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Fostering in-process inspection during process planning using tolerance charting

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Abstract

Integrated development of machining and inspection plans is essential in dynamic manufacturing environments, especially when right first time manufacturing is required. In this work, a methodology, based on a new and extended use of tolerance charting, that allows incorporation of in-process inspection operations to improve process plans is presented. The methodology proposes the transfer of the manufacturing specification tolerance between surfaces to specification tolerances established between these surfaces and a common reference system. In this way, all variability sources originated by part locating and fixturing can be separately considered from the ones originated by the process-machine system. This circumstance allows a more accurate calculation of operation capability indexes and eases the analysis and improvement of critical operations. To prove methodology potential, an application case is showed.

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1. Introduction

Traditionally, process tolerance charting has been used to generate and validate process plans. This graphic tool aids to assure that most appropriate working tolerances are assigned for a specific machining process in order to meet part blueprint specifications (Jeang, 2011). In first stages of process planning, when machining processes and

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methods are determined, meeting blueprint tolerances is the most important factor, but as process planning progresses, other important criteria must also be taken into account, such as total manufacturing cost (machining and inspection) and quality loss (Huang et al., 2005). However, no evidence has been found where tolerance charting is used to refine manufacturing plans by including in-process inspection operations that will condition the plan itself.

Nowadays, in-process inspection is considered very important, especially with the development of on machine integrated inspection technologies. But to take advantage of these new technological possibilities elaboration of machining processes that integrate inspection operations is essential. To achieve this integration new analysis and synthesis methods are required, so that machining operations, inspection operations and their interactions are processed in a unified manner. This approach is even more important in highly competitive environments, such as One Kind of a Product (OKP) manufacturing, where small or one unit lots are used and where right first time manufacturing is crucial.

To assure right first time manufacturing is important to elaborate an appropriate process plan, resulting from an accurate work where all uncertainty sources must be thoroughly analyzed and all preventive and/or corrective actions to achieve this objective must be considered. For this purpose it is essential to have not only precise and disaggregated information about machine and process capability, but it is also necessary to have information about the execution of machining operations. In-process inspection operations are the ones that provide this information about part and process state and, therefore, allow the decision making that every plan execution should consider, such as typical process corrections (tool path, part zero, tool correction, etc.) or decisions related to part acceptance, rejection or possible rework.

To make this approach feasible a methodology that allows the incorporation of new machining and/or inspection operations is proposed. This methodology serves as a means of improving the elaboration of process plans and is especially adequate in the abovementioned contexts. In the next section the methodology is described and, in order to better understand it, in the following section an application example is explained. Finally, main conclusions and future work will be shortly enlightened.

2. Methodology

The proposal is based on authors' previous work (Romero et al., 2011), where a methodology applicable during the stage of locating and fixturing surfaces (setup) selection and that allows the establishment of manufacturing specifications between active surfaces in the setup being detailed was proposed. Active surfaces are both, the ones generated in the machining/inspection operation by the interaction with machining tool/probe, and also the ones used for part locating by the interaction with fixtures. The procedure incorporates a stage aimed at validating that selected locating surfaces are appropriate by assuring that manufacturing specifications are met when comparing them with dimensional and geometrical capabilities of the process-machine system for the setup solution adopted.

Additionally, and opposite to other classical approaches, the methodology sets out that selection and validation of reference systems for part locating must be done in a back to front manner, beginning in the last process plan setup and ending in the first one. With this approach, effects of variability transmission between setups is taken into account, since a specific setup can cause additional manufacturing specifications to the previous ones and necessary to assure the fulfillment of dimensional and geometrical specifications related to the geometries to be obtained in that setup. In this way, a better and more complete fulfillment of design specifications is ensured.

One of the characteristics of this methodology is that it considers only the transfer of extrinsic specifications from design to manufacturing. This circumstance makes it necessary to compare the latter with dimensional and/or geometrical capabilities representative of the selected process-machine-setup. These capabilities must be expressed in an aggregate way, similar to the specification tolerance, and must gather all sources that can cause an error in the locating and orientation of active surfaces in a machining operation (deviation) and that, therefore, will limit the achievable tolerance in the process specification relating active surfaces in that operation. The fact that normally available aggregate capabilities are of not very good quality -since they establish very wide ranges representing the generalization of many process-machine-setup systems- has made authors think that the use of tolerance charting during detailed process planning could be improved if reasoning related to validation would be carried out on the