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Optimization of textile scheduling problems using Ants colonies algorithms

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***Abstract:* -** The purpose of this paper is to provide a method to solve the scheduling problem of a textile machine in a clothing workshop. The scheduling of the production in the textile sector clothing was the goal of many studies. The obvious interest of the mathematical approach is to guarantee the optimal solution. Unfortunately, for the real problems in the textile industry, these approaches became very complex. Thereafter, these procedures can be associated with heuristic methods or algorithms of local research; the purpose is to accelerate convergence towards the optimal result. In our work, we use optimization by the ants colonies to solve scheduling problems of the production in the textile clothing companies.

***Keywords:* -** *Heuristics, Ant Colony, Flow shop, Scheduling.*

I. INTRODUCTION

The complexity of the textile industrial problems, the computing times required and the lack of flexibility of the scheduling methods in the textile companies makes very difficult to use the exact methods for scheduling problem [1]. Consequently, to solve the scheduling problems, we use the heuristic methods. These approaches are based on the approximation and the selection by elimination. Consequently, we use these algorithms to solve the scheduling problems called NP-difficult which are difficult to be solved by the traditional methods. Indeed, in the case of textile industry where the size of the problem is large, these heuristic approaches become very used. Among the research tests, we quote that in [2]; the researchers proposed an approach which makes it possible to schedule a discontinuous workshop of fine chemistry. It consists in coupling a simulator of batch processes with a genetic algorithm. To solve the problems of scheduling of the job-shop type, certain researchers presented the genetic algorithms based on fuzzy logic [3] or only the genetic algorithms [4] and [5] or the tabu research [6].

Others studies present a platform of construction and tests of procedure by separation and evaluation (PSE) for the resolution of the hybrid scheduling problems [7]. Others papers presents a hybrid genetic algorithm for the Job Shop Scheduling problem [8] and the ant colony optimization [9].
We call technique of scheduling the method which allows the person in charge for the project to make the necessary decisions under the best possible conditions. The clothing textile field is characterized by a fast evolution in the time opposite the world circumstances and the market demands. In a workshop of clothes industry, to schedule different orders in the chain of production is to program the execution of a realization by allotting resources such as the materials and matters with the tasks and by fixing their dates of execution so as to reach the optimum of a criterion defined beforehand and while respecting the constraints of the realization.

II. SCHEDULING OPTIMIZATION BY ANTS COLONIES

Research in the data-processing field indicates that the ants could bring us ideas to the optimization of the production. The ants activities are always the research of food. The management of the organization benefited from this method of effective research and the communication between the ants which represents an opportunity interesting. The algorithm of ants colonies makes it possible to solve a problem of scheduling. An ant chooses a task I_2 after I_1 according to the trace and the arc visibility of (I_1, I_2).
A cycle is checked when each ant traversed all the tasks.

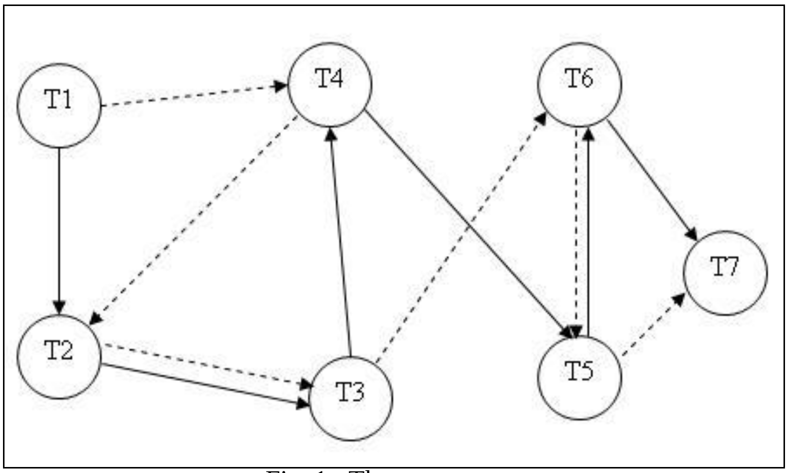

Fig. 1: The ants course.

Each operation is noted by $O_iP_jM_k$, where i, j and k represent respectively the operation number, product number and the machine number. We define the matrix of initial trace in the following way.

j= 1,…,J where J represents the products count.

i= 1,...,I_j where I_j represents the count of the operations in the product j.

k= 1,...,K where K represents the machines count.

n= 1,...,N et $N = \sum_{j=1}^{J} I_j$ where N represents the tasks count. (Equation 1)

$\tau_{n1,n2} = \tau_0$ if $n1 \neq n2$ (Equation 2)

$\tau_{n1,n2} = 0$ if n1 = n2 (Equation 3)

$\tau_{n1,n2}$ represents the trace between the task T_{n1} and the task T_{n2}.

$1 \le n1 \le N$ and $1 \le n2 \le N$.

Table 1: Matrix of initial trace

	T_1	T_2	..	T_n		T_N
T_1	0	τ_0	τ_0	τ_0	τ_0	τ_0
T_2	τ_0	0	τ_0	τ_0	τ_0	τ_0
..	τ_0	τ_0	0	τ_0	τ_0	τ_0
T_n	τ_0	τ_0	τ_0	0	τ_0	τ_0
..	τ_0	τ_0	τ_0	τ_0	0	τ_0
T_N	τ_0	τ_0	τ_0	τ_0	τ_0	0

After each cycle, a local trace is added for all the arcs followed by each ant. This modification is translated on the matrix of trace by the following rule:

$\tau_{n1,n2}(t+1) = \rho l * \tau_{n1,n2}(t) + (1-\rho l) * \Delta\tau_{n1,n2}$ (Equation 4)

$\Delta\tau_{n1,n2} = \tau 0$. (Equation 5)

ρl: constant which represents the local persistence of trace.

At the end of each cycle, the ant having the best quality of solution updates the trace matrix of pheromone according to the found solution. This best way is updated by a total trace according to the rule:

$\tau_{n1,n2}(t+1) = \rho g * \tau_{n1,n2}(t) + (1-\rho g) * \Delta\tau_{n1,n2}$ (Equation 6)

$\Delta\tau_{n1,n2=Cmax}$ (Equation 7)

Cmax: is the delivery date of the last operation.

ρg: constant which represents the global persistence of trace.

The choice of the task T_{n2} after the task T_{n1} is according to $\Phi_{n1,n2}$

$\Phi_{n1,n2} = (\tau_{n1,n2}{}^{\alpha} * \eta_{n1,n2}{}^{\beta})$ is maximum. (Equation 8)

α and β are two coefficients used to reach the best solution in a minimum time.

The visibility was calculated by the rule: $\eta_{n1,n2} = \sum_{n=1..N} \Omega_n - (\Omega_{n1} + \Omega_{n2})$ (Equation 9)

Ω_n and N represent respectively the execution time of the task T_n and the total number of tasks.
In order to converge towards the results and to find the optimal result in a reduced computing time, we add another matrix called "Selection matrix" constituted by 1 or 0.
S (T_{n1}, T_{n2}) = 1 if we can pass from the task T_{n1} to the task T_{n2}.
S (T_{n1}, T_{n2}) = 0 if we can't pass from the task T_{n1} to the task T_{n2}.
And this matrix changes as the ant moves.

Table 2: The selection matrix

	T_1	T_2	..	T_n		T_N
T_1	0	1	..	..	..	..
T_2	0	0	..	..	..	..
..	..	..	0	..	..	..
T_n	..	..		0	..	..
	..	..		..	0	..
T_N	..	..		..	..	0

To avoid the repetition of the selections, all the selected operations are recorded in a list to ensuring that an ant will not remain in the same operation.
Each ant m ($1 \le m \le M$) must visit in its course all the N tasks.

Table 3: The history of the ants

Position\ Ants	A_1	A_2	..	A_m	..	A_M
Position 1	$T_{1,1}$	$T_{2,1}$		$T_{m,1}$		$T_{M,1}$
Position 2	$T_{1,2}$	$T_{2,2}$		$T_{m,2}$		$T_{M,2}$
..	..	..		..		..
Position n	$T_{1,n}$	$T_{2,n}$		$T_{m,n}$		$T_{M,n}$
..	..	..		..		..
Position N	$T_{1,N}$	$T_{2,N}$		$T_{m,N}$		$T_{M,N}$

With $\mathbf{T_{m,n}}$: The **n** th task visited by the **m** th ant.

III. PROBLEM DESCRIPTION

3.1. Problem definition

The work consist to schedule J products {P_1 .. P_J} having a different passage orders with K machines. Each product Pj (j: 1..J) is composed by some operations O_{Ij}. Each operation is noted by $O_iP_jM_k$ where i, j and k represent respectively the operation number, the product number and the machine number. The execution time of each operation i of the product j is noted $\Omega_{i,j}$.

Table 4: Scheduling Problems

Product	Task	Machine	The execution time
P_1	O_1	M_1	$\Omega_{1,1}$
P_1	O_2	M_2	$\Omega_{1,2}$
P_1	O_3	M_3	$\Omega_{1,3}$
P_2	O_1	M_1	$\Omega_{2,1}$
P_2	O_2	M_2	$\Omega_{2,2}$
P_2	O_3	M_3	$\Omega_{2,3}$
P_3	O_1	M_1	$\Omega_{3,1}$
P_3	O_2	M_2	$\Omega_{3,2}$
P_3	O_3	M_3	$\Omega_{3,3}$

3.2. Constraints of problems

- A machine can carries out only one operation at the same time.
- The chronological order of a range must be respected.

In the calculation program, each machine must have a history on the whole of the tasks affected with the beginning date (D_b) and the finished date (D_f) of each task.

Table 5: History of assignment

TASK\ MACH	**M_1**		**..**		**M_k**		**..**		**M_K**	
N° TASK	**D_b**	**D_f**	**D_b**	**D_f**	**D_b**	**D_f**	**D_b**	**D_f**	**D_b**	**D_f**
1										
2										
..										
T_N										

IV. APPLICATION

This example was took from one company specialized in the manufacturing of the knitted clothes pull-over for a little quantity. In fact, we make the scheduling of three products which the execution time of each operation is presented in the following tables (The unit of the time is cmn where cmn=1 minute/100).

TABLE 6: Product1 description

Product 1 (P1)			
OPERATION	**OPERATION NAME**	**MACHINE**	**TIME (cmn)**
O1	JOIN FRONT CRUTCH	OVERLOCK	40
O2	JOIN BACK BOTTOM	OVERLOCK	40
O3	JOIN OF SIDE BACK PANELS	OVERLOCK	75
O4	JOIN BOTTOM + SIDE PANELS	OVERLOCK	70
O5	STITCH OF BACK YOKE AND THE SIDE	OVERLOCK	120
O6	JOIN INSIDE LEGS	OVERLOCK	35
O7	FASTENING OF THE INSIDE YOKE	LOCKSTITCH	80
O8	JOIN+ STITCH LABELS	LOCKSTITCH	70
O9	HEM OF LEG	COVERSTITCH	70
O10	WAIST HEM	COVERSTITCH	60

Table 7: Product2 description

Product 2 (P2)			
OPERATION	**OPERATION NAME**	**MACHINE**	**TIME (CMN)**
O1	JOIN OF THE SIDE PANELS	OVERLOCK	42
O2	JOIN OF THE INSIDE LEGS AND SIDE PANELS	OVERLOCK	20
O3	JOIN LINING THIGH	LOCKSTITCH	25
O4	STITSH LABELS	LOCKSTITCH	40
O5	THIGH HEM	COVERSTITCH	65
O6	WAIST HEM	COVERSTITCH	40

Table 8: Product3 description

Product 3 (P3)			
OPERATION	**OPERATION NAME**	**MACHINE**	**TIME (cmn)**
O1	JOIN OF THE FRONT CRUTCH + LINING	OVERLOCK	53
O2	JOIN OF THE SIDE PANELS	OVERLOCK	30
O3	STITCH YOKE+ SIDE PANELS	OVERLOCK	32
O4	STITCH OF FRONT YOKE	OVERLOCK	48
O5	SEWING OF YOKE	COVERSTITCH	50
O6	JOIN THE SIDES	OVERLOCK	46
O7	JOIN BACK BOTTOM	OVERLOCK	22
O8	JOIN INSIDE LEGS	OVERLOCK	25
O9	STITCH LABELS + FASTENING	LOCKSTITCH	43
O10	WAIST HEM	COVERSTITCH	55
O11	THIGH HEM	COVERSTITCH	65

We make a random assignment of the starting operations for the three ants A_1, A_2 and A_3. For example, in this case, we affect O_1P_1, O_1P_2 and O_1P_3 respectively for A_3, A_2 and A_1.

Table 9: Results of the first iteration of three ants

A_1	A_2	A_3
O_1P_3	O_1P_2	O_1P_1
O_2P_3	O_2P_2	O_2P_1
O_3P_3	O_3P_2	O_3P_1
O_4P_3	O_4P_2	O_4P_1
O_5P_3	O_5P_2	O_5P_1
O_6P_3	O_6P_2	O_6P_1
O_7P_3	O_1P_1	O_7P_1
O_8P_3	O_2P_1	O_8P_1
O_9P_3	O_3P_1	O_9P_1
$O_{10}P_3$	O_4P_1	$O_{10}P_1$
$O_{11}P_3$	O_5P_1	O_1P_2
O_1P_1	O_6P_1	O_2P_2
O_2P_1	O_7P_1	O_3P_2
O_3P_1	O_8P_1	O_4P_2
O_4P_1	O_9P_1	O_5P_2
O_5P_1	$O_{10}P_1$	O_6P_2
O_6P_1	O_1P_3	O_1P_3
O_7P_1	O_2P_3	O_2P_3
O_8P_1	O_3P_3	O_3P_3
O_9P_1	O_4P_3	O_4P_3
$O_{10}P_1$	O_5P_3	O_5P_3
O_1P_2	O_6P_3	O_6P_3
O_2P_2	O_7P_3	O_7P_3
O_3P_2	O_8P_3	O_8P_3
O_4P_2	O_9P_3	O_9P_3
O_5P_2	$O_{10}P_3$	$O_{10}P_3$
O_6P_2	$O_{11}P_3$	$O_{11}P_3$

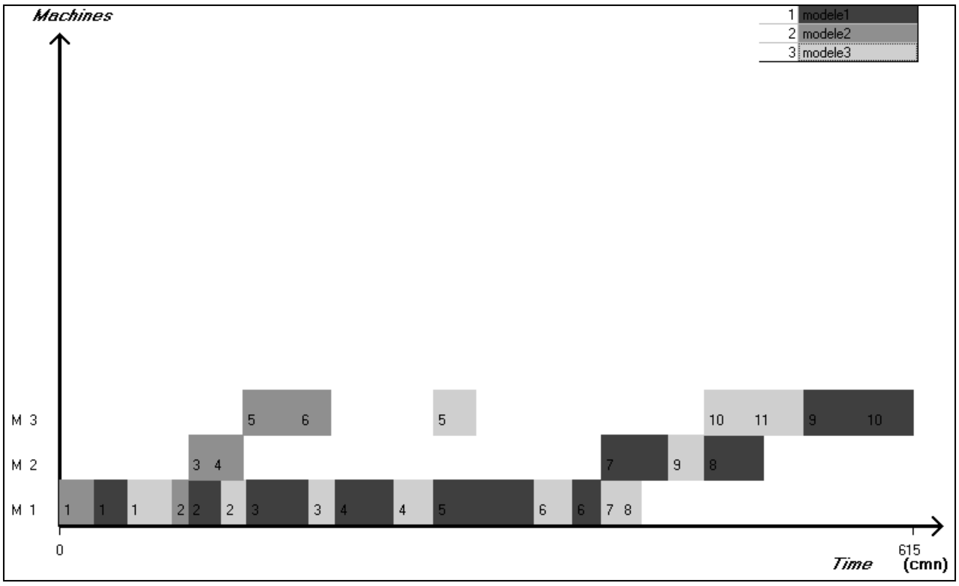

Fig. 2: Presentation of the optimal planning

Table 10: The optimal operation's assignment

OVERLOCK (M_1)			**LOCKSTITCH (M_2)**			**COVERSTITCH (M_3)**		
TASK	**D_b**	**D_f**	**TASK**	**D_b**	**D_f**	**TASK**	**D_b**	**D_f**
O_1P_2	0	25	O_3P_2	93	108	O_5P_2	132	171
O_1P_1	25	49	O_4P_2	108	132	O_6P_1	171	195
O_1P_3	49	81	O_7P_1	391	439	O_5P_3	270	300
O_2P_2	81	93	O_9P_3	439	465	$O_{10}P_2$	465	498
O_2P_1	93	117	O_8P_1	465	507	$O_{11}P_1$	498	537
O_2P_3	117	135				O_9P_3	537	579
O_3P_1	135	180				$O_{10}P_1$	579	615
O_3P_3	180	199						
O_4P_1	199	241						
O_4P_3	241	270						
O_5P_1	270	342						
O_6P_3	342	370						
O_6P_1	370	391						
O_7P_3	391	404						
O_8P_3	404	419						

After many cycles, we find that the optimal result is 615. In this application, the algorithm of ants colonies is characterized by:

- Number of cycles =10.
- Number of ants =3.
- The coefficient ρl=0.8.
- The coefficient ρg =0.9.

V. INTERPRETATIONS AND CHARACTERISTICS

The heuristic have many advantages but also a certain number of limitations. We summarize below the various characteristics of these methods:

- General information and possible application to a broad class of problems.
- Effectiveness for many problems.
- Possibility of compromise between quality of the solutions and computing time.
- Need for adjustment of the parameters.
- Difficulty in envisaging the performance.

VI. CONCLUSION

The flow-shop scheduling problems optimization is very difficult especially in the case of textile industry clothing which is characterized by the presence of several constraints and the enormous size of the data (The real size of problem). To lead to optimal results, it is necessary to pass by the optimization of the ants algorithm data of colonies (cycles number, ants number, coefficients of the visibility matrices and trace).

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