THE CLASSIFICATION OF THE CUTS THROUGH THE EQUILIBRATION OF THE COMPONENTS

Lect. univ. drd. Ioan MAXIM
Teacher Training Department
„Ştefan cel Mare" University of Suceava

Abstract: *The paper presents an algorithm to order the cutting process by using cutting diagrams and considering the conditions and the restrictions imposed by the wood industry. The cutting order and the use of the topological algorithm is essential in the cutting process.*

Keywords: *cutting diagrams, cover of plane surfaces, equilibration components, accepted cutting diagram, cutting graph.*

The total or partial covering of plane surfaces with a pre-established set of forms can be applied in many domains. The problem of covering the surface is followed by the one of creating an order and cutting the forms that cover the surface. In the wood industry, the technological cutting restrictions impose a specific cutting succession. In (Maxim 2005) I presented an hierarchical classification algorithm of the cuts (Pentiuc, 1996), (Pentiuc, 1997), which can satisfy the technological cutting restrictions too.

As, in the short-serried production the cutting way is establish manually, an important objective is the growth of the work production throw the better manipulation of the cutting surfaces. The algorithm presented in (Maxim, 2005) produces a succession of cuts, which is not unique. The succession of the cuts can only be unique by imposing some restrictions, which can lead to the equilibration of the cut resulting components, in the cut conditions.

Let's take a rectangular surface S and a finite set of rectangular forms F, named guide marks, which cover totally or partially the S surface. The F forms are placed on the S surface with the parallel sides on the edges (of the S surface) – the coordinating axes.

The covering algorithms offer the best solution of covering the S form with a not-empty sub-group of forms $F' \subseteq F$; those solutions are known by the name cut diagram (Maxim, 2003). A cut diagram is being accepted if there is the possibility of portioning the S′ surface in two disjunctive surfaces S'_1 and S'_2, in any moment of the cut operation, for any S' part from the S surface, with more than one guide mark. The S'_1 and S'_2 surfaces must contain less guide marks than the S′ surface form that they come from. The exception exists in the case of the S′ surfaces that do not contain any guide marks (residuum) and the ones which contain only one guide mark, but they don't identify with it.

Let's take a T cuts group associated with the cut diagram and f – a partial-defined function:

$$f: T \times P(S) \rightarrow P(S) \times P(S).$$

The cutting diagram for the S surface is accepted if: $\forall S' \subseteq S$, $\exists\ t \in T$, $\ni$ $f(t, S')=(S'_1,S'_2)$, with $S'_1 \cap S'_2=\varnothing$ and $S'_1 \cap S'_2= S'$.

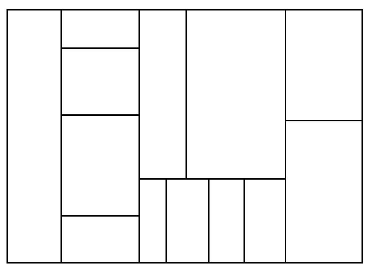

Fig. 1a). Accepted cutting diagram

The algorithm presented in (Maxim, 2005) decides if the cutting diagram is accepted or not, and if the diagram is accepted, a succession of cuts will be generated. The algorithm takes the solution of constructing a not-oriented graph that should have topological sorted knots. If the topological sorting operation ends up successfully, the cutting diagram is accepted.

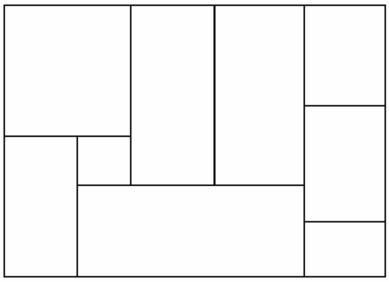

Fig. 1b). Not accepted cutting diagram

The construction algorithm of the cutting preceding graph (Maxim, 2005)

First step: For each guide mark $r_i = (x_{1i},y_{1i}, x_{2i},y_{2i})$ defined by the left-up and right-low corners there must be made a cutting list $t_k = (x_{1k},y_{1k}, x_{2k},y_{2k})$, the limited lines that represent the sides of each guide mark.
Second step: Eliminate from the cutting list the cuts on the edge of the surface and all the cuts considered to be limited lines inside other cuts.
Third step: Find all the cuts that don't have the end on any other cut. If there's no cut having this property and all the cuts were not eliminated, the algorithm is blocked.
If this type of cuts exists, than:
- create, for each of those cuts, a knot that contains the number of the cut, as information;
- for each knot, created in this manner, verify if there are any cuts, eliminated in the anterior steps, on which the current cut has an end. If such a cut exists, unify the specific knot of this cut with the one of the current cut.

Repeat the third step until all the cuts are eliminated or until the algorithm is blocked.

<u>Observation:</u> The result is a not-oriented graph of the cuts. The numbering of the graph's edges is arbitrary, because it is not essential for the algorithm. After the second step, another numbering of the cuts can be made. Construct, from this cuts graph, an oriented graph, named the preceding cuts graph.

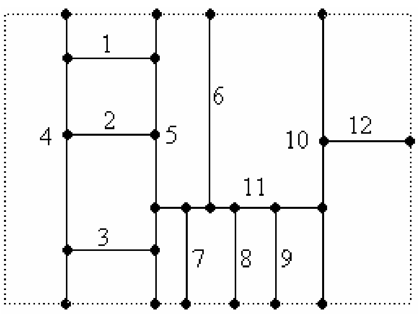

Fig. 2a). The graph before the first execution of the third step

The fig. 2a) and 2b) represents the operations described in the algorithm, for the fig.1a) diagram's case.

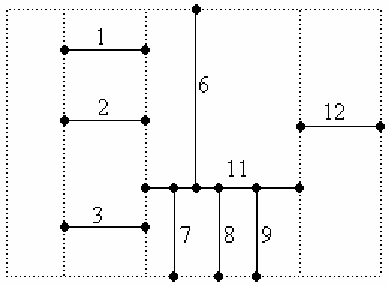

Fig. 2b). The graph after the first execution of the third step

First time you make the third step eliminate the cuts no. 4, 5 and 8 and create the three knots, correspondent to those cuts, in the preceding cuts graph. During this step no arc is traced. The cutting graph will look like in the fig. no.2 b). The second time you make the third step eliminate the cuts no.1, 2, 3, 11 and 12 and create the corresponding cuts in the preceding cuts graph. During this step trace the following arcs: (4,1), (4,2), (4,3), (5,1), (5,2), (5,3), (5,11), (10,11), (10,12). The cutting graph will look like the one in the picture no.3.

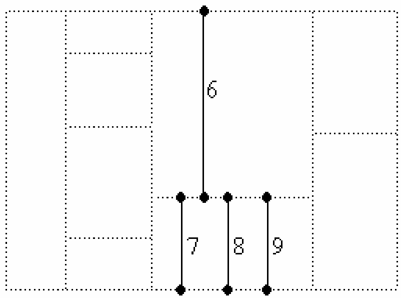

Fig. 3. The cutting graph after the second execution of the third step

The third time you make the third step eliminate the cuts no.6, 7, 8 and 9 and create the corresponding cuts in the preceding cuts graph. During this step trace the following arcs: (11,6), (11,7), (11,8), (11,9).

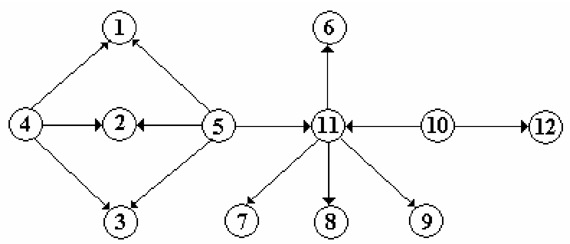

Fig. 4. The preceding cuts graph

The preceding cuts graph can be seen in the picture no.4. Throw the knot's (of the preceding cuts graph) topological sorting we can establish if the cutting diagram is accepted or not, depending on how the sorting algorithm ends up.

The incident graph - knot's topological sorting end up; the diagram form the picture no. 1 a) is accepted in this case and establishes the next cutting order: 4, 5, 1, 2, 3, 10, 11, 6, 7, 8, 9, 12.

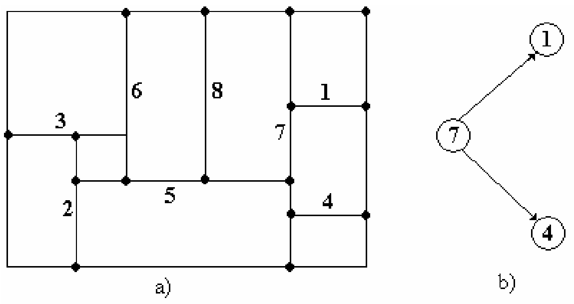

Fig. 5. The preceding cuts graph

For the diagram in the picture no.1 b) and the knot's numbering from fig. no. 5 a), the incident cutting graph is the one in the fig. no. 5 b), but the topological sorting of the incident graph's knots is not finished, because the diagram was not accepted.

The order in the topological sorting is not unique. If a knot's separating criteria is added, criteria- having a null external grade in the topological sorting, the solution is unique. The knot's separating criteria, which contains the cut's order number as information, is specific to the surface part's equilibration in cutting.

In this case, the most favorable algorithm consists into modifying the topological sorting. For the cutting diagram in fig. no. 6, where you can see the guide mark's dimensions and the cut's numbering, the preceding graph is the one in fig.no.5.

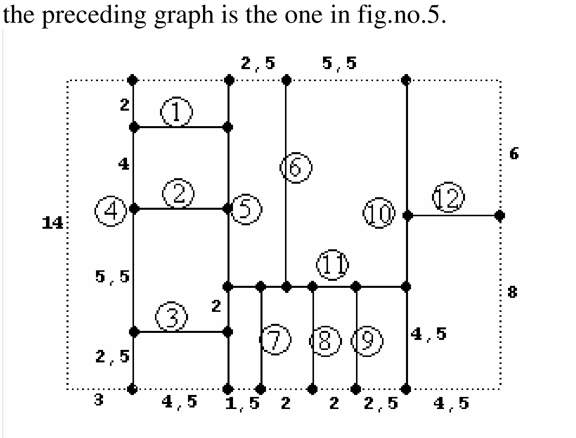

Fig. 6. The cutting diagram with the guide mark's dimensions an the cutting numbering

The vector of the preceding graph's knot's internal grades, corresponding to the cuts in the fig. No. 5 is:

Knot	1	2	3	4	5	6	7	8	9	10	11	12
Int.gr.	2	2	2	0	0	1	1	1	1	0	2	1

There are three knots having the internal grade 0: 4, 5 and 10. For each one of those cuts there is one of the next surface part's pears: (14x3, 14x17), (14x7,5, 14x12,5) and (14x15,5, 14x4,5) having as an correspondent an surface report 3/17=0,176, 7,5/12,5=0,6 and 4,5/15,5=0,290. Choose the cut no.5, as it is generating the most equilibrated surfaces (the report is the nearest to 1).

Following the topological sorting algorithm no. (Athanasiu *et al, 1993*), the vector of the internal grades becomes:

Knot	1	2	3	4	5	6	7	8	9	10	11	12
Int.gr.	1	1	1	0	+	1	1	1	1	0	1	1

The knot no. 5 is eliminated; the preceding knot's graph has now two connected components, like in fig. no.7.

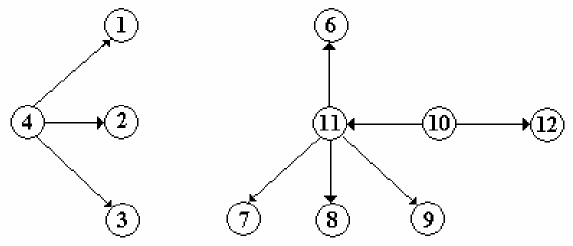
Fig. 7. The preceding knot's graph

The two connected components have tow knots with the internal grade equal 0: no.4 and no. 10, which produces the next pears of surface parts: (14x3, 14x4,5) and (14x8, 14x4,5), with the reports 3/4,5=0,666 and 4,5/8=0,562.

Choose the cut no. 4 that produces the most equilibrated cuts.

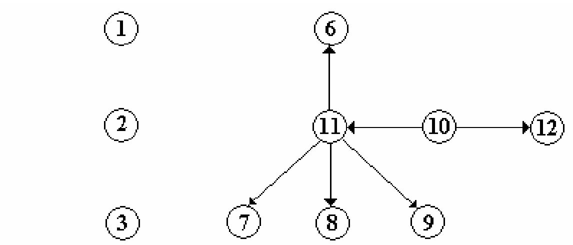
Fig. 8. The preceding knot's graph

The vector of the internal grades becomes:

Knot	1	2	3	4	5	6	7	8	9	10	11	12
Int.gr.	0	0	0	+	+	1	1	1	1	0	1	1

The preceding knot's graph will have now four connected components like in fig. no.8. Corresponding to each of the four cuts: 1, 2, 3 and 10 there can be created the next parts: (2x4,5, 12x4,5), (6x4,5, 7x4,5), (11,5x4,5, 2,5x4,5) and (6x14, 4,5x14), with the reports: 2/12=0,166, 6/7=0,857, 2,5/11,5=0,217 and 4,5/6=0,750. Select the cut no.2. Next, select cut no.10 from the cuts: 1, 3 and 10 with the cutting reports: 0,500, 0,454 and 0,75.

The graph will have four connected components, four cuts having the 0 grade: 1, 3, 11 and 12 with the cutting reports: 0,500, 0,454, 0,473 and 0,750; in this case choose the cut no.**12**, followed by the cuts no. **1** and **11**. In this moment there are left the next cuts: 3, 6, 7, 8 and 9. Select the no.**8** and then, between 3, 6, 7 and 9, with the corresponding cutting reports

2,5/5,5=0,454, 2,5/5,5=0,454 1,5/2=0,750 and 2/2,5=0,800. Select in this order: **9**, **7**, **3** and **6**.

This way, the topological sorting of the knot's graph from the fig. no 4 will lead to the next cutting order: 5, 4, 2, 10, 12, 1, 11, 8, 9, 7, 3, 6, which is a cut's classification throw the cut's equilibration.

If, at one moment of the topological sorting, before eliminating all the knots, there's no internal grade 0 knot, the topological sorting is stopped; this means that the cutting diagram is not accepted (the cutting of such a diagram cannot be made in the technological restriction given).

REFERENCES

Athanasiu Irina, Cristea Valentin, Iorga Valeriu, and Kalisz Eugenia (1993). *Tehnici de programare*, Editura Teora, Bucureşti.

Maxim Ioan (2003). *Metoda acoperirilor succesive pentru optimizarea algoritmului de acoperire a suprafeţelor planare fără restricţii*, In Tehnologii Informaţionale, Editura Universităţii „Ştefan cel Mare", Suceava, (Coordonator Alexandru Valachi).

Maxim Ioan (2005). *Clasificarea ierarhică a tăieturilor*, Analele Universităţii de Stat din Moldova, seria „Ştiinţe fizico-matematice", Chişinău.

Pentiuc Ştefan-Gheorghe (1997). *Aplicaţii ale recunoaşterii formelor în diagnosticul automat*, Editura tehnică, Bucureşti.

Pentiuc Ştefan-Gheorghe (1996. *Recunoaşterea formelor – metode, programe, aplicaţii*, Editura Universităţii „Ştefan cel Mare", Suceava.