Chapter 9

HYBRID METHODS FOR LINE BALANCING PROBLEMS

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Abstract: A line balancing problem is defined by a line along which vehicles go through and are progressively assembled. The assembly operations are performed by workstations spread along the line. The objective is to assign operations to workstations in order to minimize, for instance the number of required workstations. The basic constraints are cycle time and precedence constraints. To solve this problem, we have firstly used a genetic algorithm with different operators (some of them have been proposed in the literature). We suggest to couple this genetic algorithm with some heuristics (which have been previously published). We then obtain hybrid methods that improve the obtained offsprings, before inserting them in the population. We have tested these methods on literature instances (one range of vehicles and cycle time and precedence constraints), and on generated and industrial data. These real instances represent a real problem in the automotive industry.

Key words: line balancing, genetic algorithms, hybrid methods.

1. INTRODUCTION

The assembly line balancing problem (ALBP) is commonly met in the industry. This problem concerns the assembly of any kind of objects. So it appears in microelectronic chips or electronic household appliances assembly and of course in the automobile industry. It consists in progressively assembling an object while it is going through the assembly line (with a constant speed). The goal of the line balancing problem is to spread the assembly operations along the line, more precisely, among workstations placed on the line. Two problems can be considered: the first
one consists in fixing the cycle time and minimizing the number of workstations and the second one consists in fixing the number of workstations and minimizing the cycle time. We consider the first situation. To solve this problem, we propose to use genetic algorithms combined with heuristics.

In Section 2, we describe our industrial problem. In Section 3, we present general principle of genetic algorithm and several literature operators. In Section 4, we describe our proposed genetic algorithm, and in Section 5, hybrid methods. In Section 6, we show computational results obtained on literature instances, on generated and industrial data.

2. DESCRIPTION OF THE PROBLEM

Our balancing problem is an industrial problem (collaboration with a French automobile industry). The vehicles go through the line and are progressively assembled. The operations are performed by workstations. The line is divided in sections which contain one or more workstations (which perform, at the same time, operations on the same vehicle).

An operation requires a storage area for parts and tools used for its performance ([3]). Required operations depend on the range of the vehicle (we consider several ranges of vehicles; it is a mixed-model assembly line problem). A vehicle is available on a section during a limited duration; so required operations have to be performed during this time. Figure 9-1 describes the line.

Our balancing problem is an industrial problem with standard and specific constraints.

Standard constraints are:

– **Constraints C1 on the cycle time:**
  The vehicle is accessible by workstations placed on a given section during a limited duration called the cycle time. For each workstation $j$ (parallel stations) and each range $m$ of vehicles (the required operations depend on the range of the vehicle), the sum of processing times of all operations required by $m$ and performed by $j$ must be inferior to the cycle time.
  Specific constraints are:

– **Constraints C2 on the section length:**
  The performance of an operation requires an area to store involved parts and tools. For each section $k$, the sum of storage area required by all operations performed on $k$ must be inferior to the length available on the section $k$.

– **Constraints C3 on the operator time:**
  The number of considered vehicles (sequence of vehicles in input of the line) corresponds to the load of a given period (daily period). To assemble