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CTM METHODOLOGY AND ITS APPLICATION
IN PRODUCTION ENGINEERING

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The new technology for Computer Integrated Manufacturing system, called Constructive - Technological Modules (CTM) Methodology, which permits to reduce volume of Numerical Control data prove-out procedures on the machines and increase economical effectiveness of machining is described.

ადწერილია ახალი ტექნოლოგია კომპიუტერიზებული საწარმოო სისტემებისთვის, სახელწოდებით საკონსტრუქტორო ტექნოლოგიური მოდულების (კტმ) მეთოდოლოგია რომელიც საშუალების იძლევა შემცირდეს ტექნოლოგიური როგრამების ჩარხზე გამართვის პროცედურები და გაიზარდოს მექანიკური დამუშავების ეკონომიური ეფექტურობა.

Описывается новая технология для компьютеризированных производственных систем под названием Конструкторско - Технологически Модульная (КТМ) методология, которая позволяет сократить объем процедур отладки управляющих программ на станках и повысить экономическую эффективность механической обработки.

PROBLEM:

Provision of workability and reliability of technological processes of machining and corresponding Numerical Control (NC) data, is one of the oldest problem domain in Computer Integrated Manufacturing (CIM) system history.

According to data of a Dun & Bread street research firm, US manufacturers spend about $ 1.8 bilion per year on NC data testing, using hundred thousand dollar machines, people and machinery to find errors.

The results of observation of the 800 processes of machines settings in the 4 different industries of Germany showed that the procedures of NC data test run demands the most long standstill of machines [1].

In this case some of the Russian military organisations make request to improve the special item units production technology.

The main task involved two subjects - reduce volume of NC data test operation and cut down machine standstill; increase economical effectiveness of turning processes.

The works on new CTM technology development have started at Moscow State Technical University named after N.Bauman.

SOLUTION:

It is possible to solve this problem by stabilising the parameters of machines and appliance, machining allowances, physical and chemical quality of workpieces and cutting tools, etc. However, it never brings economical benefit, because sensitively increases the cost of machining.

Another way of solution is application of technological processes simulation modeling software tool kit.

At present many firms use the several methods. Chrysler, Boeing, McDonnell Douglas and Ingersoll use NC verification approach for simulating tool paths and material removal [2]; Black & Decker corporation uses vericut to display the material removal processes of NC tool path and simulate the wear of the machine [3]; Realistic representation of the machining workstation and 3 D simulation of CLDATA instructions [4], etc. However, those methods are working on the basis of determinate models.

Our research work showed that technological processes of turning is stochastic [5,6]. It means that non-stable value of process parameters has substantial influence on the technological decisions. Therefore, technological decisions formed via determinate models are not absolutely correct and it demands necessity to make data prove-out procedures on the machines.

New solution in this case gives CTM methodology based on the idea of transfer of some synthesis procedures, which substantially depend on the disturbances, from the Computer Aided Design (CAD) system to the Computer Aided Manufacturing (CAM) system. It means to move some tasks from the stage of technological preparation of production to the machine control stage. It permits to generate in CAD errorfree NC data via Computer Numerical Control (CNC) and Computer Aided Quality Control (CAQC) systems.
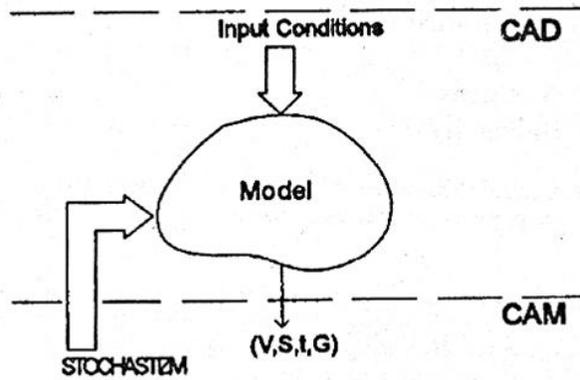
Fig.1.

Our research works showed that disturbances have the most substantial influence on the cutting conditions and geometric parameters: V - cutting speed, S - feed rate and t - depth of cut. Geometric parameters of tool path we can represent as G vector, which includes the sequence of support points and thear coordinates in the machine axis- X and Z. Quantitative analyzis described in [6] showed that in some cases fluctuation of workpiece hardness on 30%, have changed the value of feedrate up to 80%, and value of cutting speed up to 25%.; fluctuation of workpiece geomet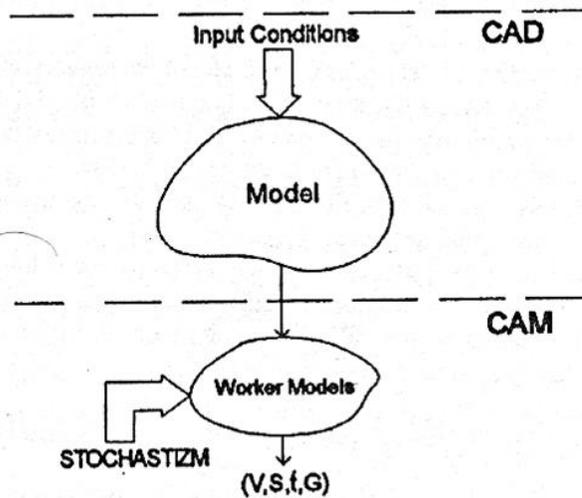rical parameters on 30% have changed feedrate up to 60%, and cutting speed - up to 30%. [7] showed that calculation of geometrical parameters of tool path accordingly the workpice actual geometry enlarge range of compensation of fluctuation and receive best results of rough pass optimisation.

Therefore it is necessary to realise in CAM cutting conditions and tool path geometry calculation procedures. Realisation of full models in CAM is not preferable [Fig.1], because it requires the special hardware for CNC. We can separate relatively simple models, called worker models from the full model. In this case definition of worker models will be carried out in CAD on the stage of technological preparation. Calculation of(V,S,t,G) will take place in CAM via worker models [Fig.2].

Worker models for calculation of cutting conditions have been formed according to the optimization model described in [8].

This model includes the most common optimization rules, existis in theoretical technology and is the base of the scientific schools majority in this field.

The model was developed on the base of Taylor's empirical equation. For V and S optimal value calculation for each fixed value of t, the joint solution of two optimization conditions [H,F] is necessary. The worker model in this case will contain two functional dependences between parameters destribed in optimisation condition and cutting conditions.

Fig.2

Generally it can be represented via the system of following equations

$$H = Ch \cdot V^{\alpha_h} \cdot S^{\beta_h} \cdot t^{\gamma_h}$$
$$F = Cf \cdot V^{\alpha_f} \cdot S^{\beta_f} \cdot t^{\gamma_f}$$

where Ch, Cf, α_n, β_n, γ_n, α_f, β_f, γ_f, - coefficients depend on turning conditions.

As it is known for the Taylor empirical equation one of the optimization condition is always the boundary condition, because the aim function has only conditional optimum. Another optimization condition includes either boundary condition or condition of optimal tool life

$$T=(\mu-1)(\tau+Q1/Q2)$$

where μ - is coefficient from the Taylor empirical equation; τ - cutting tool removal time; Q1 - cutting tool cost, Q2 - cost of machining during 1 minute.

Our research showed that first group of the optimization condition will contain restrictions by cutting speed [V], cutting power [N] and optimal tool life condition [T]; second group will contain restrictions by cutting force [P], spindle moment [M] and feedrate [S].

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Therefore the following worker models of cutting conditions calculation have been formed:[PV], [SV], [ST], [PT], [SN], [PN], [MV], [MN], [MT]. They correspond to common cases of turning. For concrete production conditions the required ones will be selected from these nine worker models.

Generally, tool path calculates for given turning zone geometry, cutting tool and tool movement scheme. It means that for worker models formation it is necessary to make typical technological decisions on the tool cutting pass level. It gives necessity to form the Constructive - Technological Module (CTM) formalism.

CTM contains the formal description of the constructive elements of parts and related to them alternative typical technological decisions on the tool cutting pass level, includes in addition the worker models for calculation of cutting conditions.

The CTM library must provide full description of part construction and technological operation of turning.

For typical parts "Perehodnik", "Vtulka", "Flanec", "Nakonechnik", produced at some military enterprises of Russia the CTM library described in [9] has been developed. The corresponding CAD-CAM software tool kit was also built.

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