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MODELING THE OPERATION OF END MILLS IN THE CINEMA 4D PROGRAM

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For successful work with milling cutters, it is important to understand the interaction of their design with the aero-hydrodynamic environment. The purpose of the research work is to study the impact of aero-and hydro-dynamic environments on the design of milling cutters and their performance. Various methods for measuring surface friction stresses are proposed. Pneumometric methods for indirect determination of the vector of surface friction stresses in spatial flows are developed. The simulation of the dynamics of milling cutters in a viscoliquid medium is shown. The results of the research are also presented. New scientific results have been obtained and methodological justifications are of scientific and practical value for the further development of the design of end mills and cutting tools.

Introduction. The use of prefabricated cutting tools in the industry reaches 70% of the total number of tools, with one third of these tools being prefabricated end mills. Prefabricated end mills consisting of interchangeable modules are becoming more and more common, the use of which significantly reduces production costs.

Currently, almost the only method for determining the flowability of structures is the floating weight element method. However, its application on surfaces with a large curvature or under the action of significant alternating inertial loads is difficult.

Of the indirect pneumatic methods, the use of Preston tubes, the Stanton nozzle, is more common. These methods are also used for measuring shear stresses in spatial flows, and the direction of the shear stress vector is previously determined using the oil drop method or a thermal meter.

The use of these pneumometric methods is difficult or even impossible in highly directional currents, as well as under the action of significant inertial loads on the object under study.

Indirect methods for determining shear stresses in the wall include the method of fluorescent coatings, the method for measuring tangential stresses along the length of strokes as a result of spreading oil droplets applied to the surface, as well as methods using the Reynolds analogy between temperature and dynamic boundary layers (Figure 1) [1].

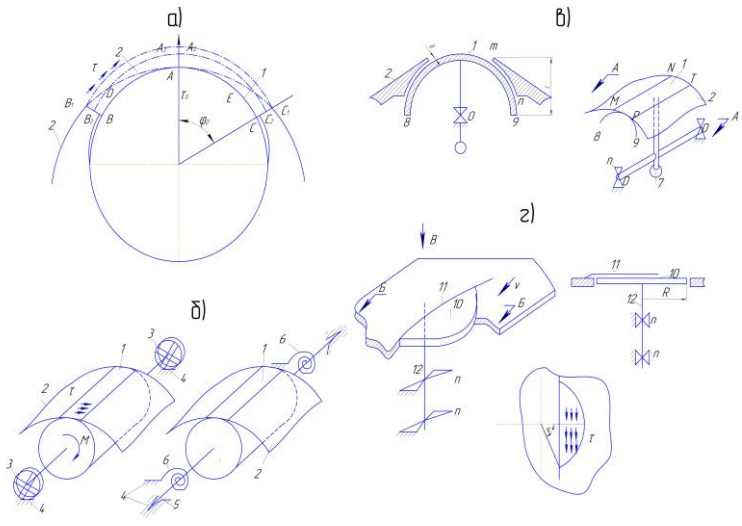


Fig. 1. – Description: a-cylindrical element touches the surface of the circle; b-modification with strain weights; c-part of the cylindrical surface; d-sensitive element in the form of a flat disk

Description of the Cinema 4D software product. For 2020, Cinema 4D is the easiest-to-use program for 3D artists, at least as stated on the developers ' website. All the main advantages are also present: ease of use, everyone's favorite intuitive interface, stability, integrated help, a procedural workflow and the availability of the program in different versions, depending on the purpose of use.

Cinema 4D is a universal program for 3D modeling, editing objects and creating effects. It also renders objects using the Gouraud method (the shading method, which is based on intensity interpolation and is known as the Gouraud method (after its developer), allows you to eliminate the discreteness of intensity changes). Renderers can be either "native " or embedded directly into the program itself using plugins and connectors.

Students love to use this program, as it does not take much time and effort to learn the principles of work. It was in this editor that the operation of milling cutters in a visco-liquid medium was investigated.

Plugins and settings for Cinema 4D. To simulate the operation of milling cutters in a liquid environment, the "RealFlow"plugin was used. This plugin is designed for modeling and simulating a variety of physical bodies in dynamics and is intended for use primarily in the computer graphics, animation, and special effects industries, rather than in scientific calculations and research. Basically, it uses particle systems to calculate the dynamics of the shape of physical bodies. The "RealFlow" calculation algorithm uses the method of smoothed particle hydrodynamics (eng. Smoothed Particle Hydrodynamics (SPH), which allows the particles modeling the environment to interact with each other. The essence of SPH is that, depending on the distance between two particles, these particles can "stick together" or "push apart". Each particle can have its own mass and the so — called "smoothing length", which determines at what distance this particle will be attracted to others, and at what distance it will repel. All bodies modeled by "RealFlow", built on point particles, the mechanism of which is described above. Initially, "RealFlow" was intended for modeling only fluid and viscous bodies, primarily liquids, but later the set of supported physical bodies has significantly expanded. As a result, "RealFlow" version 5 supports solid and deformable bodies, gases, and "meshes".

"RealFlow" can work as a completely separate (standalone) application, and can be used as a component (plugin) to other programs, such as 3D Max, Maya, LightWave, Softimage, Cinema 4D and Houdini.

In the project where the study was conducted, the following elements were used (Figure 2):

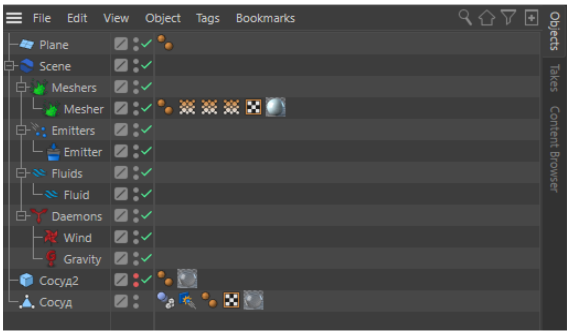


Fig. 2. – Project elements

The plugin creates a "Scene" section that contains all the elements and settings of the fluid.

"Meshers" is the texture of the water itself. The "Emitters" object stores all the configurable water properties that can be changed at any time (Figure 3). Where the " Body "indicates the" Vessel " object, so that water does not spill through it.

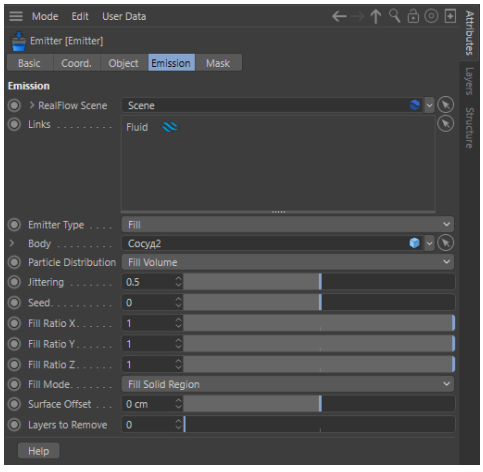


Figure 3. – Setting up "Emmiter"

"Fluids" is responsible for the quality and resolution of the granules that make up the water. In this case, the water resolution is set to 5 (Figure 4).

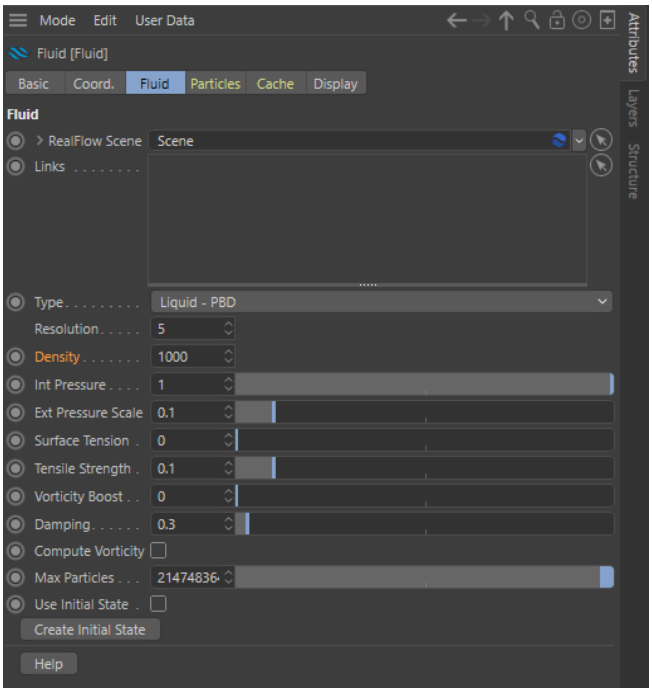


Fig. 4. – Setting up "Fluid"

The "Daemons" section stores all the physics of water ("Wind", "Gravity"). Where "Wind" is responsible for the wind created by the rotation of the cutter, and "Gravity" is responsible for the gravity of the water

Research. Table 1 and 2 show the frame-by-frame (fragmentary) changes in the liquid (waves, flows, splashes) over a certain period of time t=1, 2, 3 s.

Table 1. – Investigation of the dynamics of the first milling cutter in a liquid medium

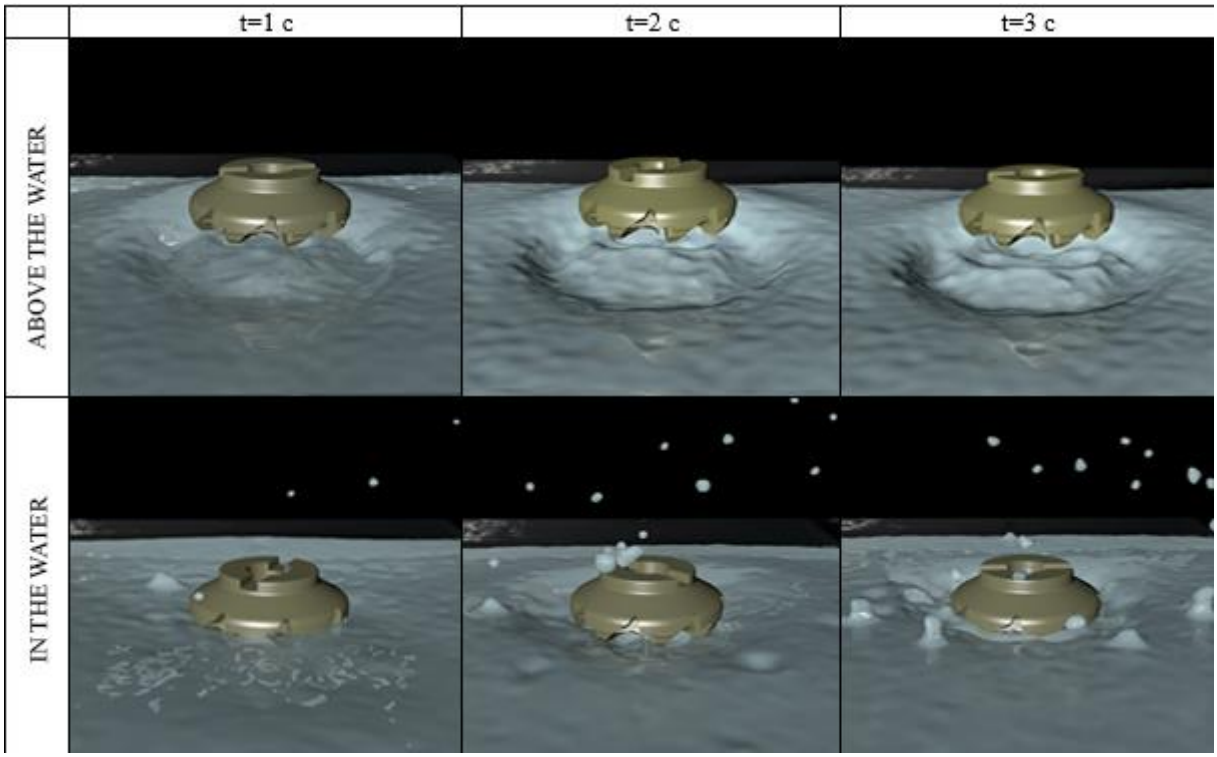


Table 2. – Investigation of the dynamics of the second milling cutter in a liquid medium

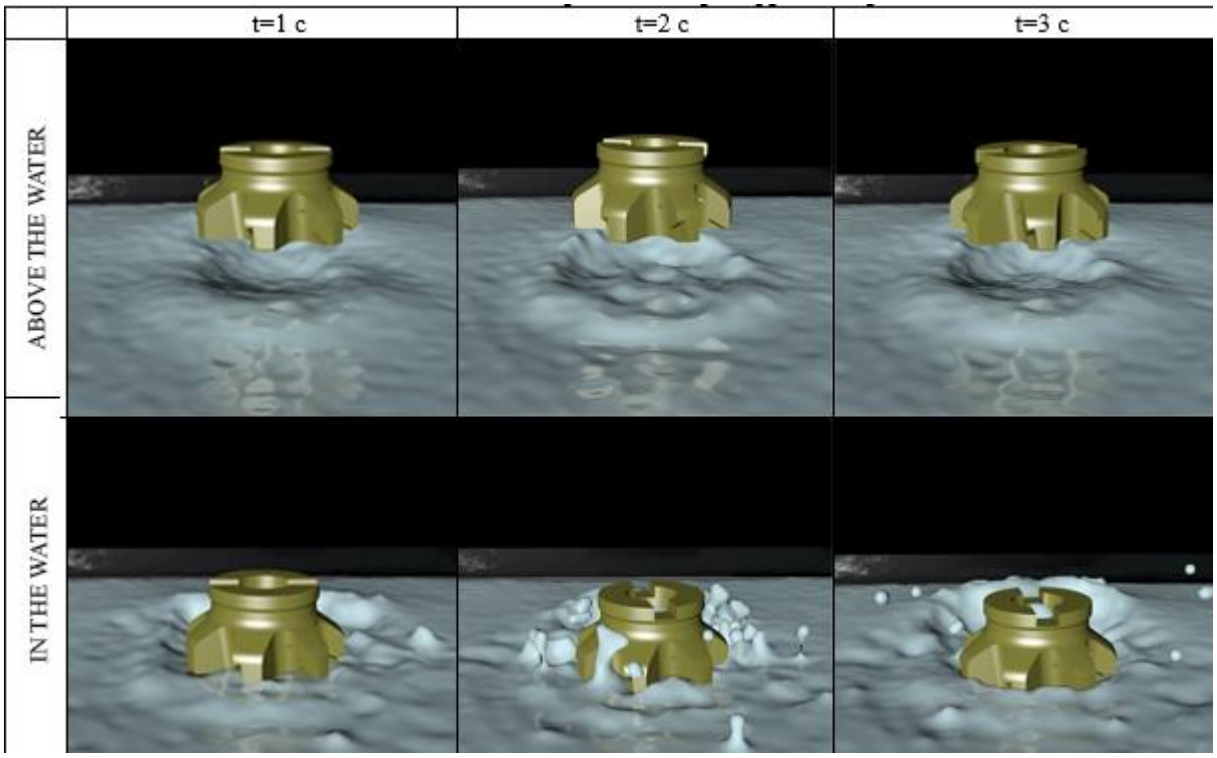
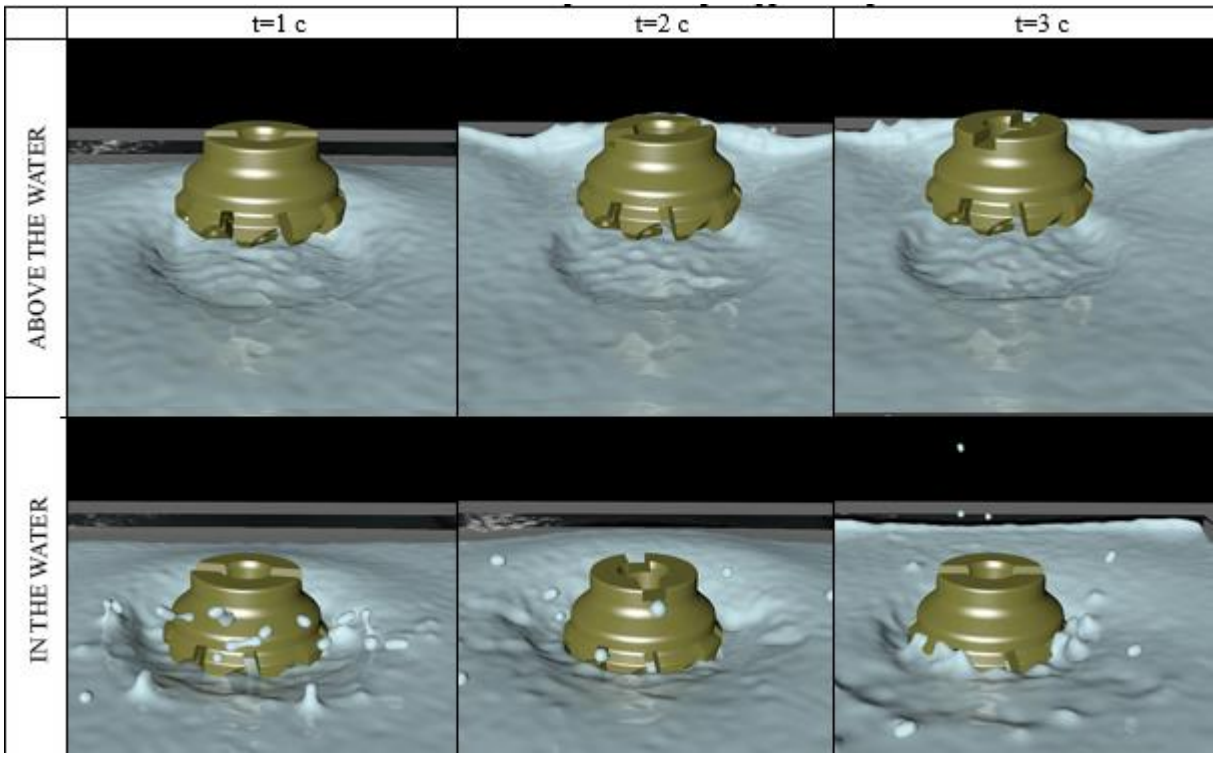


Table 3. – Investigation of the dynamics of the third milling cutter in a liquid medium



Description. Milling is one of the most common processing methods. In terms of productivity, milling is superior to planing and in large-scale production is second only to external stretching. The kinematics of the milling process are characterized by a rapid rotation of the tool around its axis and a slow feed movement. The feed movement during milling can be straight-forward, rotational, or helical. In the rectilinear movement of the feed, the milling cutters process all kinds of cylindrical surfaces: planes, all kinds of grooves and grooves, shaped cylindrical surfaces.

Experimental studies were conducted in the Cinema 4D software, using an additional plugin that allows you to simulate the behavior of the liquid and interaction with it. The results of the study are presented in the tables, which show the impact of the milling cutters on the surface of the liquid. In our case, the surface is the surface of the liquid, which is affected by the milling cutter air flow. Each milling cutter rotated on its axis above the surface, acting on the liquid. machine spindle speed n: 1000 rpm. Due to the different sizes of the grooves on the milling cutter design, they have different properties of passing air flows through them.

The milling cutter 2 affects the surface of the liquid least of all, since it has a large area. In the case of the 1 and 3 milling cutters, they affect a smaller area, but with greater force, as can be seen in the images in the tables.

If you put the rotating cutters in the liquid, we will see that during the rotation, the cutters will divert water through the grooves and form waves, bursts on the surface of the liquid. The milling cutter with a larger area during rotation, a larger number of waves are formed, when the milling cutters 1 and 3, with a smaller size of the grooves, more liquid is discharged, which causes a larger number of bursts.

Conclusion. In the course of the study, the possibilities of the methodology for studying the aero-hydrodynamic flowability, the effect of air flows on the shape of the milling cutter design were revealed. Also, using the Cinema 4D software and the "RealFlow" add-on, we modeled a simulation of the liquid environment for interaction with the 3D model of various milling cutters, respectively, we studied the effects of chip removal grooves on the liquid environment, both with the help of air passing through them, and the direct interaction of the cutter with water.

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