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Control and Supervision Function Reference Model and Auditing

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Abstract

The control and supervision function of a manufacturing organization is in its operational core. Because of its importance, there have been initiatives such as ISA95 and IEC62264 aiming at the creation of frameworks for structuring its resources and the execution of its processes. There is, however, a need for the consolidation of these works and their operationalization and application as diagnosis and improvement tools to existing manufacturing systems from the perspective of different industries. This work addresses these issues by proposing both a control and supervision reference model for manufacturing organizations and an auditing procedure for it. The reference model is built through the synthesis of different frameworks and recommendations found in the literature. The auditing procedure is developed from the Process-Aware Enterprise Engineering (PAEE) framework that is based on the Cambridge Process Approach. Methods and tools used include interviews, surveys, observation and documents and records analysis. The reference model and the auditing procedure are applied to a textile company case study. Conclusions are drawn for the reference model validity, the PAEE framework application to the auditing procedure, the proposed and applied data collection instruments and the auditing results.

Keywords
Control and supervision function, enterprise engineering, process approach, auditing procedure

1. Introduction
In a manufacturing context, control and supervision can be defined as the organizational function concerned with the assurance that what was planned is being executed [1, 2]. This involves making sure resources are available and that the manufacturing system is able to perform its duties, tracking activities, recording and analyzing data related to the production, assessing the performance of the manufacturing system and taking necessary actions to steer this performance to its expected level whenever necessary. In this sense, it can be seen that this function plays a vital role in a manufacturing organizations, as it interfaces with many other organizational functions and areas, such as production planning and maintenance [3, 4], for instance.

To help manufacturing organizations in deploying this function and others, as well as their interfaces, different reference models have emerged in the enterprise engineering literature [5–14]. These models vary in content, but they mainly describe what activities should be performed in a specific function, how they should be performed and what elements are necessary to perform them [15]. Two problems usually arise in the application of these models [16]. The first one is related to its content. As content and its breadth vary according to model, encompassing several functions at once, it is sometimes difficult to apply them specifically to the control and supervision function. The second problem is related to the process through which the model is applied. Besides describing content, most models do not determine how the reference model should be applied. For instance, reference models do not state how the model could be used for either auditing or designing a manufacturing system.

This paper aims at addressing these issues by proposing both a reference model for the control and supervision function of a manufacturing organization and an auditing procedure able to assess to what extent that model is applied. The reference model is developed from recommendations and other more general reference models found in the literature. The auditing procedure is derived from the Process-Aware Enterprise Engineering (PAEE) framework based on the Cambridge process approach [17–19]. This framework understands process-based initiatives as being composed of a set of steps organized in phases and performed in a cyclic way, each cycle planned after the previous.

Such a reference model cannot be limited to a particular industry – although industry specific versions can be later derived from it – and has to account for the interaction of the control and supervision function with other organizational functions and areas. Additionally, although initially used for auditing the control and supervision function, it should also be considered as a guide for its implementation and/or improvement.

Based on this premises, this paper develops its objectives as follows: in the next section, the research method employed is explained. Section 3 lays the foundations on which the reference model was constructed and details it. Section 4 explains the auditing procedure, whereas Section 5 presents the results of a case study in which it was applied. Section 6 draws conclusions about this work in general and, in particular, about the application of the reference model, the use of the auditing procedure, its results and the data collection instruments.

2. Research Method

The research method used in this work was composed of three stages. The first stage was the construction of the reference model. For this to be made, the literature related to the control and supervision function was reviewed in search for both reference models containing it and recommendations to how it should perform. Pieces of literature reviewed included journal and conference papers, thesis, dissertations, standards and technical reports. Reference models were studied in order to highlight their main elements and relationships. Recommendations were listed in a table for further reference. The reference model for the control and supervision function was created as a synthesis of both the models and recommendations. Stage #1 and its results are further explained in Section 3.

Next, in the second stage, the auditing procedure was developed. The auditing procedure, as already mentioned, was based on the PAEE framework and the discovery and diagnosis phases were used. The reference model was decomposed in parts and analysis points were defined, with each analysis point providing information that could be used in the assessment of one or more parts. Information sources related to each analysis point were chosen (interviews, surveys, observation, documents and records) and best practices were defined for each analysis point based on the recommendations and the literature reviewed in Stage #1 in order to facilitate its assessment. Data collection instruments were defined for the information sources of each analysis point – questions in a survey and in an interview, observation points and general documents to be asked for. In this stage, it was also determined that more than one reviewer would assess the use of the reference model by the organization based on the collected evidence. Stage #2 and its results are further explained in Section 4.

Finally, a case study was conducted in order for both the reference model and the auditing procedure to be tested. An organization was chosen taking into account the possibility of easy access to the information sources defined in the auditing procedure. Data was collected and organized both by its source and by analysis point in an electronic spreadsheet. Reviewers rated each analysis point based on the evidence collected for it and an overall score to the extent the organization addressed each part of the model was calculated. An overall score to the use of the reference model by the organization was also calculated based on the scores from the different parts. Stage #3 and its results are further explained in Section 5.

3. Literature Review – Reference Models and Recommendations

This section discusses some of the foundations used for the construction of the control and supervision function reference model – the reference models containing this function and a sample of recommendations from the literature. From these foundations, the reference model created is then presented and explained in Section 4.

Several works in the literature were considered to gather information regarding reference models and recommendations for a control and supervision function reference model. Table 1 shows the eight main reference models studied and their main literature references.

Table 1: Reference Models Containing the Control and Supervision Function.

Reference Model	Literature Reference	Reference Model	Literature Reference
OOSIM	[11]	TOVE	[10]

Reference Model	Literature Reference	Reference Model	Literature Reference
SALMONS	[13]	GIM	[20]
IEC62264/ISA95	[21–24]	CIMOSA	[4], [6], [25–27]
HMS (IFCF, PROSA, PDCH)	[14]	PERA	[7]

There are two classes of models in Table 1. The first class is composed of models whose main focus is the control and supervision function (OOSIM, SALMONS, IEC62264/ISA95 and HMS). The second class is composed of models whose focus is to describe the whole enterprise, with the control and supervision function as one of the elements to be modeled (TOVE, GIM, CIMOSA and PERA). The characteristics of these models will not be discussed here – in addition to their basic references, they can be found in another work [15], including their components and relationships. It is interesting to note, though, that one of the main models of the first class, IEC62264/ISA95 was an effort to develop a manufacturing control and enterprise systems interface standard derived from a model from the second class, PERA. Because it is more focused on manufacturing control and has its roots in a general model, this model was chosen as a basis upon which the control and supervision reference model was built, incorporating relevant aspects of other reference models and the recommendations.

For the extraction of recommendations regarding the control and supervision function, 15 different works were analyzed. Recommendations are varied and cover topics such as the design of the function, the allocation of its resources, the activities that should be performed, how it should be implemented, performance evaluation and performance metrics and roles and responsibilities, among others. 26 recommendations were extracted. A sample of these recommendations with the reference from which they were extracted can be seen on Table 2.

Table 2: Sample of Recommendations Extracted from the Literature Review

ID	Model	Reference
3	The proper integration of human operators provides a good base for human and computerized controls	[11]
6	There must be a balance between the amount of work, deadlines and the amount of used resources	[13]
16	Utility and the timeliness are aspects to be considered for the interoperability of information	[12]
20	Integration of the maintenance system to the control and supervision function improves production time minimizes unpredicted costs	[2]

It must be mentioned that not all of the recommendations were incorporated in the control and supervision reference model created. As will be explained later, the proposed reference model represents the process dimension of the control and supervision function and only recommendations related to this dimension were used. Other recommendations, related to other dimensions should be used when these other dimensions are addressed.

4. Control and Supervision Reference Model

Figure 1 shows the developed control and supervision reference model based on the reference models from Table 1 and the recommendations from Table 2. The model is represented in the form of a flowchart showing the main processes and the different hierarchical levels of the control and supervision function. The model was developed taking the IEC62264/ISA95 standard as its basis and incorporating elements from the other reference models and recommendations into it. Not all recommendations were used – only those related to a process dimension of the function. As can be seen by the activities represented in Figure 1, the first level is more closely related to the control function. The third level is more closely related to the supervisory function whereas the fifth level is more closely related to functions that are beyond the scope of this work, such as accounting, marketing and inventory control, among others. The second and fourth levels serve as interface levels between the aforementioned levels. The flowchart of the model is quite extensive and has important features that should be noted. This will be done in the next paragraphs.

At level 1, related to the control of the Manufacturing System (MS), the process can be initiated in several ways, e.g. after a pre-determined period of time, by processes from other areas of the company and by alarms. Along with the collection of MS data, its adaptation and validation are done, as wrong information, at this point, may have a great impact, generating false alarms and starting actions that waste production time. Shortly after these tasks, four tasks are spawn – three addressed in other levels, and another at level 1, related to the diagnosis of the MS. In this task, data is evaluated in order to take actions to maintain the production level of the MS in standard conditions. Hence the block "Control of Physical Processes" may receive adjustments from the "Production Optimization" or simply follow the standard procedures. Finally, adjustments are performed according to specifications.

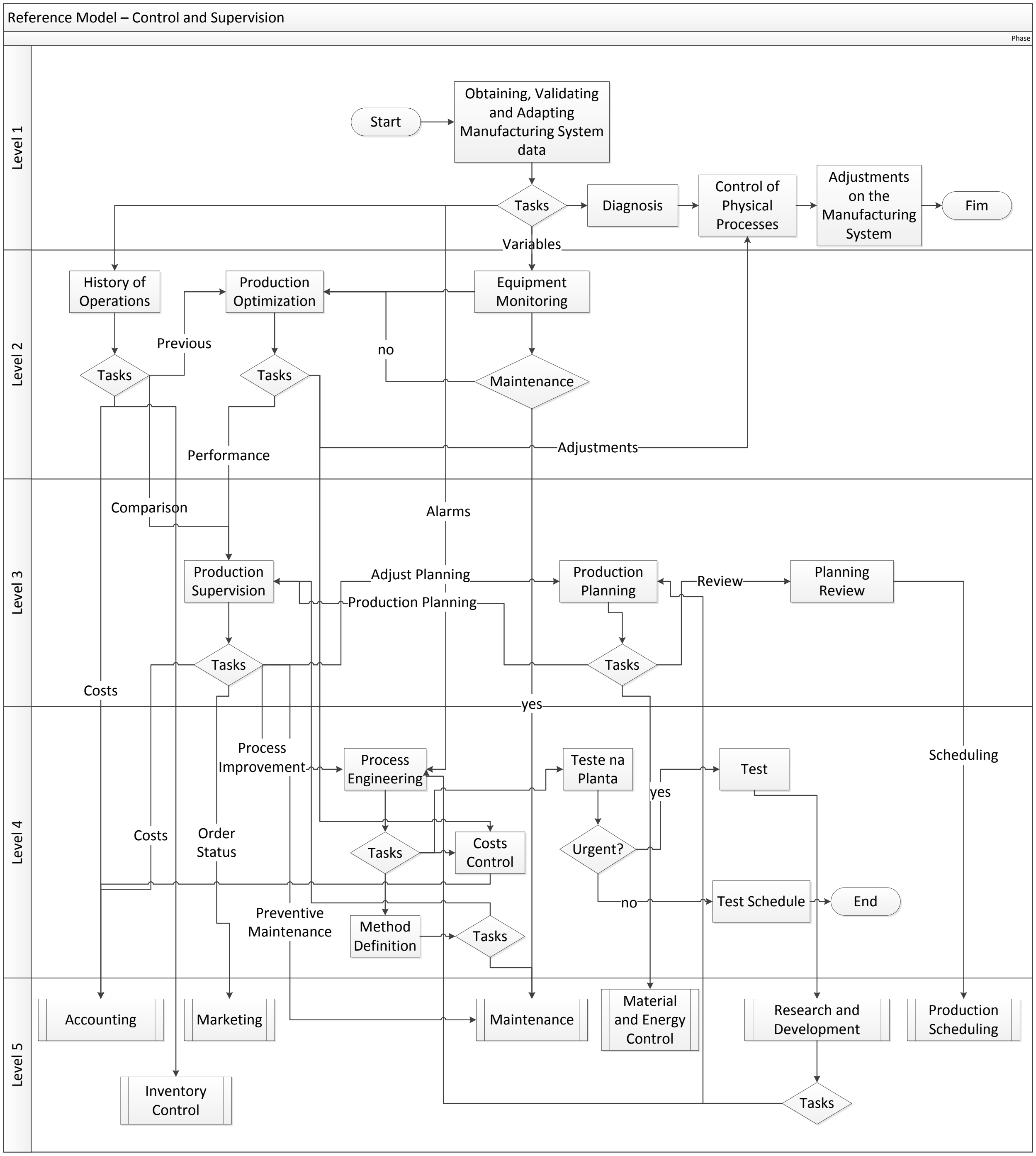

Figure 1: Flowchart of the Control and Supervision Reference Model.

At level 2, the transition between control and supervision, two more tasks directly linked to the tasks "Collection, Validation and Adaptation of Information SM" are started. These tasks are the "History of Operations" task, which has the objective of storing and processing collected data, and the "Equipment Monitoring" task, which is connected to the equipment mainly for maintenance purposes. The "History of Operations" task sends vital data for accounting, inventory control and the supervision of production, and the "Equipment Monitoring" task makes decisions related to maintenance. It can be observed that both the "History of Operations" and "Monitoring Equipment" tasks supply the "Production Optimization" task with information. The later is the same task that provides adjustments to the plant and is directly connected to supervision, providing parameters that allow for the proper operation of the MS based on its performance.

At level 3, related to supervision, there are two tasks involved with production planning besides the main one. The "Supervision of Production" has four entries: a comparison among information from the "History of Operations", the performance of the "Optimization Process", the plan from "Production Planning" and other tasks related to process engineering. Besides coordinating the production planning, supervision sends data to process engineering, maintenance and other tasks outside the scope of this model, such as accounting and marketing. The "Production Planning" task, in turn, receives data from the "Research and Development" task, since data collection and possible implementations require a proper planning. After that, the result is sent to the "Planning Review" task, which eventually schedules the production. One can also notice that the "Production Planning" task feeds the "Control of Material and Energy" task, an important function that keeps record and accounts for production costs.

At level 4, there is the transition between supervision and functions beyond the scope of this model. There are five tasks associated to the process engineering and one to the cost of production. The "Process Engineering" task handles all production processes and establishes methods and procedures, performs tests, and starts tasks related to process improvement. When performing the "Method Definition" task, it sends the definitions to supervision and maintenance, and in the "Test on the Plant" task, priorities are taken into account to generate adequate results. It can be observed that both the "Production Optimization" task, in the lowest level, and the "Process Engineering" task send data to the "Cost Control" task, since they may have optional modifications that fall into a different category of costs.

At level 5, functions beyond the scope of this model are taken into account. There are seven of these functions, all of them requiring data generated by the control and supervision system.

Due to the fragmentation of this model and the number of tasks involved, one can notice a gradual change regarding the degree of relationship between the tasks within each level. For instance, the "Obtaining of information" and "Diagnosis of the MS" tasks at level 1 are much more closely associated with one another than with the "Marketing" and "Maintenance" tasks at level 5. This progress is a trend that would stand if the development of this model were continued. It happens due to the adopted point of view of two closely related functions, control and supervision, which makes the general model of the company to have tasks not so directly associated at the same level. This brings the concern about communication between the functions within the organization, which justifies modeling features that enable a future implementer of the model to understand such tasks in a way that is more widely interrelated with other areas of the company.

5. Auditing Procedure

In order to use the reference model as a basis for the auditing of the manufacturing control and supervision function of an organization, an auditing procedure was designed. This auditing procedure was based on the Process-Aware Enterprise Engineering (PAEE) framework still under development as a result of a research project and based on the Cambridge process approach. In this work, the discovery and diagnosis phases of the PAEE framework were used. The discovery phase involves the gathering of information through a set of data collection instruments and the diagnosis phase involves the consolidation of this information and its analysis.

The first step in this design was to understand and define the expected result by the auditing procedure through its analysis procedure. The expected result is to verify the adherence of the practices of an organization in comparison with those present in the reference model.

The phases underlying the design of this procedure were: (i) translating the reference model into a list of points which can be effectively investigated; (ii) developing appropriate tools to facilitate the collection and the analysis of the points investigated. The first phase was accomplished by: (1) breaking-down the reference model into a set of model parts in order to allow its deeper investigation – the reference model contains a set of parts; (2) establishing a set of points of analysis so that each part of the model could be properly investigated – each point of analysis could lend insight to either one or more model parts, and it can be said that each point corresponds to a manufacturing control and/or supervision practice in the organization. The second phase included: (3) identifying the sources of information from which evidence of practices related to the points of analysis could be verified – each point of analysis could have different sources of information as evidence to it; and (4) designing the data collection instruments to operationalize the gathering of evidence from a list of items related to where evidence can be found – each source of information contains one data collection instrument, and each data collection instrument contains a set of items which could correspond to several points of analysis.

The relationship between the elements of the auditing procedure contained in the previous explanation is represented in the data structure diagram in Figure 2.

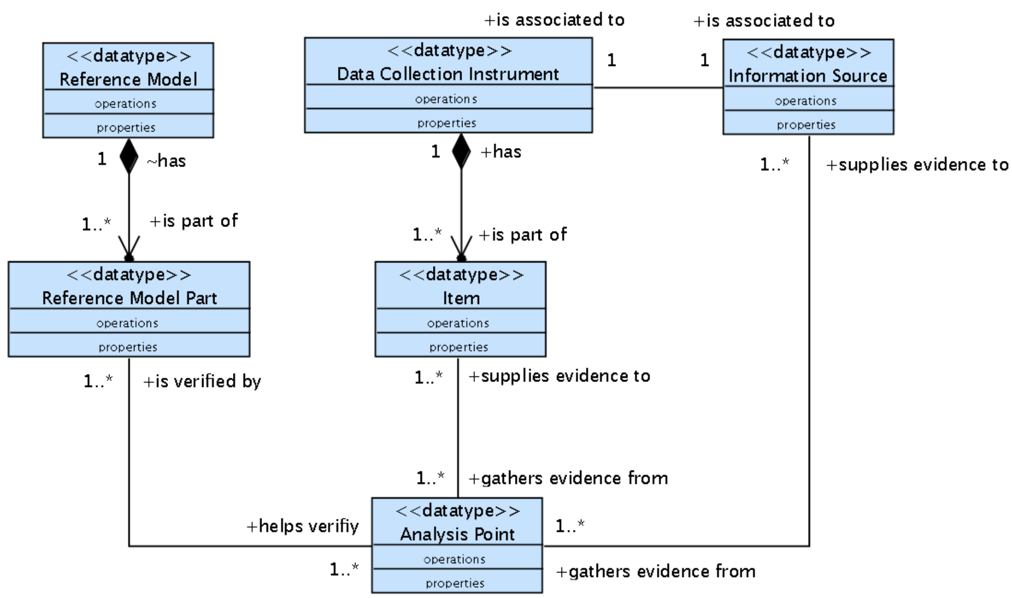

Figure 2: Data Structure Diagram Containing the Elements of the Auditing Procedure.

In summary, the steps for the design of the auditing procedure or the discovery phase of the PAEE framework are:

1) Break down the reference model into parts that can be properly investigated.
2) For each model part, identify points of analysis so that the parts can be properly investigated.
3) For each point to be analyzed, define the most appropriate sources of information – more than one information source may be necessary and define which specific items need to be analyzed so that each point of analysis can be spotlighted.
4) By grouping the items, design the data collection instruments for each source of information.

A reverse process must be followed for the analysis of the collected information, with the aid of a rating scale. These steps correspond to the diagnosis phase of the PAEE framework:

1) Before starting to analyze the data collected in the company, the ideal results must be kept in mind. For this, a list describing the expected practices for each point of analysis must be created.
2) Gather all items providing evidence for the analysis of a given point in all data collection instruments. Do this for all points and prepare an analysis for each of the points. Graduate the analysis with a zero-to-ten score, considering the expected practices of the corresponding point as a reference for the maximum score. The use of more than one reviewer is recommended.
3) Consolidate the analysis of the points corresponding to each of the model parts. This should come to a verification of the company's practices with respect to each part of the model. Compile the score of each part of the model, by calculating the average score of its points of analysis.
4) Based on the verification of each part of the model, develop an opinion regarding the compliance of the company's practices to the reference model built. Calculate the score of the reference model, by calculating the average score of its parts.

The Auditing Procedure just described was applied to the control and supervision reference model created and generated the following results:

1) The reference model was broke down into 23 parts, according to the nature of the practices.
2) For each part of the model, a set of points of analysis was defined and described in the form of questions. The relationship between each point of analysis and the corresponding model parts was described by using codes. A common denominator could be noticed among the points of analysis, resulting in the creation of a few categories of support. Thus, the points of analysis were organized according to these categories, since it facilitated the visualization of the model as a whole.
3) For each point of analysis, the most appropriate sources of information were defined. Five types of information sources were identified: interview, survey, observation in the shop floor, documents gathering and analysis of processes records. Each point of analysis was decomposed into one or more items to gather evidence from.
4) A data collection instrument was designed for each source of information, by grouping the points of analysis along with its items.

6. Case Study

The company chosen for testing the auditing procedure is a small regional clothing manufacturer from the textile industry, with approximately 30 employees. The willingness to collaborate with the research project was decisive to its selection by the authors of this work. For privacy reasons, the company will simply be named MSK in this paper.

The work plan for auditing the company's manufacturing control and supervision function was as follows:

- Planning and scheduling of the interventions (0,5 hour).
- Interview with the manufacturing supervisor (2,0 hours).
- Observation in the shop floor (2,0 hours).
- Interviews with manufacturing team leaders (2,0 hours).
- Documents gathering and analysis of processes records (1,0 hour).
- Review of points of doubt (1,0 hour).

After these interventions, the information collected was organized in an electronic spreadsheet and analyzed according to the method described in the previous section. Three different reviewers compared each point of analysis to the expected practices found in the reference model. This comparison resulted in each analysis point being rated with a score between 0 (zero) and 10 (ten). Subsequently, it was possible to evaluate and calculate the score of each model part. This can be seen in Table 3.

The evaluation score of MSK's adherence to the control and supervision reference model was 2.25 out of 10.00. The low result is either due to the lack of practices from the reference model or the low performance of the practices implemented by the company. The result was not surprising, since MSK is a small company with an increasing demand, and it can be regarded that its management model is still in a low maturity level. Some of the findings from the analysis of the data collected and the results of Table 3 are summarized as follows:

- There is no software infrastructure to aid the manufacturing's control and supervision function (only simple electronic spreadsheets are used throughout the organization), what makes both the manufacturing system error prone and data collection for performance evaluation difficult.
- Absence of systematic performance measurement and of a performance management system.
- Absence of strategic orientation for both the medium and the long term – only the short-term demand is taken into account while planning the production.
- Poor communication, with few, inefficient and non-standardized meetings and non-structured and informal handoff of information.
- Poor handling of failures – over-concentrated in one person and dependent upon the experience of this person in dealing with the situation.
- Absence of analysis aimed at preventing failures, particularly because of the lack of testing and standardized quality assurance/control procedures.
- Lack of improvement initiatives or any kind of change in the production process, which is unsystematically done.
- Actions focused on the short term, with decisions aimed mostly at meeting deadlines and not at planning future capacity in order to respond to future demands and environmental changes.

- Lack of standardization.
- Supervisor too much involved with daily routine activities, with little time devoted to improvement activities.
- Poor decision making, with lack of analysis to support decisions.
- Absence of risk identification, analysis and control.
- Lack of application of industrial engineering methodologies, with most changes based on intuition.
- Lack of preventive maintenance.

Table 3: Results For The Assessment Of The Organization In The Case Study To Its Adherence To The Control And Supervision Reference Model.

Part of the model	Point of analysis	Score of point of analysis	Score of part of the model
1 - Informations	1.1	2,17	1,77
	1.2	0,00	
	1.3	1,67	
	1.4	5,03	
	5.1	0,00	
2 - Diagnosis	1.1	2,17	2,37
	1.2	0,00	
	1.4	5,03	
	2.1	4,83	
	2.2	2,17	
	5.1	0,00	
3 - Physical processes control	1.4	5,03	3,24
	2.1	4,83	
	2.2	2,17	
	2.4	4,17	
	5.1	0,00	
4 - Adjustments	1.4	5,03	2,84
	2.2	2,17	
	2.4	4,17	
	5.1	0,00	
5 - Historical information	1.1	2,17	1,33
	1.2	0,00	
	1.4	5,03	
	3.1	2,10	
	5.1	0,00	
	5.4	0,00	
	5.5	0,00	
6 - Otimization	1.1	2,17	1,56
	1.2	0,00	
	1.4	5,03	
	2.3	1,50	
	2.4	4,17	
	3.1	2,10	
	4.2	0,67	
	5.1	0,00	
	5.4	0,00	
	5.5	0,00	
7 - Equipment monitoring	1.1	2,17	1,78
	1.2	0,00	
	1.4	5,03	
	2.1	4,83	
	2.2	2,17	
	5.1	0,00	
	5.4	0,00	
	5.5	0,00	
8 - Supervision activities	1.1	2,17	1,97
	1.2	0,00	
	1.4	5,03	
	3.1	2,10	
	3.2	2,67	
	3.3	3,83	
	3.4	0,00	
	3.5	5,83	
	5.1	0,00	
	5.4	0,00	
	5.5	0,00	
9 - Production Planning	1.4	5,03	2,94
	3.1	2,10	
	3.2	2,67	
	3.4	0,00	
	3.5	5,83	
	3.6	6,83	
	3.7	6,33	
	3.8	3,50	
	5.1	0,00	
	5.4	0,00	
	5.5	0,00	
10 - Planning Review	1.4	5,03	3,06
	3.4	0,00	
	3.5	5,83	
	3.6	6,83	
	3.7	6,33	
	3.8	3,50	
	5.1	0,00	
	5.4	0,00	
	5.5	0,00	
11 - Processes Engineering	1.4	5,03	1,41
	4.1	0,00	
	4.2	0,67	
	5.1	0,00	
	5.2	1,33	
12 - Tests in the shop floor	1.4	5,03	1,43
	4.1	0,00	
	4.2	0,67	
	5.1	0,00	
13 - Other Tests	1.4	5,03	1,43
	4.1	0,00	
	4.2	0,67	
	5.1	0,00	
14 - Costs Control	1.4	5,03	2,52
	5.1	0,00	
15 - Standardization	1.4	5,03	1,56
	3.1	2,10	
	4.1	0,00	
	4.2	0,67	
	5.1	0,00	
16 - Test Scheduling	1.4	5,03	1,43
	4.1	0,00	
	4.2	0,67	
	5.1	0,00	
17 - Accounting	1.4	5,03	2,38
	3.1	2,10	
	5.1	0,00	
18 - Marketing	1.4	5,03	2,88
	3.1	2,10	
	5.1	0,00	
	5.3	4,40	
19 - Maintenance	1.4	5,03	2,38
	3.1	2,10	
	5.1	0,00	
20 - Energy Control	1.4	5,03	2,52
	5.1	0,00	
21 - Research and Development	1.4	5,03	1,90
	4.2	0,67	
	5.1	0,00	
22 - Production Scheduling	1.4	5,03	3,96
	3.6	6,83	
	5.1	0,00	
23 - Inventory Control	1.4	5,03	3,12
	5.1	0,00	
	5.6	4,33	

From Table 3, the following can also be noted about the different model parts and how the organization performs in them:

- The highest scores are from the "Physical processes control", "Planning review" and "Production scheduling" model parts. This shows that the manufacturing system under analysis has a concern in planning and executing the tasks necessary for production. It is interesting to note that: (i) "Physical processes control" is a model part from level 1 of the reference model, related to control; (ii) "Planning review" is a model part from level 3 of the reference model, related to supervision; and (iii) "Production scheduling" is a model part from level 5 of the reference model, related to other functions. This implies that planning is the strongest function of the system, although it does not have depth – planning is carried out only to define what to do in the short term (next actions) and not in the long term, to define capacity and to guide structural changes.
- The lowest scores are from the "Historical information", "Process engineering", "Tests in the shop floor", "Other tests" and "Test scheduling" model parts. This implies that: (i) historical information is usually disregarded in the manufacturing system because of the lack of a structured procedure to collect data; (ii) process engineering in order to change production does not happen in a standardized way; and (iii) tests in the production environment are few and infrequent, what may compromise product quality.

6. Conclusions

In this paper, a reference model and auditing procedure for the control and supervision function of manufacturing organizations were presented. Both model and procedure were tested in an organization of the textile industry, with results presented for the assessment of its control and supervision function. The main focus, however, is not on these results by themselves, but on the validity of the reference model and the auditing procedure. Both of these points are discussed next.

Regarding the reference model, it can be argued that its use correctly represented the incipient stage of development of the control and supervision function of the organization studied. However, for a complete validation of the model, more case studies in organizations with varying degrees of maturity of this function and of different industries must be conducted. These case studies will lend insight to the completeness and necessity of the elements of the model and their relationships. The model, after more thoroughly validated, can also be specialized to represent particular aspects of the control and supervision function of particular industries if more case studies are conducted within organizations of that industry.

Another point to be noted is that there still is room for improvement and extension of the reference model. First, the model is limited to the recommendations and reference models analyzed. Second, the model covers only the process dimension of the control and supervision function. Although the process dimension is arguably the most visible one for the impact of the activities in the organization, it is not the only one. The model could be extended to also cover dimensions related to organizational and informational structure, information flow and the interaction with internal and external entities (other organizational areas and supplies, for instance).

With regard to the auditing procedure, data collection instruments and data analysis could also be improved. Although the different information sources used (interviews, surveys, observation, documents and records) are thought to be comprehensive, their structuring could be standardized in order to guarantee consistency throughout different cases. Data collection instruments could also be specialized to certain cases, for instance, to organizations of the textile industry.

Data analysis could be automated by the use of a system to help consolidate the information from the data collection and the assessment from all reviewers. This would make the assessment process simpler. Better rating scales could also be used, which could more meaningful represent the views of different raters. These scales could be used to assess if there is evidence of needed information or if that information is conflicting and to what extent the organization addresses the points in the reference model through the analysis of the evidence. The analysis of this later aspect would also benefit from a better definition of the practices expected to be encountered in organizations with different levels of maturity in that particular point. Agreement/reliability among raters could also be calculated in order for one to determine whether the collection of more information or the judgment of additional raters is needed.

Lastly, reference model and auditing procedure could give rise to the development of a maturity framework for the control and supervision function within manufacturing organizations. This framework could depict best practices in this area and help in benchmarking efforts. This framework would be the result of the development of multiple case studies and their analysis towards the definition of what maturity levels exist and how they are characterized, as well as the practices involved in each one of them.

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