Manufacturing System Flexibility Control

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Abstract

The paper provides a study of the manufacturing system flexibility principles. Flexibility is conceived as a manufacturing system ability to transfer to the manufacture of new products that are characteristic for the multipart, small-, or medium-batch production. Product, operation, and route flexibility, as well as the starting-up and development flexibility assurance methods are described. The manufacturing systems classification based on the combination of different flexibility forms and its level is provided.

In order to choose a system flexibility ensuring option, it is proposed to divide the whole set of manufacturing systems into classes, for each of which a dimensionless weight coefficient is introduced taking into account the degree of utilizing the capabilities of processing units and machines, and to use geometrical average of the volumetric equipment flexibility and the part geometry flexibility for the flexibility assessment.

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1. Introduction

Today, when the demand for goods and services is constantly changing and companies are always under conditions of severe competition, fundamentally new manufacturing systems are needed that may quickly and, more importantly, cost-effectively respond to all the market changes.

In the world practice of machine-building industry development such systems are called flexible manufacturing systems (FMS) [1,2]. At present, within the framework of further "flexibility" increase study on the development of...

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reconfigurable manufacturing systems able to change its configuration and layout to adapt to production requirements are being carried out [3-14].

The control system of a modern multipart manufacturing system (MS) should provide a number of important functions: selection of the option of using CAM flexibility in case of receiving different subcontract orders, current modernization and manufacturing system based on simulation modelling and opportunities and individual manufacturing complexes assessment in case of receiving different subcontract orders [15-17].

Flexibility here means not only a prompt response to the ever-changing customer needs but also ensuring the flexibility of the manufacture itself - its ability to transform and adjust to changing conditions.

2. Relevance

In the scientific literature, there is a description of flexibility forms sets: machine flexibility, machine tool system flexibility, technological flexibility, manufacturing flexibility, delivery and volumetric flexibility, and etc., so a unified approach to their classification is required.

Flexibility characterizes production ability to be readjusted to the multipart, small- or medium-batch production.

I type flexibility (tunability) is related to the ability to manufacture various kinds (groups) of products in multiproduct production.

II type flexibility (adaptability) makes possible reconfiguring of production when production schedule is changed.

CAM flexibility is enabled by the operation flexibility of processing machines and manufacturing routing flexibility.

Processing machines flexibility is essential for maintaining product flexibility, flexibility of running different parts batches in the group of processing machines and operation flexibility.

The routing flexibility has broader impacts on the material flow dynamics in FPS and supports volumetric flexibility and also FPS modernization and development flexibility.

Processing machines (automated process module) flexibility provides for processing different type parts within the range of technological possibilities (usually from a standard agents series).

Generally, flexibility is reflected in the workload procedure changes and parts transfer; in the implementation of various technological sequences with tools swap in the right sequence from the tool storage magazine, and in changes in the parts unloading processes.

The machining equipment flexibility is also determined by the programming system and applied CNC software.

Flexibility can be assessed by the workpiece, tool, CNC control programs, etc., changeover time. Processing machines flexibility determines the product, operation, routing and volumetric flexibility as well as by the starting-up and development flexibility [18-21]. The relationship between flexibility types under discussion is shown in Fig 1.

Product flexibility is the manufactured products changeability within minimum time. This kind of flexibility is determined by the ability to fulfill new orders in new circumstances.

The flexibility of this type can be assessed by the time of putting into production of a certain type parts lot from a specified types set.

Product flexibility may be increased by means of a design automation system which has an interface with the FPS reconfigurable manufacturing system (RMS) for the FPS production planning, automatic assigning RMS processing operations and process batches distribution, machining equipment flexibility;

Flexibility of running parts batches in the processing equipment group - allows putting into production different type parts made from various materials in various manufacturing routs, at different workplaces. This type of flexibility also determines flexibility of description of processing tasks that are mixed in the manufacturing process. The highest manifestation of such flexibility is the possibility of a one-off production in the MS. Assessment of flexibility of running parts batches on the set of processing machinery is determined by the number of part types that can be simultaneously run in the processing process.

This type of flexibility is secured by the presence of processing equipment flexibility and by introduction of adaptively controlled multi-tasking machining centers into MS;

Operation flexibility is the ability to change the sequence of various processing operations for each parts type. Generally, there are many acceptable options of structure, sequence and duration of manufacturing operations for
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