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OPTIMIZATION OF GENERATIVE CAPP SYSTEM WITH MINIMUM COST PER PIECE

Rahimić, S. & Višekruna, V.
University of "Džemal Bijedić" Mostar, Faculty of Mechanical Engineering,
Mostar, Bosnia and Herzegovina
E-Mail: senad.rahimic@unmo.ba

Abstract:
This paper describes the model for process planning optimization taken minimum cost per piece and cutting speed into account. The number of variants depends on resources in manufactured system, machine labour, overhead rate and tools. The optimization model will be used in generative CAPP system for rotation parts. The developed mathematical model for minimum cost per piece includes all parameters of process planning. Determining of machining and manufacturing times is important for maximum profit, what the leading aim is in all manufacturing industry. Is the optimal cutting speed determines a maximum profit. The maximum profit is a combination of criterion minimum cost per piece, variant process planning and criterion of optimal of cutting speed.

Key Words: Generative CAPP, Process Planning, Methodology

1. INTRODUCTION

The manufacturing industry has been pushed to adopt more effective and efficient production strategies to meet the challenge of shorter life cycle, higher quality, lower cost, wider variety of customer demands [1].

This increased emphasis on achieving highly adaptive manufacturing to reduce manufacturing costs and to better utilize manufacturing capacity has led to a critical focus on agile manufacturing as a strategy to achieve these goals. In manufacturing, process planning is the task that transforms the design information into the manufacturing processes and determines the operation sequence.

CAPP considered a crucial link between Computer -Aided Design (CAD) and Computer - Aided Manufacturing (CAM) [2]. Research of over 30 years in CAPP has resulted in a wealth of knowledge on CAPP and many experimental and commercial CAP'P systems have been developed as a result.

2. METHODOLOGY PROPOSED FOR CAPP

Computer-assisted process planning was originated in the 1960s (Niebel 1965) and has been a very active area of research and development since. During the late 1970s, the science of computer-aided process planning (CAPP) evolved into two basic approaches: variant or generative process planning (Chang 1998). Modern approaches toward CAPP include using case-based reasoning [3].

In this paper methodology show on Figure 1 is proposed, which is start by geometric information about part using basic features. Target is to make all alternative technological variants of processes like planning (organize by sequence phases), scheduled and operations.

The module is developed for searching basic manufacturing features (groove revolution, slot, thread, plane, cylinder cone outer, cylinder cone inner, etc.) It should fulfil two basic conditions: the first requires all features to be simple, and make together complex features, which then defined rotational part. The second condition defined features from each simple feature, which are individual.

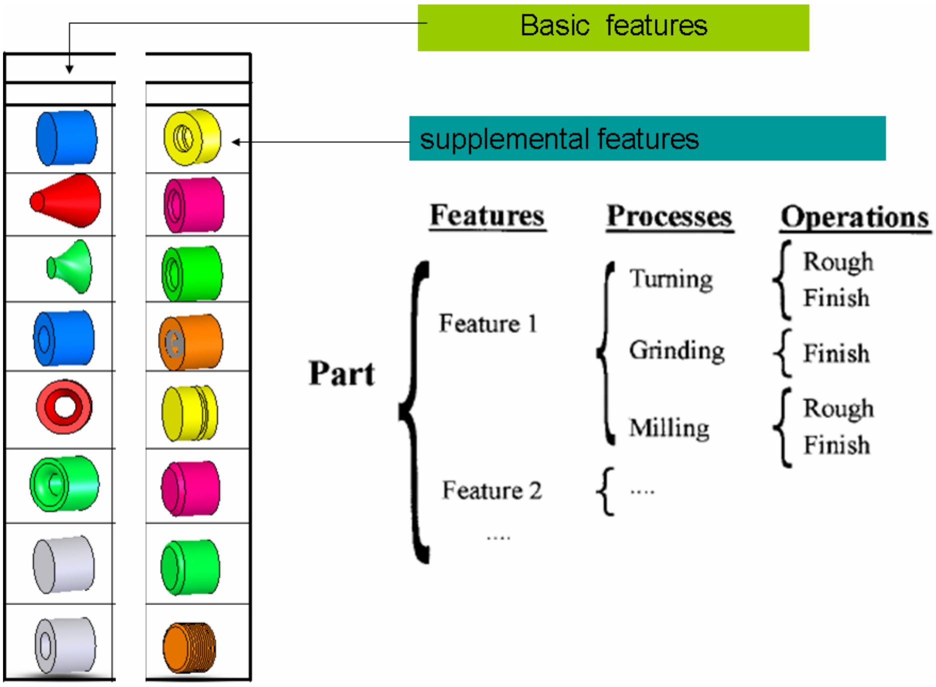


Figure 1: Assignment of alternative processes and operations [5].

3. AN OBJECT- ORIENTED KNOWLEDGE REPRESENTATION SCHEME

Whole part is represented by simple features, which made complex rotational parts. All individual information, definition of possible processes and commission technology are included. Resumption of destitute operations makes any basic features possible. Included are all features, all processes and operations, which can to be applied with acceptable declaration quality.

We propose an appropriate knowledge representation scheme which attends to address various facets of the process-planning task. We recommended object-oriented approach for describing process planning related entities and the relations among them, and for development of automated process planning systems.

The object-oriented approach, which during process planning exchange messages, is shown of Figure 2 as semantic network. Each object carries data that identify it, a set of attributes and functions that define its behaviour through appropriate methods, and links to other object through associations with other objects.

Each kind of object is represented as a hierarchy with relationship between them and instance at the bottom level. Lower objects in the hierarchy inherit common attributes and/or their values from a higher level objects.

Taxonomies of features, processes, machines and tools exist in the semantic network. Inheritance is used to infer attributes and behaviour of more specific object, a number of represent manufacturing capabilities and reasoning in process planning [4].

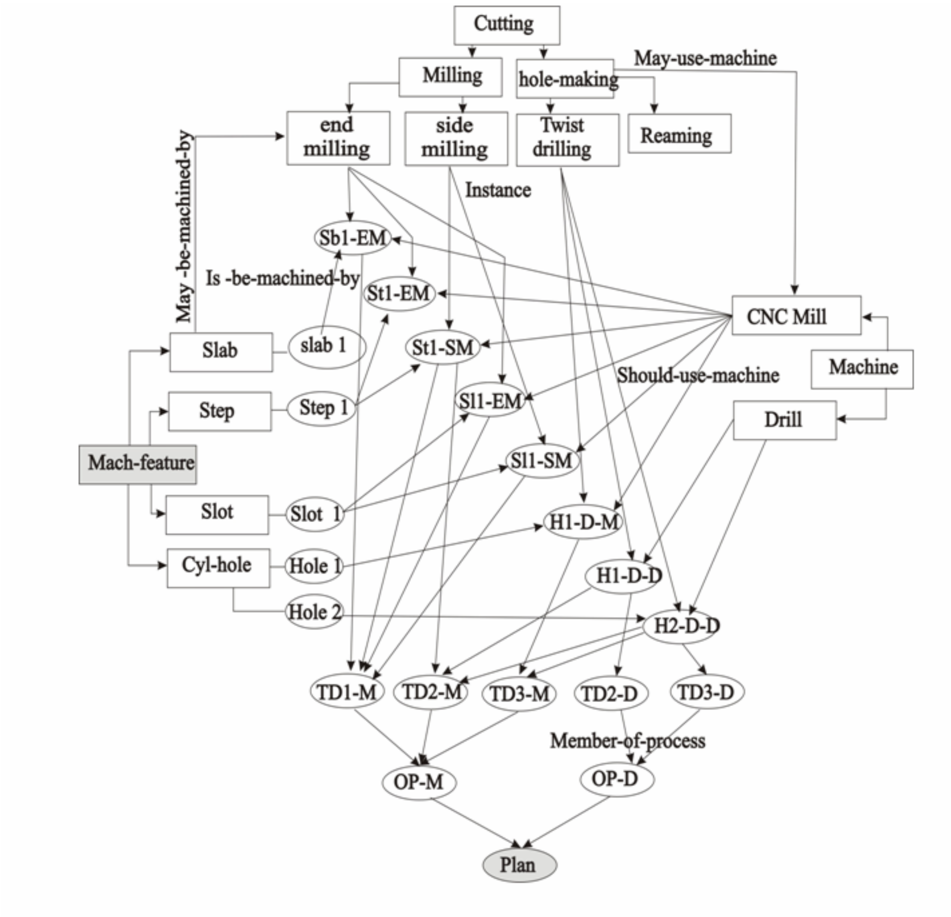


Figure 2: The process planning semantic network [5].

4. MINIMUM COST PER PIECE

The average cost per piece to produce a work piece consists of the following costs: non-productive cost per piece, machining time cost per piece, tool changing cost per piece and tooling cost per piece. Mathematically, this can be expressed as equation (1).

$$c_1 = c_o t_1 + c_o t_c + c_o t_a \left(\frac{t_{ac}}{T}\right) + c_a . \left(\frac{t_{ac}}{T}\right) \qquad (1)$$

Upon partially differentiating c_1 with respect to v, equating to zero, and solving (1), we obtain the minimum unit cost cutting speed (v_{min}) as follows equation (2).

$$\frac{\partial c_u}{\partial v} = 0 \qquad (2)$$

Upon partially differentiating c_1 with respect to v, equation to zero, and solving (2) for v, we obtain showed on equation (3).

$$v_{coj} = \sum_{j=1}^{i_p} \frac{C}{\left[\left(\frac{1}{n} - 1\right)\left(\frac{c_o \cdot t_{aj} + c_a}{c_o}\right)\right]^n} \qquad (3)$$

Optimization of mathematically systems can be expressed as systems of equation (4).

$$c_{1f1} = c_o\left[\frac{t_{ps}}{N_0} + t_{ss} + \left(t_p + \frac{L}{1000v_{ph}}\right)i_p\right] + \sum_{j=1}^{i_p}\left[c_o\left(\frac{\pi D_j l}{1000v_{cj} f}\right) + c_o\left(\frac{\pi D_j l}{1000v_{cj} f}\right)\left(\frac{v_{cj}}{C}\right)^{1/n} t_a + c_a\left(\frac{\pi D_j l}{1000v_{cj} f}\right)\left(\frac{v_{cj}}{C}\right)^{1/n}\right]$$

$$c_{1f2} = c_o\left[\frac{t_{ps}}{N_0} + t_{ss} + \left(t_p + \frac{L}{1000v_{ph}}\right)i_p\right] + \sum_{j=1}^{i_p}\left[c_o\left(\frac{\pi D_j l}{1000v_{cj} f}\right) + c_o\left(\frac{\pi D_j l}{1000v_{cj} f}\right)\left(\frac{v_{cj}}{C}\right)^{1/n} t_a + c_a\left(\frac{\pi D_j l}{1000v_{cj} f}\right)\left(\frac{v_{cj}}{C}\right)^{1/n}\right]$$

....

$$c_{1fn} = c_o\left[\frac{t_{ps}}{N_0} + t_{ss} + \left(t_p + \frac{L}{1000v_{ph}}\right)i_p\right] + \sum_{j=1}^{i_p}\left[c_o\left(\frac{\pi D_j l}{1000v_{cj} f}\right) + c_o\left(\frac{\pi D_j l}{1000v_{cj} f}\right)\left(\frac{v_{cj}}{C}\right)^{1/n} t_a + c_a\left(\frac{\pi D_j l}{1000v_{cj} f}\right)\left(\frac{v_{cj}}{C}\right)^{1/n}\right] \quad (4)$$

The minimum cost per piece for one operation in process planning is representation of sums of all phases consisted in operation as stated in equation (5)

$$c_{1o} = \sum_{i=1}^{f} c^{i}{}_{1f} \quad (5)$$

5. EXAMPLE OF PART

Rotational part shown in Figure 3 was tested for given mathematically module. It corresponds to the following types:

- Groove revolution: GRO1, GRO2.
- Slot: SLO1, SLO2, SLO3.
- Thread: THR1.
- Plane: OD1, OD3, OD5, OD7, OD10.
- Cylinder cone outer: OD2, OD4, OD6, OD8, OD9.
- Cylinder cone inner: HO1.

The production media developed for particularly process plan is consisting of a group of machine tools and fixtures and provides support for conventional machining processes. The capacities established for these manufacturing systems are the usual ones for standard quality.

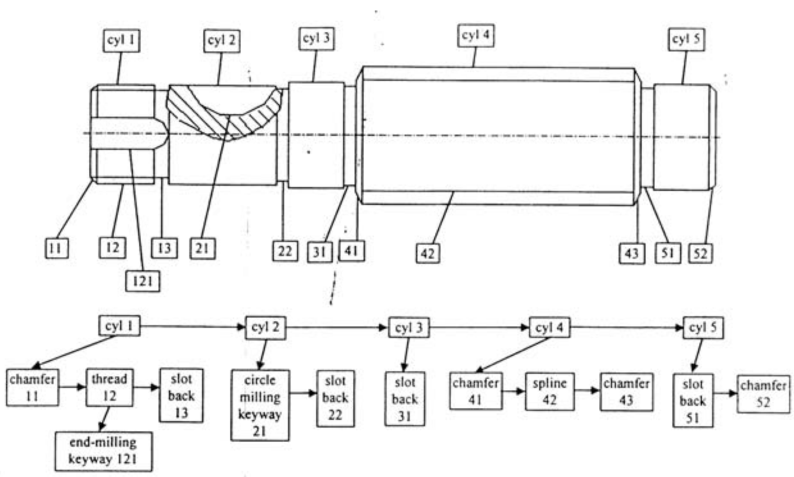


Figure 3: Drawing model with features.

In this paper CAD software Solid Works was used for an example of the rotation parts shown in Figure 4 [6].

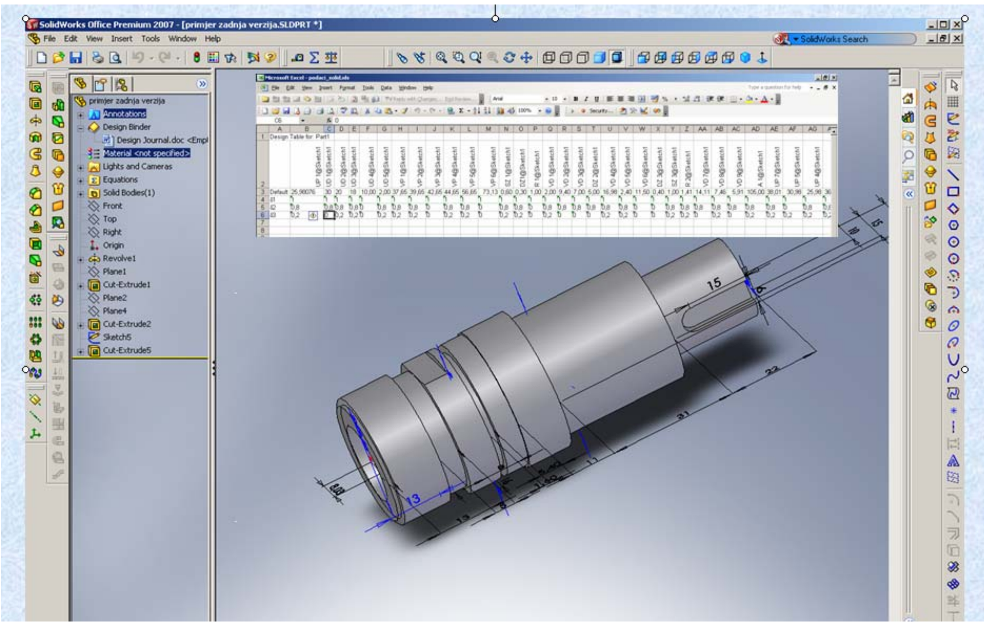
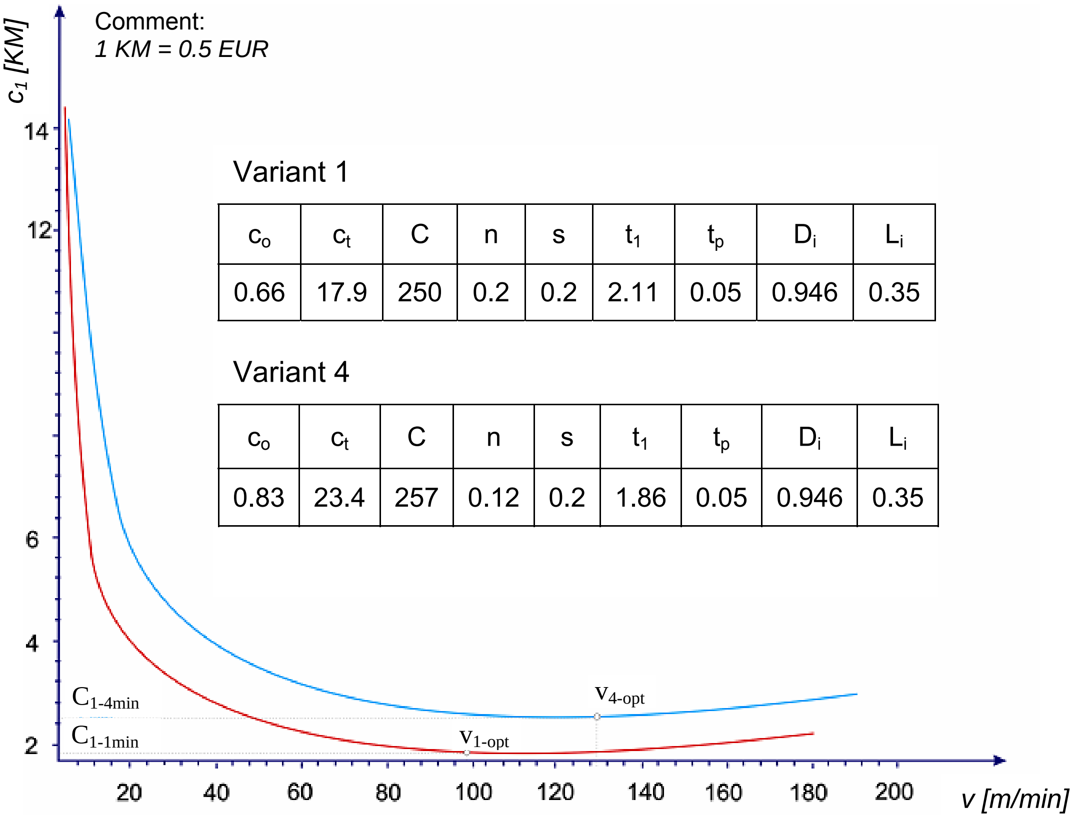


Figure 4: Drawing part connection with features [6].

Function graph for minimum cost per piece for all possible variants process planning is shown in Figure 5.



Variant 1

c_o	c_t	C	n	s	t_1	t_p	D_i	L_i
0.66	17.9	250	0.2	0.2	2.11	0.05	0.946	0.35

Variant 4

c_o	c_t	C	n	s	t_1	t_p	D_i	L_i
0.83	23.4	257	0.12	0.2	1.86	0.05	0.946	0.35

Figure 5: Graph of function for minimum cost per piece for cutting [6].

By testing of rotation part shown in Figure 6, we got function of cutting speed and minimum cost per piece and number of workpieces for all possible variants of process planning.

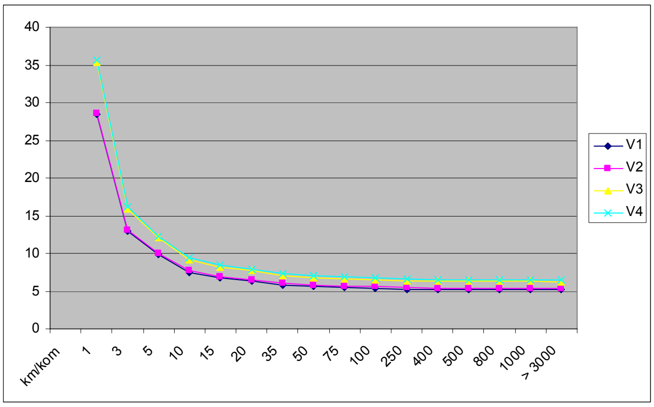


Figure 6: Representation of all possible variants.

On Figure 7 graph of function for minimum cost per piece for different machining regime is shown for all possible variants process planning [7].

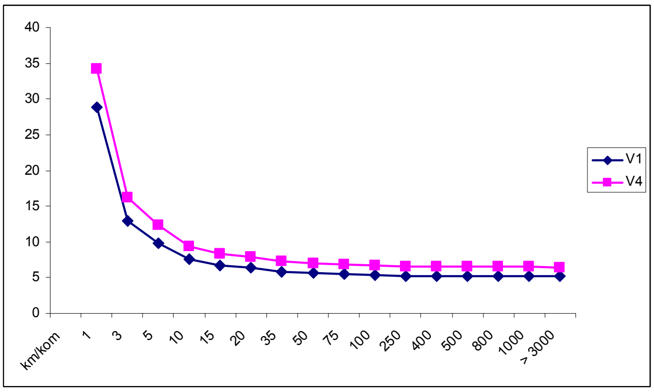


Figure 7: The considered variant 1 and variant 4.

Table I shows minimum cost per piece for variants with different machining regime in function of number workpieces and given coefficient rate of dependent [7].

Table I: Achieving coefficient rate of dependent.

number workpieces	V1	V4	k
1	28,83	34,27	0,16
3	12,95	16,17	0,20
5	9,84	12,28	0,20
10	7,51	9,37	0,20
15	6,73	8,4	0,20
20	6,34	7,91	0,20
35	5,84	7,29	0,20
50	5,64	7,04	0,20
75	5,49	6,84	0,20
100	5,41	6,75	0,20
250	5,27	6,57	0,20
400	5,24	6,53	0,20
500	5,22	6,51	0,20
800	5,21	6,49	0,20
1000	5,2	6,48	0,20
> 3000	5,18	6,46	0,20

Figure 7 shows the rate of variant 1 and variant 4, in function on number of workpieces. We can conclude to mathematically dependence, which is declared through coefficient showed on equation (6).

$$k = \frac{c_1 - c_4}{c_4} \tag{6}$$

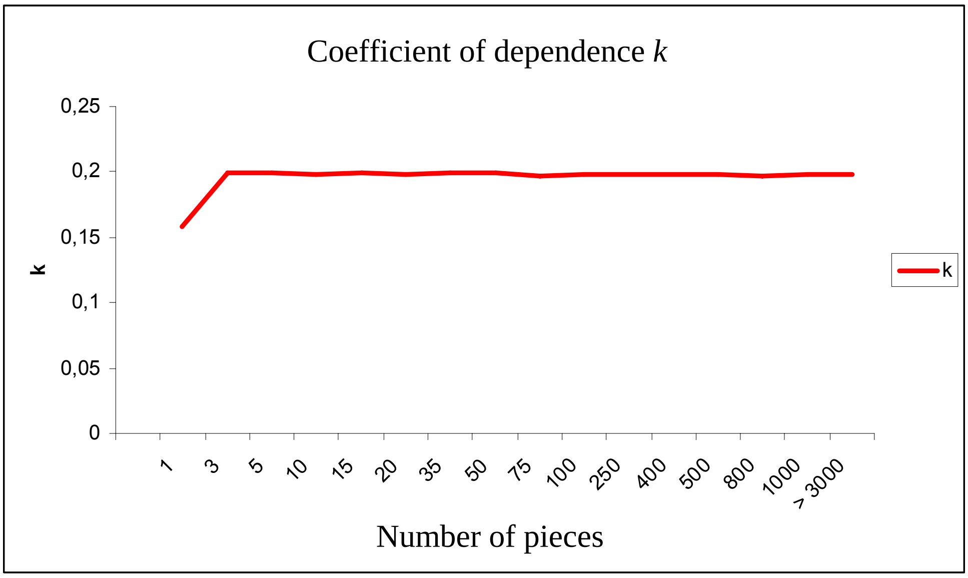


Figure 8: The coefficient of dependence between variants.

5. CONCLUSION

In this paper a methodology and architecture suitable for generative process plan of machining parts is proposed. It is a proposal in which the peripheral processes needed for these parts, are taken into account and they enable the development of alternative process plans.

These characteristics are largely based on the methodology proposed, the functional structure, the use of general information models and the general functional procedures. All these factors working together give the system its qualities. The development of the CAPP system based on this proposal has demonstrated the system's feasibility and its optimal qualities.

The process plans offered by the system all constitute of the alternatives for the sequence of phases, guaranteed by a high degree of optimization with regard to cost and number of phases. These alternatives explicitly include feasible alternatives for machines and tools for operations (depending on the type of machine for each phase).

The introduction of modern CAD/CAM system is an important step to compete with production systems on the world market. Parameter modelling and integration which is realized with modern CAD/CAM systems, display on example of modelling rotational parts, gives possibility of integration between CAD and CAM modules.

The target is to connect CAD and CAM system over information flow from design of product to its manufacturing. The development of the CAPP system based on this proposal has demonstrated the system's feasibility and efficiency.

The process plans offered in CAPP system alternative variants, which are composed of sequence and phases. The optimization of the process variant depends of the minimal cost per peace and optimal speed of cutting.

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