Optimizing task reassignments in the design of reconfigurable manufacturing lines
Abdelkrim R. Yelles-Chaouche, Evgeny Gurevsky, Alexandre Dolgui, Nadjib Brahimi

To cite this version:
Abdelkrim R. Yelles-Chaouche, Evgeny Gurevsky, Alexandre Dolgui, Nadjib Brahimi. Optimizing task reassignments in the design of reconfigurable manufacturing lines. 21st Congress of the French Society of Operations Research and Decision Aid (ROADEF 2020), Feb 2020, Montpellier, France. hal-02485673

HAL Id: hal-02485673
https://hal.science/hal-02485673
Submitted on 7 Aug 2021

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
Optimizing task reassignments in the design of reconfigurable manufacturing lines

Abdelkrim R. Yelles-Chaouche\textsuperscript{1,4}, Evgeny Gurevsky\textsuperscript{2}, Nadjib Brahimi\textsuperscript{3}, Alexandre Dolgui\textsuperscript{1}

\textsuperscript{1} LS2N, IMT Atlantique, Nantes, France
\textsuperscript{2} LS2N, Université de Nantes, France
\textsuperscript{3} Rennes School of Business, France
\textsuperscript{4} IRT Jules Verne, Bouguenais, France

Keywords: reconfigurable manufacturing systems (RMS), balancing, multi-product, MILP.

1 Context

The concept of reconfigurable manufacturing systems (RMS) is considered as the most suitable solution, which is able to cope with the current changeable and dynamic market situation. This concept was introduced by Koren et al [3] in 1999, and is characterized by the ability of a manufacturing system to change and reorient its components easily, quickly and cost effectively. RMS are designed to manufacture a wide variety of products within the same family. This is possible by using the so-called reconfigurable machine tools (RMT), which are mainly composed of physical modules that can be rapidly moved and removed from one machine to another. These characteristics give more advantageous to RMS comparing with the well-known dedicated manufacturing lines and flexible manufacturing systems.

However, the RMS concept remains relatively recent and, as a consequence, new approaches and tools have to be developed in order to design and operate them efficiently. This tends to be a very challenging issue, since both the reconfigurable and multi-product aspects need to be taken into consideration. This usually leads to study highly combinatorial optimization problems (see recent literature reviews [1, 2]).

Within this context, we are interested in the design of multi-product reconfigurable manufacturing lines. We consider in this paper that such lines are composed of a linearly-ordered set of workstations. Each workstation sequentially performs a given set of production tasks. The number of tasks per workstation is limited, and the sum of the processing time of the tasks allocated to the workstation represents its load. This latter cannot exceed the so-called cycle time, which reflects the production rate of the line.

In such a line, a given number of products has to be manufactured. Since the products belong to the same family, we consider that they are associated with exactly the same set of tasks to be executed, which are subject to precedence constraints, usually expressed by a directed acyclic graph. However, the latter and the processing time of the tasks may differ from one product to another.

In order to manufacture a product, a corresponding admissible line configuration is needed. This latter refers to an assignment of the corresponding set of tasks to a given set of workstations while satisfying all the mentioned above constraints. In the case, where several products are manufactured, an admissible line configuration is necessary for each of them. Moreover, this design has to be done such that switching from one configuration to another is provided as efficient as possible by the reassignment of tasks between existing workstations.
2 Studied problems

The context described in the previous section arises two relevant optimization problems noted here as $Q$ and $R$. In both problems, a precedence graph of each product, a cycle time as well as a set of workstations are given.

For the problem $Q$, we suppose that the order of products arriving is cyclic, already known and expressed as follows $P[n] := P_1 \rightarrow P_2 \rightarrow \cdots \rightarrow P_n \rightarrow P_1$, where $n$ is the number of products, $P_i$ is the $i$-th product and an arrow represents a reassignment of tasks. Given $P[n]$, the goal of $Q$ is to design an admissible configuration for each of $n$ products such that the total number of reassigned tasks when switching from one configuration to another is minimized.

Unlike $Q$, we suppose in $R$ that the order $P[n]$, is not given. In this case, $R$ aims at designing an admissible configuration for each of $n$ products such that the number of reassigned tasks between any two configurations is minimized.

Mixed-integer linear programming (MILP) models are formulated for both problems $Q$ and $R$, where in $Q$ the objective function is the sum on the number of task reassignments when switching between the different configurations according to the order of products arriving $P[n]$. Whereas the objective of $R$ is formulated as a min-max function on the number of task reassignments between any two different admissible configurations.

Both MILP formulations are tested for $n \in \{2, 3\}$ on two categories of instances with 20 and 50 tasks using CPLEX 12.9. A detailed analysis of the obtained results as well as a comparison between the problems will be presented at the conference. The preliminary results have already shown that the developed MILP models are efficient when solving the first category of instances for both cases of two and three products.

References

