Early tardy scheduling problem in flexible job shop system

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Abstract: Delivery deadline of pieces is one essential data for implementation of Early/Tardy maximum objective function. Delivery deadline is a significant input which has a direct effect on objective function. If we don't consider the necessary accuracy at production time of delivery deadline, it is possible that a good or bad performance of an algorithm be affected by setting delivery deadlines in limit state. In this paper, we present improved tabu search algorithm for earliness/tardiness scheduling problem. We use two various rules in order to produce parameter of delivery deadline for studied sample problems. Then we study the effect of parameter of delivery deadline on Early/Tardy maximum delivery deadline. Then a new composition of improved tabu search algorithm is introduced. The computational results approves efficiency of proposed rule for producing parameter of delivery deadline in scheduling problem in comparison to two existing rule.

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1. Introduction

Scheduling studies in which objective function is related to delivery deadline are divisible into two groups. In the first group, delivery deadline of pieces is an input parameter. In this state, there isn't a specific standard for producing parameter of delivery deadline and different functions and relations are used in various references. In second group of researches, delivery deadline is a decision variable that determination of its optimum amount is one of problem objectives. In present research, the study supposes that delivery deadline is an input variable. Scheduling models with both early and tardy costs are compatible with the philosophy of just-in-time production, which emphasizes producing goods only when they are needed, since jobs are scheduled to complete as close as possible to their due dates. The early cost may represent deterioration in the production of perishable goods or a holding cost for finished goods, while the tardy cost can represent rush shipping costs lost sales and loss of good will. The assumption of no machine idle time represents a type of production setting where the machine idleness cost is higher than the earliness cost incurred by completing a job before its due date, or the capacity of the machine is limited when compared with its demand, so that the machine must be kept running. Some specific examples of production setting with this characteristics have been given by korman(1994) and landis (1993). Formally, the present study is limited to manufacturing production systems. In productive systems, machines and equipments having the role of resources and needed operations having the role of duties to manufacture any piece or order. the study defines general scheduling problem as follows: n is work (piece) and m is the present machine. Performance of each work requires a private operation set. Work processing of j_i by m_j machine is called o_{ij} operation. Processing duration of o_{ij} operation is definite p_{ij}. The movement order of each work, among different machines, is called "flow pattern" and "structure route". This route can be equal or different for various works. Each work has entrance time (r_i) and delivery time (d_i).given a schedule, the earliness is defined as $Ei = Max[\alpha_i(D_i - C_i)]$,while the tardiness can be defined as Ti=max[$\beta_i(C_i - D_i)]$ where α_i is the penalty of earliness and β_i is the penalty of tardiness , D_i is delivery time and C_i is completion time. The objective is to find a schedule that minimizes the sum of weighted earliness and tardiness.

The problem is strongly np-hard, since it is a generalization of weighted tardiness scheduling (Lenstra, Rinnoy Kan, & brucker, 1977), and both exact and heuristic approaches have been proposed. Among the exact approaches, branch and bound algorithms were presented by abdol-razagh and Potts (1988), Li (1977) and Liaw(1999).the lower bounding procedure of abdol-razagh and Potts was based on the sub gradient optimization approach and the dynamic programming state-space relaxation technique, while Li and Liaw used lagrangean relaxation and the multiplier adjustment method. Valente and Alves(in press)show that using better initial sequences can improve the lower bounds developed by Li and Liaw. Among the heuristic,Ow and Morton(1989)developed several early/tardy dispatch rules and a filtered search procedure. Valente and Alves(2005)presented an additional dispatch rule and a greedy procedure, and also considered the use of dominance rules to further improve the schedule obtained by the heuristics. a neighborhood search algorithm was also presented by Li(1997).

2. Material and Methods

Two various rules are used to determine delivery deadline in trial problems:

The first rule: development of an existing rule in literature is for uni-machine problem with objective function of sum of precipitation and postponement (Ow and Morton, 1989). the study uses relation (1) in order to determine delivery time in uni-machine problem with objective of minimizing sum of gain weight of precipitation and postponement. In the relation, parameter of delivery deadline is controlled by two factors. The first factor is postponement factor and is shown with τ. This factor determines average delivery deadline of works using relation (2). In this relation, Pi and $\bar{d}$ respectively represent average delivery deadline of works and processing time of work i. The second factor is range factor of delivery deadline and is represented with R.

$$U \sim \left[\bar{\mathrm{d}}(1-\frac{\mathrm{R}}{2}),\bar{\mathrm{d}}(1-\frac{\mathrm{R}}{2})\right] \tag{1}$$

$$\bar{d} = (1-\tau)\sum P_i \tag{2}$$

Zegordi et al, 1995 turn relation (2) to underneath relation in order to produce parameter of delivery deadline in flow shop problem.

$$\bar{d} = (1-\tau)\sum\sum P_{ij} \tag{3}$$

If we use relation (3) in timing program, concerning any operation can be perform by various machines and with different processing times, sum of processing time enlarges pro rata. Accordingly delivery deadline of each work will enlarge in comparison to sum of needed time for its processing and therefore most of the works have unavoidable precipitation. Moslehi, 1999, entering a criticism to method of Zegordi et al, 1995 write relation (2) in form of relation (4). In his opinion, M parameter, in problem of uni-machine, is equal to completion time of lateral work in order or C_{max}. In order to use relation (4) to produce parameter of delivery deadline in flow shop problem, he uses C_{max} amount instead of M for each random order in works.

$$\bar{d} = (1-\tau)M \tag{4}$$

In present research, a similar method is used for producing parameter of delivery deadline in timing problem from C_{max} average for each sample problem instead of M parameter in relation (4). Thus parameter of delivery deadline is determined for each piece by specifying M, T, R parameters and using relation (1) and (4). the study considers factor amount equal to 0.2 or 0.6 and factor amount of postponement equal to 0.6 or 1.6 as references (Zegordi et al, 1995. Thus the study will gain a set of delivery deadline for each sample problem for each of (0.2, 0.6), (0.2, 1.6), (0.6, 0.6), (0.6, 1.6) compositions.

Second rule: PR is a proposed rule. The rule is based on idea that each job has a share in comparison to average time of its processing from sum of work load of workshop and determination of its delivery deadline to this ratio can be realistic. Delivery time of I work in proposed rule is determined by using relation (5).

$$di = \frac{MPT_i}{TPT} \times WL \tag{5}$$

In which MPTi and TPT are respectively average processing time of I work and sum of average processing time of works and is computed by relation (6) and (7).

$$MPT_i = \sum_{j=1}^{n_i} \frac{\sum_{KeKij} Pt_{ijk}}{|k_{ij}|} \tag{6}$$

$$TPT = \sum_{i=1}^{N} MPT_i \tag{7}$$

In above-mentioned relation, $Pt_{ijk}$is processing time j operation from i work on k machine and K_{ij} is set of possible machines for implementation of j operation in i work. WL parameter expresses sum of work load that is equal to sum of completion time of works. Thus it is necessary to solve each sample problem first with $\bar{C}$ objective function and via using proposed algorithm and sum of completion time of its pieces are fulfilled averagely. By setting this amount in relation (5), delivery time of each piece is computable.

By studying parameter effect of delivery deadline on ET_{max} objective function and selecting proper rule for parameter determination of delivery deadline, the study select 5 problem groups P1, P2, P3, P4, P6 from (7-4) table and 5 random samples are produced from each set. Parameter of delivery deadline of pieces is produced for each sample problem using two defined rules in previous section. Considering that the study gain a set of delivery deadline of pieces for each composition of (T,R) parameters, altogether there will be 5 sets of delivery deadline for each sample problem. Then each sample problem is solved with ET_{max} objective problem and for each of delivery deadline sets. Similar to prior tests, each problem s solved with 5 primary random answers and 5 times for each answer (with various cores).

Diagrams' behavior approves that production status of delivery deadline of pieces has a direct effect on ET_{max} objective function. On the other hand, we observe that while delivery deadline of pieces are determine using (PR) proposed rule, diagrams have a stable behavior in each 5 set of studied problem. In proposed rule, delivery deadline of each piece is fulfilled proper to requirements of piece but not in form of probability. In other words, the proposed rule is designed for determining parameters of delivery deadline proper to problem characteristics of flexible job shop production and therefore has more efficiency in comparison to the first rule.

3. Results

The study uses numerical tests with ET_{max} objective function on five sample problems . Table (1) shows numerical test results. The first and second columns, respectively, represent set code and sample number for each set. In the third column, the study has initial amount of objective function and the best known amount in the forth column for objective function in each problem. The fifth columns up to eighth column, respectively, represent average, variance, frequency number that the best answer is achieved and average implementation time.

In table 6 operation comparisons of two method are basis of three criteria of average, variance and frequency number in finding the best amount (column 5 to 7). This quality improvement and time increase is because TS1 composition improves quickly in initial frequencies of answer and algorithm quickly falls on local optimization. Therefore the study gain stoppage provision sooner and implementation time is shorter as a result.

Table 1: numerical test results on two method

Problem	Sample no.	1				2			
		mean	Var.	No.best	Cput.(s)	mean	Var.	No.best	Cput.(s)
1	1	7.2	0.2	22	0.21	7.0	0.0	25	0.25
	2	4.2	1.7	3	0.15	2.0	0.0	24	0.28
	3	7.3	0.8	22	0.16	7.0	0.0	25	0.22
	4	3.0	1.0	2	0.18	1.2	0.2	20	0.34
	5	7.0	0.7	8	0.13	6.0	0.0	25	0.24
Total/average				57	0.17			119	0.27

In this paper the study has presented and discussed an algorithm base on tabu search approach in the job shop problem. Considering performance criteria (ETmax,), proposed Tabu search algorithm is able to solve scheduling in flexible job-shop manufacturing and production system untidily and presents an acceptable answer which fulfils related limitations to prerequisite and timing relations in an acceptable time. Studying the effect of parameter of delivery deadline of pieces on ETmax objective function approves efficiency of (PR) proposed rule for producing parameter of delivery deadline in timing problem in comparison to two existing rules. Performance comparison of two various composition of proposed Tabu search algorithm on ETmax represents priority of TS2 composition toward TS1 based on criterion of answer quality. As it is predicted, time increases versus improvement of quality that this amount of time increase is acceptable in comparison to improvement rate of answer versus rate of time increase.

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