COMPUTER AIDED CELL LAYOUT INTEGRATED WITH GROUP TECHNOLOGY CELL DEFINITION ALGORITHM

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Abstract. *This work presents an automated methodology for machining cell design through the development of a system that translate the result of a group technology algorithm to different graphical options for cell layout design. The different groupings part families and manufacture cells are generated by distinct algorithms. Once the algorithms are processed, the purpose is to use graphical resources from a Computer Aided Design environment, with a library of machine-tools graphical models to show, on shop-floor, different flow options for the layout.*

Keywords*: Cell layout; group technology; manufacturing automation*

1. INTRODUCTION

The constant production systems evolution, from mass production systems to production systems focusing on the customers needs, increases the importance given to industrial plants projects, because the strategy of production embodied in the physical arrangement requires increasing flexibility. The physical arrangement or shop-floor layout concerns with the physical location of processing resources and it is one of the most important characteristics of a production system, conditioned by their shape and arrangement the efficiency of the operational flow.

Different new designs or changes in the plant layout affect directly the material flow and people involved in the operations, in addition to the costs and production timing. The designs of a physical arrange activity is usually a rather complex and long to be consolidated considering all the factors directly associated. The physical re-arrangement of an existing installation can results in their subsequent, generating bottlenecks or delays that involve loss or delays in production. Patterns of flow too long or confusing, stocks of material or handling systems inadequate can result in high costs with non-productive activities. These points, associated to the minimization of distances and spaces, illustrate the importance of a detailed study for the establishment of an appropriate layout.

This analysis, that in principle involves sectors related directly to production implementation and management, should make use of technical resources and support tools facilitating the documentation of design ideas, involving problem control and variable conditions.

With the computing evolution, integrated systems for decision support on planning and implementation of industrial plants appears, and some also helping on the analysis of appropriate physical arrays according to the designers demands, but rather devoted to some aspects. However, despite the considerable technological advances, much still needs to be done, although in some sectors such as equipments the costs have been reduced in recent times, in the acquisition and development of specific software they are still high. In this context, this study aims to develop a system and application for 3D modeling of cells layout, streamlining data previously defined by algorithm, using group technology principles.

2. INDUSTRIAL LAYOUT

The layout or physical arrangement consists of a rational organization of all resources and technologies needed to achieve, on the operational level, the industrial goals, materializing in the way as these resources are arranged in the three-dimensional space. Rational organization means the pursuit of harmonization and equipment integration, labor (direct and indirect), materials, handling and storage areas and other resources and technologies (Oliverio, 1985). This physical arrangement may be characterize into different types, depending on the specifications of methods and production modes to be covered. There are, basically, four types of physical arrangement with very specific characteristics and different potential to contribute and impulse different performances in each case. There are identified as: Positional Layout (fixed position), online (by product), Functional (by process) and Group layout (cellular).

2.1. Positional Layout

Layout type where the material (processed resources) remains fixed at a certain position and the machines, people, equipment, etc. (processor resources) moving to the location performing the required operations. Design of layout used when the product is large to be moved in a convenient way, or may be (or be in a state) very delicate to be moved or

may object to being moved. Typical examples of this type of layout come from construction, manufacturing of ships, aircraft, large electrical transformers, turbines, cranes, large presses, etc.

2.2. Line Layout (product)

This type of layout arranges the processors productive resources (machines, equipment, people, etc.) according to the more convenient resource that is being processed (product) or the machines are allocated according to the logical flow of product operations and implemented in accordance with the established sequence without alternative paths. The resources are physically arranged as the need of the product to be produced, so dedicated. The online layout is justified when a sequence of process steps is covered by a large volume of production. Industries with relatively simple processes, production or assembly lines with little or no diversification, in a constant amount over time and in large quantities are used for this type of layout. Productivity is dependent on the line speed, which must be properly balanced, and the labor used is relatively small. Classic examples are the assembly line of cars, electronics, chemical, petrochemical, steel, etc.

2.3. Functional Layout (by process)

The logic of this type of arrangement is to pool resources with similar function or process. In this approach all the processes and equipment of the same type are developed in the same area and also mounted or similar operations are grouped in the same area. The material moves seeking the different processes. It is generally applied when the flow to various sectors are very diverse and occurs intermittently. According to Corrêa (2005), the challenge in this type of layout is to find the relative position and areas of each sector in order to bring that intense flow together avoiding unnecessary travel in order to fit the position adequately and areas resulting in the total area available, with a number of restrictions. Features of this arrangement is the flexibility to meet changing market and demand, meet diversified products in varying quantities over time, produce a large flow within the plant and is suitable for production in small and medium quantities. This type of layout is the most common found in manufacturing (Lorini, 1993). All machines from the same type are arranged together, forming sections, for example, of turning, milling machines, drills, etc.

2.4. Group Layout (cell)

The physical cell arrangement is one in which the transformed resources, entering in process, are pre-selected to move to a specific area of operation (cell) in which all the processor resources (equipment) useful to meet the immediate needs of processing must be present. Briefly, a cell manufacturing means to arrange in the same area (a cell) different machines that allow producing a whole product or parts family. This arrangement has as a characteristic a relative flexibility in relation to the lot size, which must be specific to a products family, reducing the transport of equipment and stocks, centralizes the responsibility on the manufactured product, enables high quality level and productivity.

According to Correa (2005), the cell arrangement is based on the concept of group technology, where no similar resources are grouped in a way that, with sufficiency, could process a group of items that require similar processing steps. A cell array in its definition involves a few steps related to:

1 - identification of produced items families that, combined, have similarity on resources set to be processed;

2 - identification and pooling of resources (machines, people) in a way they could, with sufficiency, process identified items families, defining cells;

3 - for each cell, find the resources, using the general principles of arrangement by product, establishing a small operation within the operation, in a way that the movement and families flows are adequate and distances minimized.

The configuration of the physical arrangement on the cell concept is the type of layout with a greater tendency to use in the current industrial engineering, which seeks, in the supply of the necessary process to produce certain parts, a specialization by parts, when determining the arrangement elements. This arrangement combines the advantages of in line and functional configurations, as it has all the machines next to each other, in the most appropriate sequence to the process, at the same time it has the implementation flexibility, no more for a single product, but for a family of them (Lorini, 1993).

The definition of machines groups linked to the parts families is based on the so called group technology as a philosophy that defines the solution of problems exploiting similarities, for obtaining operational and economic benefits through a group treatment. This philosophy, applied to industrial engineering, is much more comprehensive by applying its principles on major tasks in the industrial organization, such as:

- adequacy of existing layout definition for a new project;
- deployment of a coding and classification system of equipment and components,
- streamlining of design and manufacturing processes;
- parts families and machines cells definition.

For the formation of parts families and cells machines many clustering algorithms have been developed and applied, using various methods and techniques for improvement and rationalization. In the light of several methodologies used, the algorithms can provide very different results, even on a given array of data. These results are always a combination of methodologies associated with different criteria and limitations, resulting in a greater degree of processing or

complexity of decision analysis. However, the algorithms are fundamental tools to defining the families and cells, allowing them enjoy all the benefits mentioned on Group Layout. Once defined the equipment groupings it is important to define also how they should be arranged in the physical space on the shop-floor, or provide them in order to facilitate the production logical flow of the respective parts family members.

3. PROJECT LAYOUT AIDED TOOLS

The design of a cell layout means to define the possibilities of distributing the set resources in the process equipment group and devices for handling in a physical space, in a way to answer the logical sequence of implementation of manufacturing tasks. Some techniques and computational tools can be applied to develop different forms of physical arrangements. These tools can only be a checklist or organized methods, and they are associated with algorithms and graphic applications. Some of these computer applications used in developing projects of industrial plants can be considered as tools for:

• computer aided design: to represent both the plants as aspects of the projects for three-dimensional analysis of the architectural project and volume of equipment. Given its distribution, there are now available several software that adds specific functions to programs of CAD some specific to the design of physical arrangement;

• simulation of discrete event systems - these software have evolved since the 1950s and are applied to the analysis of production processes and the production planning, especially on performance, allowing to analyze the process effects or the programming production on a layout, and vice versa;

• human simulation - applications developed for analysing the human element in her job, for making these posts more suitable to men, reducing the problems of human work space interaction, in an ergonomical approach.

According to Torres (2001), none of these solutions are fully developed and each one has its strengths and limitations, stressing the integration of these types of software (AutoCAD, AutoMod and Arena) as a way to harness the potential of each software, incorporating the results of one as an input for the others.

3.1. Integrated Application for Layout Project

The application developed in this paper proposes an integrative function, between the three-dimensional models of equipment, and its representation in graphic software for cell layout defined according to a group technology methodology through specific algorithms. The modeling of different configurations of cell layout is shown in the Solid Edge graphic software. The graphic software used offers the necessary resources for modeling and necessary customization to generate, in an automated mode, an interface to the layout project. The interface, developed in Visual Basic, allows the processing algorithm to define groups of machines and the representation in the graphical system, further necessary interaction with the database in Access standard.

The application includes modules for registration of machines and parts as well as the process flows that define the association of parts with machines under consideration to generate the clusters and their layouts. Processed an algorithm of groups definitions, or imported from another application performance, it is possible to represent the data in different configurations in a graphical environment (CAD system).

In layout definition and representation, it is possible to set the minimum functional dimensions of spacing between each machine, allowing defining the minimum required area on the shop-floor for each specified configuration of layout. The forms of flow cell to the layout have the option of in line, on "L" or "U". For the flow forms in "L" and "U" it is allowed different options of machines placement, as shown in Figure 1.

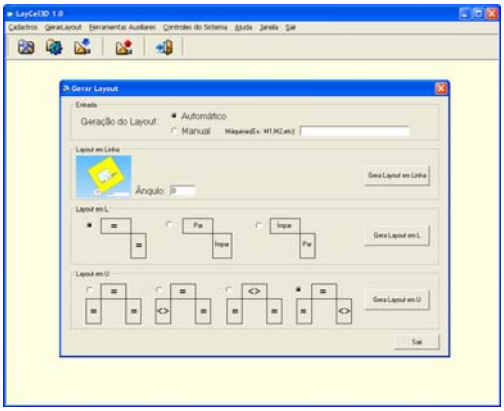

Figure 1. Flow forms options for the layout.

The result of the application in a graphical environment allows the option of viewing layout specified in the shop-floor, as shown in Figure 2, where for a single cell was asked modeling the flow form in line, then L, and last in U. For each type of flow the application calculates the required area for cell rental on the industrial space, with minimum functional dimensions from each machine and representing this area modeling a kind of "virtual mat" in 3D representation.

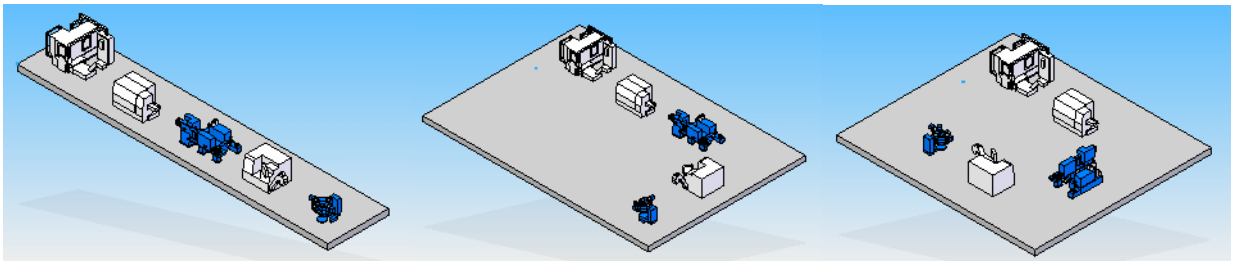

Figure 2. Modeling options for layout in line, in "L" and "U" for 5 machines cell.

4. CONSIDERATIONS

The developed application has features that allow its use on academic environment, for studying production systems, but mainly at industries. Implemented with friendly interface allows the user to edit the template or export it to other graphics environments, but also become integrated into analysis of ergonomical aspects, production flow simulators or CAD systems for macro layout. Has important application as a tool on planning and layout design, while makes use of resources in a commercial graphics platform (CAD) to represent the automatic mode, resulted of algorithms that normally are only textual information. This work complements several others done previously, on cells definitions, but that not represented them graphically, moreover allows the choice of flow shape to be taken by the cell, which is of fundamental importance for those who are designing or promoting improvements in an industrial environmental.

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