5. Just-in-Time scheduling problems

5.1 Presentation of Just-in-Time (JiT) scheduling problems

One of the classical objectives in shop scheduling is linked to the respect of the due dates which attend, for example, the meetings with customers on the delivery dates of the manufactured products. For numerous problems, the criterion used in this case is a measure of the tardiness of the finished products, as for example the *average tardiness*, the *maximum tardiness* or yet *the number of late jobs*. Nevertheless, even though for example, storage of products means a non negligible cost, it is necessary to optimise, at least, just as well a criterion linked to the earliness of jobs.
Historically, interest in JiT for manufacturing appeared after the second world war in the Toyota company factories (described in [Pinedo and Chao, 1999]). In the context of vehicles production, a certain number of components are produced by subcontractors. The JiT scheduling problem appears for the latter since the subcontracted parts must be delivered at the moment of the vehicle assembly. A late delivery leads to the halt of the assembly line because it is necessary to withdraw the vehicle concerned in order to be able to reposition it at the head of the line. This means a penalty for the customer. Conversely, manufacture of the subcontracted parts in advance means a storage charge for the subcontractor which may not be negligible. This is notably the case, nowadays, for car seats for which storage costs are very high. More generally, we note that a JiT scheduling problem appears when the due dates have to be respected and when parts do not have a negligible storage cost.

Contrary to mass production, where a stock of finished products is built up, JiT production consists of regulating manufacture. In terms of stocks, the objective is to plan the regular arrival of the materials which are necessary for the manufacture of the products. We wish to reduce not only the intermediate stocks but equally the stock of finished products. In this situation, we want to calculate a plan such that all these products are manufactured just at the moment when they have to be used. In scheduling terms the objective is therefore to calculate a schedule such that the finished products (or jobs) should be available "Just-in-Time". We must therefore optimise, at least, a

measure of the tardiness of the jobs as well as a measure of their earliness. For the latter we distinguish two categories of criteria: those which measure the earliness of a job in relation to a desired start time and those which measure this earliness in relation to a due date. In the first case, we only consider that processing a job earlier than necessary will disrupt the supply chain of raw materials, which leads to disruption of stock levels and which therefore must be penalised. For the second category of criteria we only consider that stocks of finished product generate a cost which we want to reduce. When the difference between the due date and the desired start time for each job is equal to the total processing time of the job, we can then show that these two categories of criteria are equivalent.

Literature on JiT scheduling problems addresses essentially single machine and parallel machines problems. The objective of this chapter is to present a set of significant works in the domain.
We first present a typology of such problems as dealt with in the literature, and next provide a general model of Just-in-Time shop scheduling problems. We conclude this chapter by providing a literature review of major works.

5.2 Typology of JiT scheduling problems

The literature contains numerous works on JiT scheduling problems and several states-of-the-art surveys have been published (see among others [Baker and Scudder, 1990], [Hall and Posner, 1991], [Gordon et al., 2002a], [Gordon et al., 2002b] and more recently [Kaminsky and Hochbaum, 2004] and [Gordon et al., 2004]). The JiT scheduling problems can be separated according to the definition of *their due dates* and the *optimised criteria.*

5.2.1 Definition of the due dates

The *due dates* often result from a choice made by the decision maker and constitute a data for the analyst. In this case, we consider that *these dates are fixed.* Conversely, problems occur for which the due date of a job or an order result in negotiations between the decision maker and his customer. In this case, the decision maker must set up an algorithm which returns a schedule and a due date taking account of other jobs already scheduled. We consider then that *the due date is unknown.* If the date which is calculated is far from that desired by the customer, then a reduction of the order price may be suggested, and therefore a compromise solution is looked for. On the other hand, the more the due dates are spaced the greater is the probability that the order will be delivered on time. Thus, for the decision maker, the problem is to find a trade-off between the cost created by a potential delay and a non negligible storage cost. Besides, we encounter problems for which