Manufacturing Management - a New Approach

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Main topics

1. Introduction
2. Manufacturing activity
3. Manufacturing management
4. Illustrative example
5. Conclusion

1. Introduction

Premises

- Production is defined as “the step-by-step conversion of one form of material into another form through chemical or mechanical process to create or enhance the utility of the product to the user” [1].
- Manufacturing is a particular form of production and refers to the processing of raw materials or parts into finished goods through the use of tools, human labor, machinery, and chemical processing [2].
- In other words, manufacturing means the transformation of materials into industrial products, through natural phenomena (physical, chemical, biological), artificially provoked [3].
- Manufacturing is one of the most important components of the economy, hereby its efficiency and degree of compliance to the expected results is crucial.

1. Introduction

Plant level management

- At each processing step, there will be value addition. Manufacturing management refers to those aspects of the product manufacturing process that impact this.
- Managing a manufacturing plant means responsibility for the process, from assembly design to packaging and sending out the finished product [4].
- Manufacturing managers plan, schedule, and direct an efficient layout of equipment and flow of materials.
- Being a manufacturing manager means ensuring that manufacturing performance, volume, and quality goals are met [5].

1. Introduction

Operation level management

- Operation management is the administration of business practices to create the highest level of efficiency possible for each manufactured product. It is concerned with converting materials and labor into goods and services **as efficiently as possible** to maximize the profit of an organization [6].
- To get confirmations regarding the fulfilling of their objectives and goals **organizations must keep checking over their performance**. To achieve this purpose, organizations must use the performance management systems.
- For measuring, managing, and comparing the performance the organizations are required to know about the performance indicators [7]. At operation management level, **the performance indicators can be defined as the physical values which are used to measure, compare, and manage the overall organizational performance** [8].

1. Introduction

Challenge

- Despite the operation management works on the base of successive decisions, current approaches regarding the increase of management performance focus on the physical processes. Thus, **the management process currently shows a particular character**, according to each physical process.
- Under these circumstances, the challenge to which this paper answers is to release a new approach concerning the manufacturing operation management, based on decisional process modeling.
- This will further enable **to create a general and unitary conceptual basis for the management process**, no matter of the physical process through which manufacturing takes place, **and to perform online management**.

2. Manufacturing activity

Manufacturing process

- The manufacturing process means, according to here introduced approach, the matching up of the following three actions:
  - **learning**, which means jobs modeling,
  - **deciding**, which means tasks releasing, and
  - **processing**, which means transforming of material and generating information related to this.

- **The manufacturing process is here addressed as decisional process**, instead of physical process, as current approaches do.

2. Manufacturing activity

Manufacturing task

- The manufacturing task is here approached as the change of state undergone by a certain unit of product, being under manufacture in a given manufacturing system, from the **current** state **up to** its **final** state.
- The manufacturing task is **qualitatively described by *T*** vector, which can be defined at three levels:
  - Features level $\boldsymbol{T}_{features} = \{\boldsymbol{S}, \boldsymbol{P}, \boldsymbol{Q}\}$,
  - Attributes level $\boldsymbol{T}_{attributes} = \left\{\{S_i\}, \{P_j\}, \{Q_k\}\right\}$, and
  - Variables level

$$\boldsymbol{T}_{variables} = \left\{\{S_i'\}, \{P_j'\}, \{Q_k'\}, \{S_i''\}, \{P_j''\}, \{Q_k''\}, \{S_i'''\}, \{P_j'''\}, \{Q_k'''\}\right\}$$

2. Manufacturing activity

Manufacturing task

- The manufacturing task is **quantitatively described by the values** of the variables, which can be retrieved in three sets having different extension and application, as it follows:
  - The values of the imposed level of attributes,

$$\widehat{\boldsymbol{T}} = \left\{\{s_i{}'\}, \{p_j{}'\}, \{q_k{}'\}\right\},$$

  - The values of the imposed and set levels of attributes,

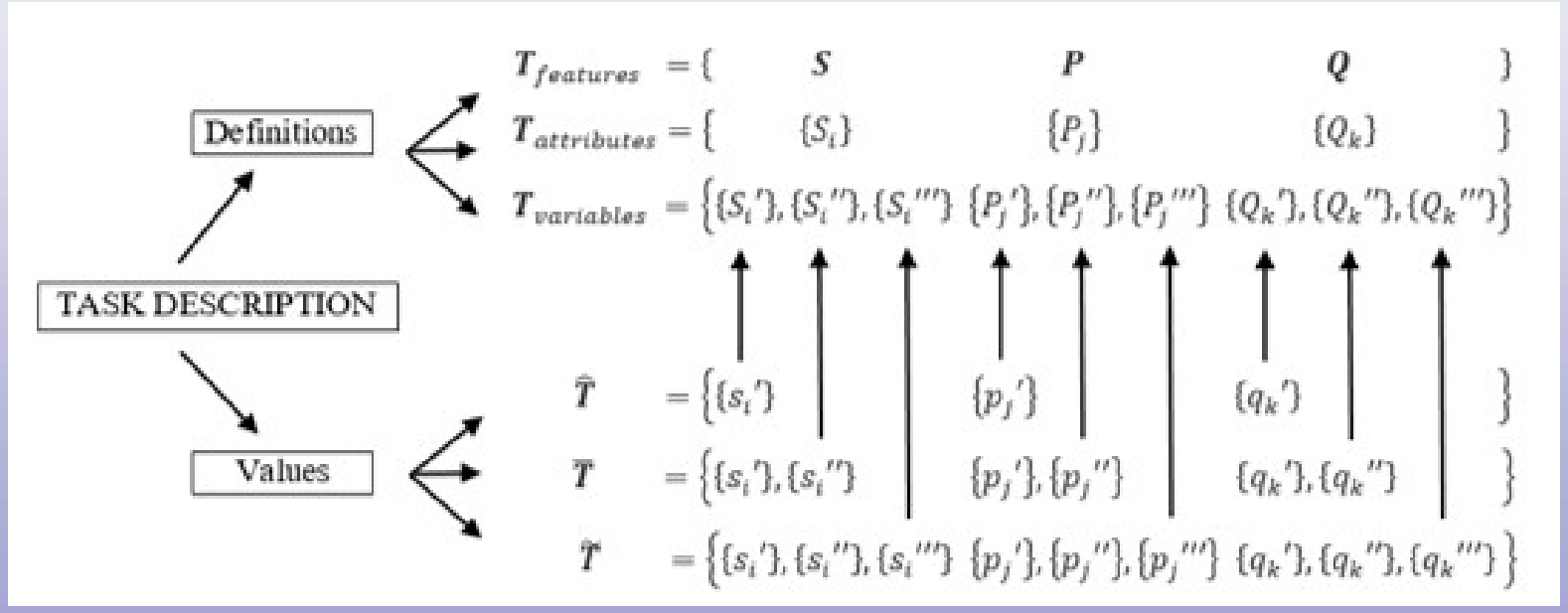
$$\overline{\boldsymbol{T}} = \left\{\{s_i{}'\}, \{p_j{}'\}, \{q_k{}'\}, \{s_i{}''\}, \{p_j{}''\}, \{q_k{}''\}\right\}, \text{ and}$$

  - The values of the imposed, set, and measured levels of attributes,

$$\widetilde{\boldsymbol{T}} = \left\{\{s_i{}'\}, \{p_j{}'\}, \{q_k{}'\}, \{s_i{}''\}, \{p_j{}''\}, \{q_k{}''\}, \{s_i{}'''\}, \{p_j{}'''\}, \{q_k{}'''\}\right\}.$$

2. Manufacturing activity

Manufacturing task



2. Manufacturing activity

Manufacturing job, procedure and cycle

- The manufacturing job is addressed as a family of tasks that concomitantly satisfy two conditions:
  - They have the **same definitions of the features, attributes, and variables,** while the variables values can be different, and
  - They are modeled by the **same model,** describing the relationships between variable values.
- The manufacturing procedure is addressed as an organized cluster (family) of **techniques** intended to carry out the manufacturing activity stages, namely the ordering, design, planning, programming, and processing.
- The manufacturing cycle means a sequence, during which **a given task** is accomplished. It comprises a set of interdependent **learning, deciding,** and **processing** actions, associated with a set of **precedence** and **belonging** conditions.

3. Manufacturing management

Proposed approach

- According to proposed approach, the manufacturing management consists in **performance - model-based decision making** that includes performance **assessment**, **monitoring** and **driving**.
- The operation management action means monitoring-based **adjustment** of the three manufacturing process components, namely learning, deciding, and processing, aiming performance improvement.
- The manufacturing management is addressed at **task, job**, and **variable** level.

3. Manufacturing management

Task-level management

- Making of the best decision regarding the reconfiguring of the initial task, i.e., by replacing it with one or several newly generated tasks, which may be execution tasks $\overline{\boldsymbol{T_\alpha}} = \left\{\{s_i'\}, \{p_j'\}, \{q_k'\}, \{s_i''\}, \{p_j''\}, \{q_k''\}\right\}$ or released tasks $\widehat{\boldsymbol{T_n}} = \left\{\{s_i'\}, \{p_j'\}, \{q_k'\}\right\}$.

- Driving of the released tasks, which is based on the assessment of the monitored levels for the attributes - $\{s_i'''\}$, indicators - $\{p_j'''\}$, and conditions - $\{q_k'''\}$, for the current execution task

- The task-level management ends when the initial task is fully replaced by a set of executable tasks.

3. Manufacturing management

Job-level management

- Model structure can take two forms, depending on the nature of the task that will be further addressed.

$$F_1\left(\left\{\{s_i'\},\{p_j'\},\{q_k'\}\right\}_{T_0}\right)=\left\{\{s_i'\},\{p_j'\},\{q_k'\}\right\}_{T_n}\cup\left\{\{s_i'\},\{p_j'\},\{q_k'\},\{s_i''\},\{p_j''\},\{q_k''\}\right\}_{T_\alpha}$$

$$F_2\left(\left\{\{s_i'\},\{p_j'\},\{q_k'\}\right\}_{T_0}\right)=\left\{\{s_i''\},\{p_j''\},\{q_k''\}\right\}_{T_\alpha}$$

- Model building algorithm is based on holistic monitoring [14], which generates an instances dataset of completed tasks, and on causal modeling [15], which generates clusters of causally related task variables.
- Model usage algorithm is based on comparative assessment [16].
- Model driving is based on the basic model $m(T_n)$, obtained by learning.

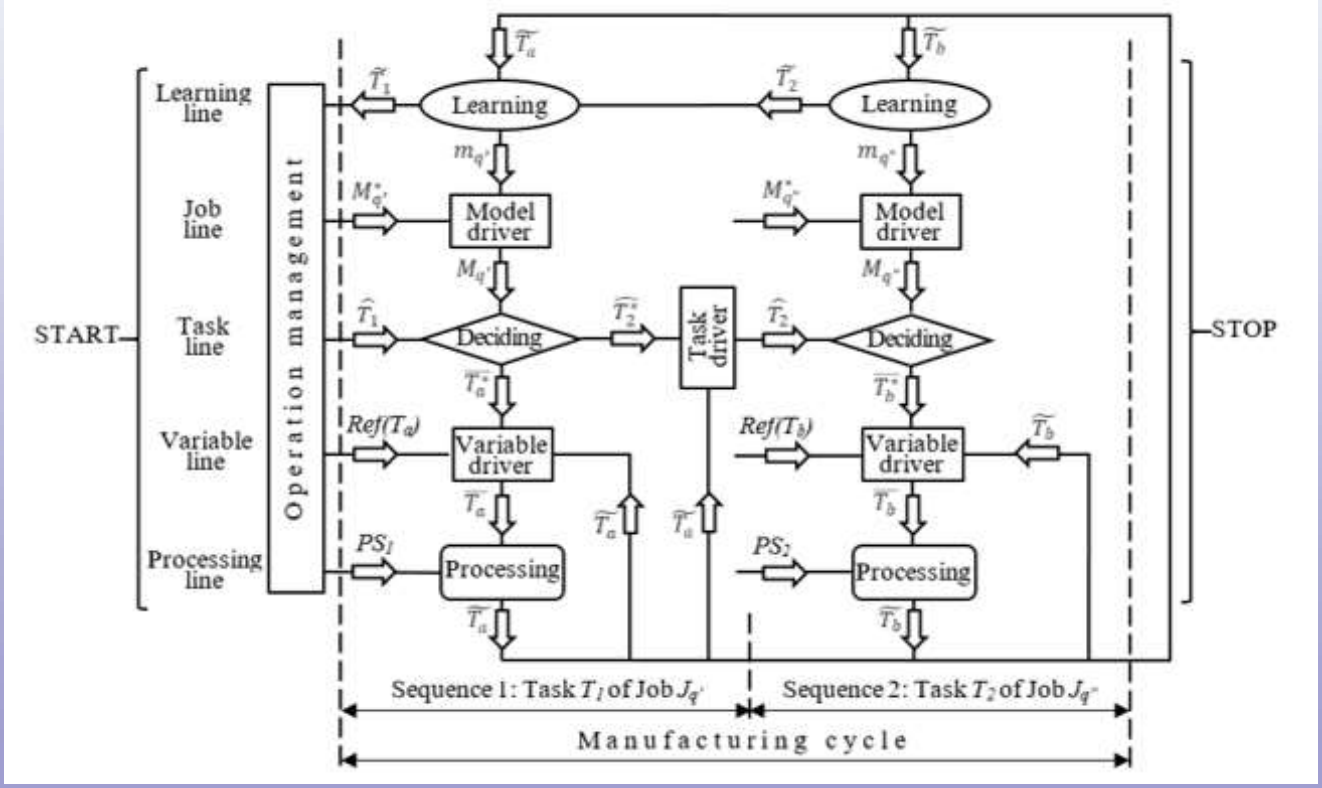
3. Manufacturing management

Variable-level management

- It refers to adjusting the reference values of the variables for the execution task, $\overline{T_\alpha}^*$, based on assessment of the monitored levels of the attributes – $\{s_i'''\}$, indicators – $\{p_j'''\}$, and conditions – $\{q_k'''\}$, for the current execution task.
- "Reference value" may refer to the reference of variable measuring frame, to the reference of variable control loop, or to both. On this manner, the final form of the vector $\overline{T_\alpha}$ results.
- After processing, the vector $\widetilde{\boldsymbol{T}_\alpha}\left\{\{s_i'\},\{p_j'\},\{q_k'\},\{s_i''\},\{p_j''\},\{q_k''\},\{s_i'''\},\{p_j'''\},\{q_k'''\}\right\}$, that includes the values of the imposed, set, and measured levels of the attributes for the current execution task is generated.

3. Manufacturing management

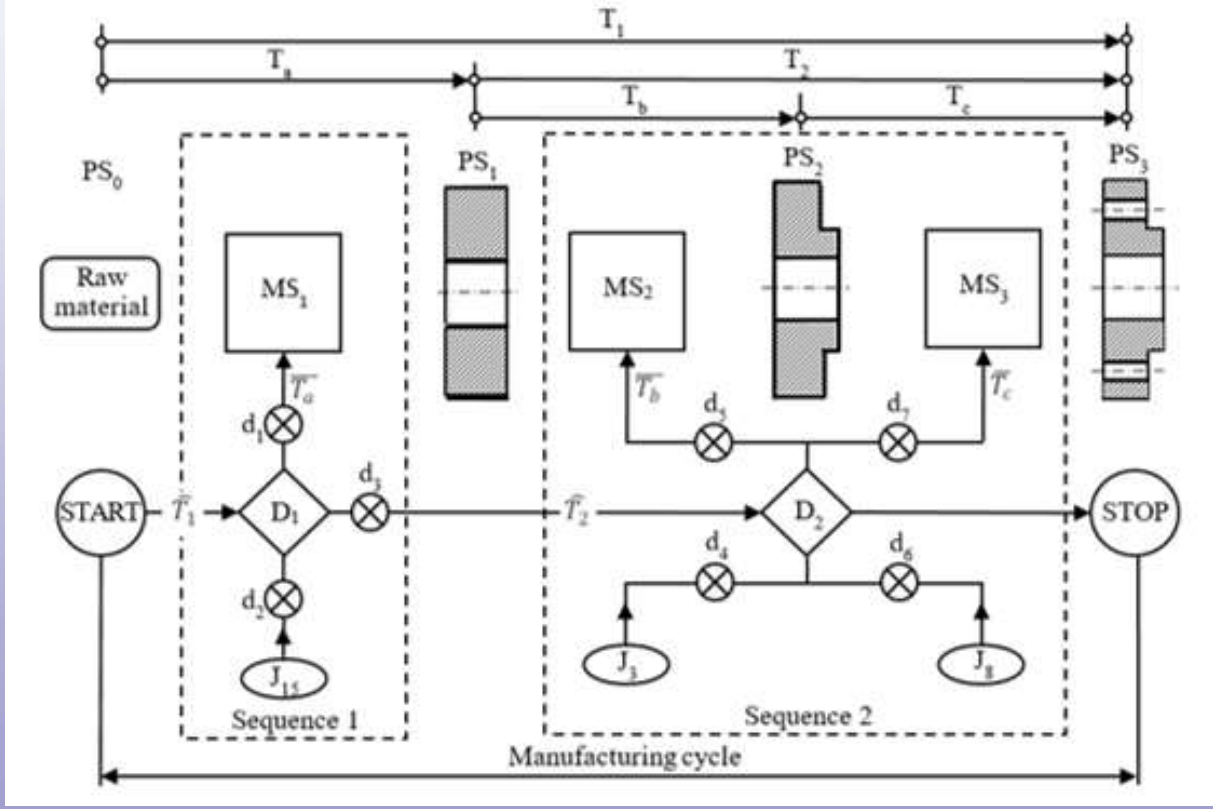
Manufacturing management algorithm & diagram



4. Illustrative example

Pipe flanges

4. Illustrative example



5. Conclusion

- The operation management is based on the use of digital models, taking full advantage from digital technologies capabilities.
- The resulted model is no longer dependent on the physical process nature, as in current, conventional situation. The only element that differentiates two distinct cases is the dataset to which the model follows to be applied.
- The manufacturing system is seen as cyber-physical system: the cyber-subsystem supports learning actions, the physical-subsystem enables processing actions, while operation management represents the decisional actions leading to task accomplishment.
- The management may be performed both offline or online. In second case, the management can be set more or less coarse, depending on the relation between the numbers of decision stations and manufacturing stations. On this way, a convenient trade-off between decisions accuracy (finer setting) and decisional process simplicity (coarser setting) can be made.

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