Production Systems Planning, Control & Networking

Flexibility In Manufacturing Systems

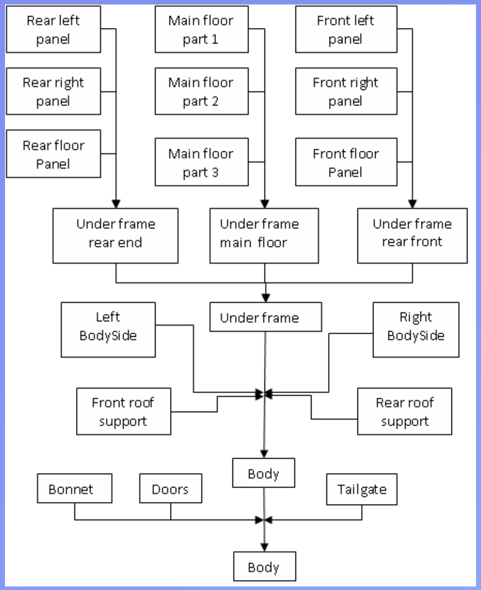

Figure 1: Assembly System Model

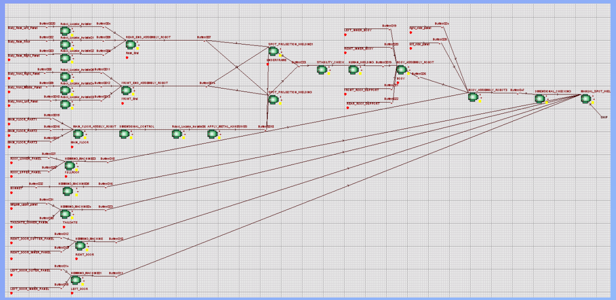

Figure 2: Assembly System Model

- ❑ **Flexibility quantification in complex assembly systems**
- ❑ **Typical BIW assembly system (1300 vehicles/day)**
- ❑ **Flexibility of the system (FLEXIMAC) increases with MTBF**
- ❑ **Higher MTBF denotes higher machine uptime thus greater availability. Therefore flexibility is directly connected with availability**
- ❑ **Flexibility converges to a final value which is the maximum for the given system**

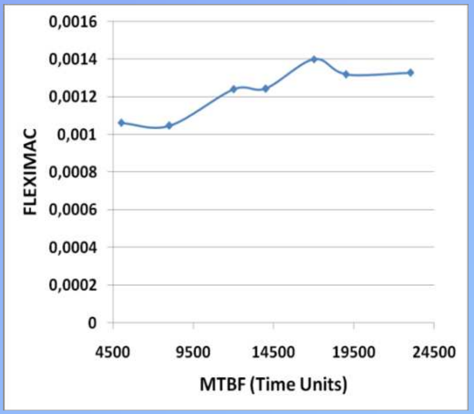

Figure 6: FLEXIMAC indicator vs. MTBF

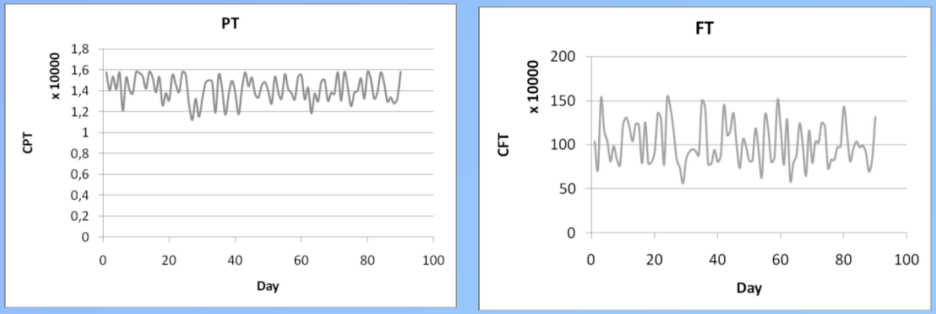

Figure 3 & 4: Cumulative Processing Time (CPT) and Flow Time (CFT) diagrams

Mourtzis, D., G. Michalos, S. Makris, K. Georgoulias and G. Chryssolouris, "Flexibility quantification in complex assembly systems", Proceedings of the IFAC Workshop on Manufacturing Modelling, Management and Control, Budapest, Hungary, (November 2007), pp. 193-198.

Production Systems Planning, Control & Networking

Flexibility In Manufacturing Systems

Human Considerations in automotive assembly systems (1/2)

- The ***Information Flow Network*** (IFN) through ***wireless*** technologies, ***touch-screens*** and ***augmented reality*** devices can provide all the necessary information on the local ***terminals*** in the form of graphical ***illustrations***, ***multimedia*** files, ***CAD*** drawings and more.

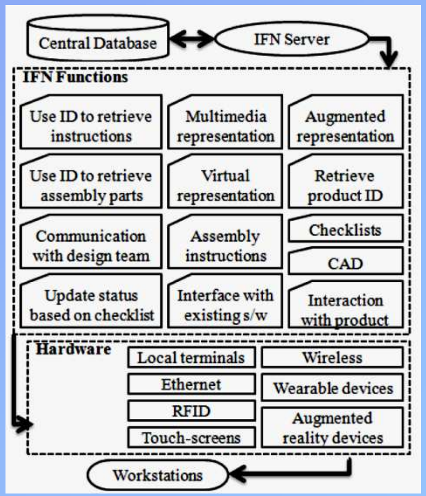

Figure 1: Architecture of the IFN

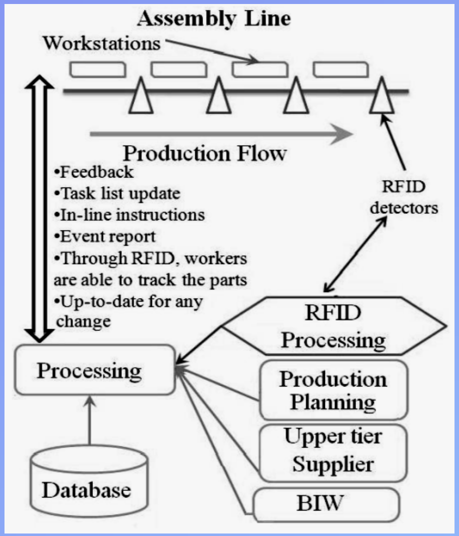

Figure 2: Integrated Network concept

- The ***Integrated Network*** concept consists of the ***interaction*** between shop-floor elements that enhance the ***speed*** and ***adaptability*** of the ***assembly processes***.
- ***Human-machine interface*** should be ***ergonomically*** designed to provide correct and actual ***information*** at any time at any workplace.
- Through ***remote control*** means, the ***shop floor***, is more easily and efficiently ***monitored*** and ***managed***.

Michalos,G., N. Papakostas, D. Mourtzis, S. Makris, L. Rentzos and G. Chryssolouris, "Human Considerations in automotive assembly systems: Conceptual design", Proceedings of the IFAC Workshop on Manufacturing Modelling, Management and Control, Budapest, Hungary, (November 2007), pp. 175-180.

Production Systems Planning, Control & Networking

Flexibility In Manufacturing Systems

Human Considerations in automotive assembly systems (2/2)

- ***RFID*** **technology is a *tool* that helps to overcome *obstacles* appearing on the *shop-floor* such as the time consuming process of putting cards on parts.**
- ***Production planning*** **and *scheduling* centre is able to *monitor* the *parts*, the *operations* and the *products* that are complete.**
- ***Fast*** **and *efficient* way of constantly and safely *reconfiguring* the *production planning***
- **Better time *response* to the *availability* and *requirements* of *parts*.**

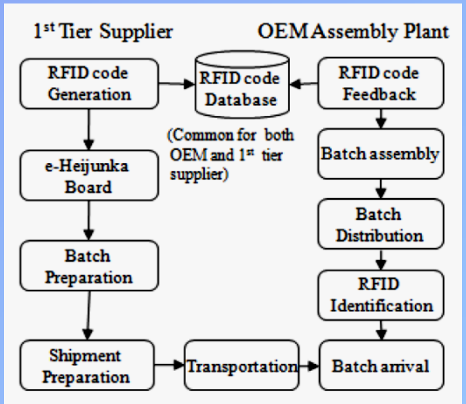

Figure 3: General concept of RFID implementation scenario

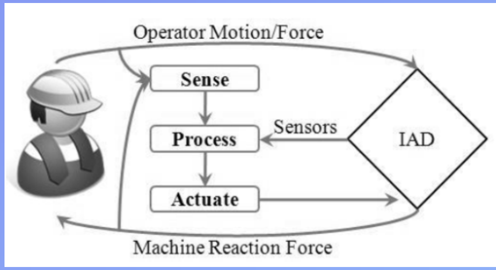

Figure 4: IADs control concept

- ***Intelligent Assisting Devices*** **are a useful *aid* for *material handling* during assembly operations.**
- **IAD contribute to *higher productivity*, improved *safety* and superior *quality*.**
- **IAD are *designed to work* in an advanced *"sense/process/actuate"* control concept.**

Other Human Considerations :

Job rotation, Training, Ergonomics, Hybrid Assembly Systems, Cooperative task execution

Michalos,G., N. Papakostas, D. Mourtzis, S. Makris, L. Rentzos and G. Chryssolouris, "Human Considerations in automotive assembly systems: Conceptual design", Proceedings of the IFAC Workshop on Manufacturing Modelling, Management and Control, Budapest, Hungary, (November 2007), pp. 175-180.

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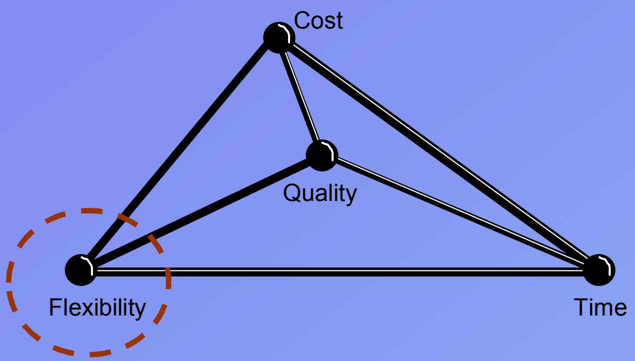
Flexibility In Manufacturing Systems



It is increasingly evident that the era of mass production is being replaced by the era of market niches. The key to creating products that can meet the demands of a diversified customer base, is a short development cycle yielding low cost, high quality goods in sufficient quantity to meet demand. This makes *flexibility* an increasingly important attribute to manufacturing.

***Flexibility cannot be properly considered in the decision making process if it is not properly defined in a quantitative fashion*. The quantification of flexibility has been the focus of academic work, but industrial applications have been meagre.**

A generic measure that is nonetheless relatively easy to apply to realistic manufacturing situations, is based on the premise that *the flexibility of a manufacturing system is determined by its sensitivity to change*. *The lower the sensitivity, the higher the flexibility*.

It is convenient to think of flexibility advantages as arising from the various types of flexibility, which can be summarized in three main categories:

- ***Product flexibility* enables a manufacturing system to make a variety of part types with the same equipment.**
- ***Operation flexibility* refers to the ability to produce a set of products using different machines, materials, operations, and sequences of operations.**
- ***Capacity flexibility* allows a manufacturing system to vary the production volumes of different products to accommodate changes in demand, while remaining profitable**

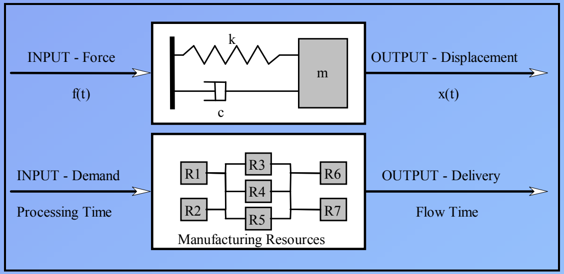
Chryssolouris, G., Manufacturing Systems: Theory and Practice , 2nd Edition, Springer-Verlag, New York, New York, (2005).

Production Systems Planning, Control & Networking

Flexibility In Manufacturing Systems

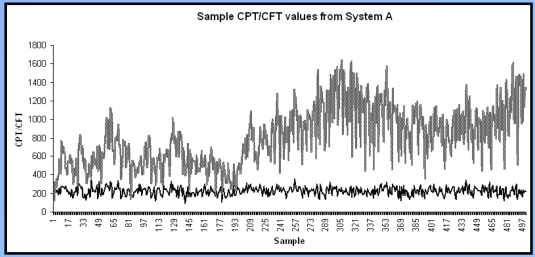
Principle

Flexibility assessment based on the dynamic behaviour analogy between a mechanical and a manufacturing system.



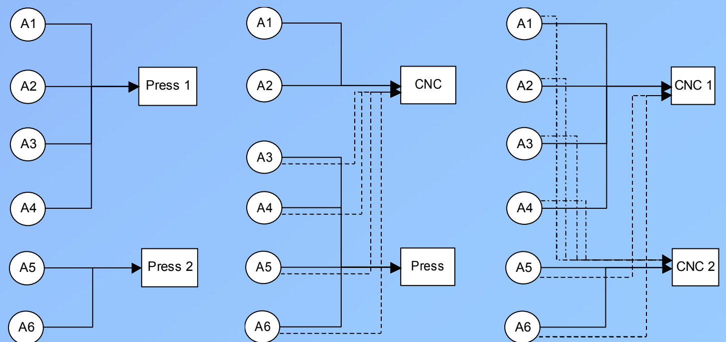
Method

- **Record Processing Time(input data) and Flow Time (output data) of produced parts.**
- **Calculate the Transfer Function from input/output data**
- **Evaluate flexibility from the transfer function**



Industrial Application

Assessment of flexibility in commercial refrigerators plant: Alternative routes of assigning parts to machines



Low flexibility **Medium flexibility** **High flexibility**

K. Alexopoulos, N Papakostas, D. Mourtzis, P. Gogos, G. Chryssolouris, Quantifying the flexibility of a manufacturing system by applying the transfer function, to be published in the *International Journal of Computer Integrated Manufacturing* (2006)

Production Systems Planning, Control & Networking

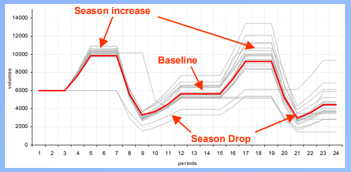
Flexibility In Manufacturing Systems

Principle

The flexibility of a manufacturing system is determined by its sensitivity to change. The less sensitive a system is to changes the more flexible it should be considered.

Method

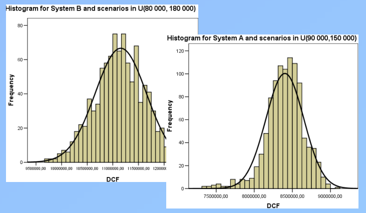
- Define a number of possible market scenarios



- Calculate the optimum lifecycle cost

$$DCF_i = Inv + \text{minimize}\left\{\sum_{t=1}^{T}\frac{\{O_m(t)+S_{km}(t)\}}{(1+r)^t}\right\}$$

- Evaluate the spread of the lifecycle cost



Industrial Application

Assessment of flexibility in automotive body in white

Alexopoulos, K., Mourtzis D, Papakostas N., and Chryssolouris G., "DESYMA - Assessing flexibility for the lifecycle of manufacturing systems", to be published in the *International Journal of Production Research*, (2006).

Production Systems Planning, Control & Networking

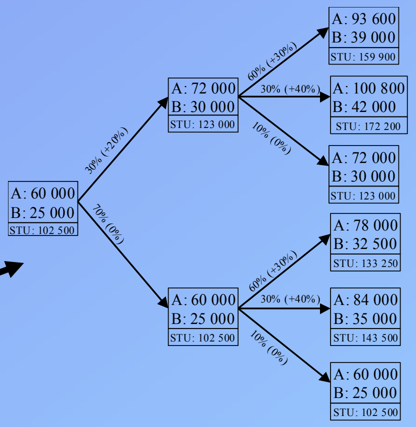
Flexibility In Manufacturing Systems

Principle

The flexibility of a manufacturing system is determined by its sensitivity to change. The less sensitive a system is to changes the more flexible it should be considered.

Method

- **Define changes in the environment and their probability of occurrence.**
- **Calculate the Penalty of Change in the manufacturing system**



$$POC = \sum_{i=1}^{D} Pn(X_i)Pr(X_i)$$

Industrial Applications

Assessment of flexibility in automotive plant

Assessment of flexibility in commercial refrigerators plant

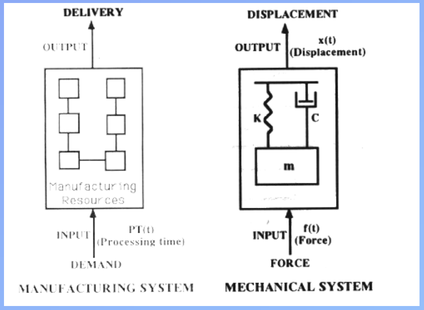
Chryssolouris, G., and M. Lee, "An Assessment of Flexibility in Manufacturing Systems", *Manufacturing Review*, (Vol.5, No.2, June 1992), pp.105-116.

Alexopoulos, K., A. Mamassioulas, D. Mourtzis and G. Chryssolouris, "Volume and Product Flexibility: a Case Study for a refrigerators Producing Facility", *Proceedings of the 10th IEEE International Conference on Emerging Technologies and Factory Automation (ETFA 2005)*, Catania, Italy, (19-22 September 2005), pp. 891-897.

Production Systems Planning, Control & Networking

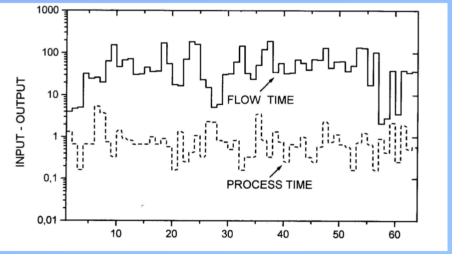
Flexibility In Manufacturing Systems

Principle → **Flexibility assessment based on the dynamic behaviour analogy between a mechanical and a manufacturing system .**

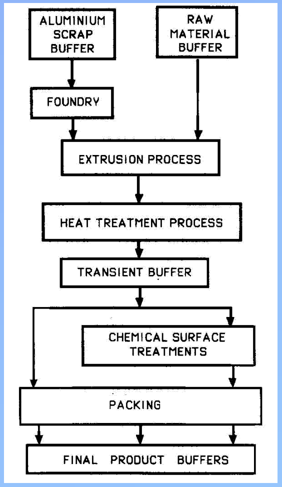


Method →

- **Calculate the transfer function of a production system from input/output data**
- **Evaluate manufacturing system flexibility**



Industrial Application → **Assessment of flexibility in manufacturing system producing aluminium profiles**



Chryssolouris, G., N. Anifantis and S. Karagiannis, "An approach to the Dynamic Modelling of Manufacturing Systems", *International Journal of Production Research*, (Vol.36, No.2, 1998), pp. 475-483.