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Indicators for measuring performances of morphology and material handling systems in flexible manufacturing systems

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Abstract

The aim of this paper is to present some existing and several new indicators of performances useful to help the designer to find a good solution for morphology and choice of material handling systems in flexible manufacturing systems. Our purpose here is to focus on the evaluation of the pair *morphology–material handling systems*, studied concurrently due to their strong interdependence. As a result of a survey of literature in this area, we present in this paper the indicators we have retained as suited to this purpose and easily implemented. New indicators related to the performances of these systems, such as the flexibility, are also suggested. A classification of indicators is introduced: (1) the operational indicators, which characterise the dynamic behaviour of the studied FMS such as the mean flow-time of jobs or the utilisation rates of machines; (2) the strategic indicators which measure the capacity of the system to evolve toward manufacturing new products such as the flexibility on which the emphasis is put; (3) the economic indicators such as the purchasing cost, the functioning cost or the maintenance cost. To better introduce the role, the usefulness of each indicator and their practical use, an illustrative example is presented.

Keywords: Material handling systems; Morphologies; Performance indicators; Flexible manufacturing systems

1. Introduction

Nowadays manufacturing systems have become more and more complex. The design or the reorganisation of manufacturing systems is a very difficult activity. That is why it is essential that decision makers possess decision tools and assistances necessary to manage this activity. For these reasons, we are interested in the evaluation of the performances of physical part of the flexible manufacturing system (FMS). It is widely known that the material handling systems (MHSs) now represent a major part of the total manufacturing cost [1–3]. This fact highlights the necessity to choose adequately the MHSs when a manufacturing system is designed. Indeed this choice greatly affects the performances and is complex for several reasons [4,5]. Firstly, there are considerable interactions between machines and MHSs; secondly the workshop morphology exerts a major influence over it [6]; thirdly many various MHSs are available. The design of an FMS is also a very difficult activity because existing methods only evaluate specific aspects of the solutions proposed by designers [7]. In order to help the designer and/or the decision

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makers in their work, it would be very useful to have indicators which could measure the performance of the various solutions. A few useful indicators have been suggested in the literature related to FMS design [8–11]. Our purpose here is to focus on the evaluation of the morphology and the MHS, studied concurrently due to their strong interdependence. As a result of a survey of literature in this area, we present in this paper the indicators we have retained as suited to this purpose and easily implemented. New indicators related to the performances of these systems, such as the flexibility, are also suggested.

This paper is organised as follows. First, the main features of morphology and MHSs are introduced. The choice of MHSs and the interactions between the morphology and the MHSs are pointed out. Then, we use the classification proposed by [12] to describe in detail each new indicator that we propose. To better explain the benefits of indicators, we present a simple application example, in which the application of each indicator allows its role and its usefulness to be more precisely understood.

2. MHSs and morphology evaluation in FMS

An FMS can be defined as basically a production facility consisting of a number of flexible machines or workstations connected by an automated material handling system, all under the control of one or more computers [13]. The related papers show that the design of a workshop is based on the choice of machines, control systems, MHS and morphology, on which emphasis is put in the following.

2.1. Morphology

The morphology of a workshop, a cell or an FMS is defined by the forms and the main structure of the workshop relative to the machines and the MHS [14]. Some authors [15,16] have proposed a classification of the various morphologies (see Fig. 1):

In related works, others kinds of morphologies may be found such as T, X, H or L form. Each

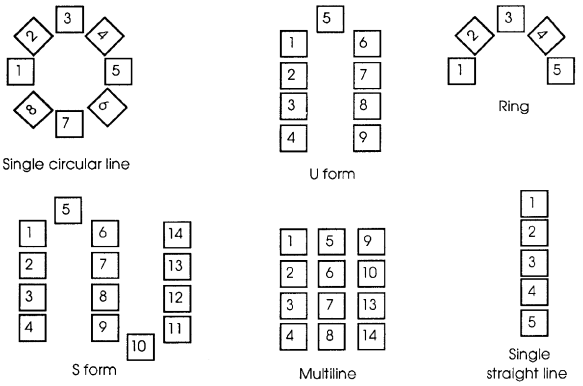

Fig. 1. Most common morphologies of a workshop.

morphology possesses its advantages and disadvantages, which are summarised in Table 1.

The various criteria introduced in Table 1 are useful to choose the morphology. Among the main factors to take into account, in addition to flow and production analysis [17], we find the number of machines, the bulkiness (i.e. number of machines in the volume hull), the management of MHSs (e.g. control and scheduling of automatic guided vehicles) and the number of operators. The most important of them is probably the bulkiness which represents a strong constraint, that has to be satisfied.

2.2. Choice of the MHS

The MHSs represent a key issue in the design of FMS. In several works related to the FMS design, a special attention has been given to the selection and optimisation of a kind of MHSs. Unfortunately, these works do not take into account the morphology while in fact, the contribution of MHSs to the FMS functioning is very important. Tompkins and White [3] argue that the MHSs cannot be neglected since their costs represent between 10% and 80% of the total production cost. The choice of MHSs is crucial for many reasons, such as its impact on the number of job in-process (queue lengths), the utilisation rate of machines, the makespan, etc.

Unfortunately, this choice is very difficult because MHSs cover a wide area including many possible technological solutions, from workers to