cost of controlling 3+2 shafts).
But the cost of control can be reduced to a fraction of the original by application of correct function analysis.
Nevertheless, the machining, geometric and manufacturing requirements must be kept in mind.
The universal thread-grinding machine should be suitable for the machining of thread surface as shown in Figure 1. To achieve this, the followings should be controlled:

1. speed of the object spindle either as a function of coordinates or of time;
2. the radial displacement of the grinding wheel housing in relation to the axis of the workpiece;
3. horizontal swivelling of the grinding wheel head round a given axis;
4. vertical displacement of the wheel truing device.

In the case of controlling five shafts, the types of thread surfaces shown in Figure 1. can be ground.
To grind a thread surface of varying lead it is useful to control the movement of the object table lengthwise. For five-shaft control the work can be divided into: control of three shafts for kinematic generation of the thread surface, and control of two shafts for truing of the grinding wheel profile.
All the other tasks that arise during generation of all the thread surfaces can be solved by use of simple control and operational commands.

1.3. Development of a possible version

To take into consideration the kinematic and control tasks enumerated above in the present state of development of the universal thread-grinding machine is the aim of our team. The structure of the project can be seen in Figure 2.
Control has been achieved with partial success by applying this structure. CNC control having provided fulfilment of basic functions or cycles.
The condition for exact, geometrically precise manufacture is a proper wheel profile, for which a licensed version is available built in the form of a wheel truing CNC device technically equipped with proper software [1, 2]. This will not be discussed in detail here.

After realizing in practice the tasks involved in control problems the universal thread-grinding machine will be suitable for machining to the exact geometry using the software system intended for control for all types of thread surfaces enumerated in Figure 1.

2. CONCLUSIONS

The intelligent automation of the manufacture of worm gear drives has come about because of the requirements of modern manufacturing. In the present state of manufacturing only some of these requirements have been fulfilled because a comprehensive system has not been built at present.

In this chapter the structure of an overall system was described as well as the considerations and methods relating to some elements of it. Some elements of the system (CNC wheel truing, measuring program and conceptual design programs) have already been realized. The working out of others (eg the thread-grinding machine) and incorporating them into the system is the most important theme for our team as a research activity. We estimate that both the theoretical bases and methods and the up-to-date available tools will improve both the productivity and the quality of products.

3. ACKNOWLEDGEMENTS

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