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Quality management systems development based on a production systems taxonomy

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Abstract

Purpose – This paper aims to propose a method for the development of quality management systems (QMS) that allows the consultant that undertakes the support of the organisation to take advantage of a corporate memory. The consultant develops a new QMS based on a preliminary draft that is created using suitable reference processes from a library, selected according to the features of the organisation's production system.

Design/methodology/approach – The method adopts a taxonomy of production systems, based on a set of features (e.g. degree of the products' customisation, form of purchasing, etc.) and creates a library of reference processes that satisfy the requirements of the standard and are suitable for each particular type of production system.

Findings – The QMS developed according to the proposed method satisfy both the requirements of the standard ISO 9001 and the needs of the organisation in which the QMS is installed in the biggest possible degree. The duration and cost of the project for the new QMS is reduced and the effort is oriented towards the process adaptation and improvement.

Research limitations/implications – The proposed approach is general and can be applied to several types of industries. However, the proposed taxonomy is applicable to manufacturing companies. For other types of organisations specific taxonomies should be developed.

Originality/value – The originality of the paper stems from the development of a QMS based on reference processes rather than the modelling and reviewing of as-is processes.

Keywords ISO 9001, Production, Quality management systems, Taxonomy of production systems

Paper type Research paper

Introduction

With the development, implementation and maintenance of quality management systems (QMS) that satisfy the requirements of the ISO 9001:2008 (2008) standard, organisations aim at the continuous improvement of their results and the simultaneous satisfaction of needs and expectations of customers. Companies expect that by installing a QMS they will have important benefits, as the improvement of quality of provided products and services, the reduction of the quality related costs, the improvement of the internal organisation and the creation of a corporate memory through the documentation. They expect also retaining and increase of their cliental base, as often managers feel their customers expect them to be ISO 9001:2008 (2008) certified (Briscoe *et al.*, 2005).

On the other hand, although critical approaches towards ISO 9001:2008 (2008) are relatively scarce in the literature, certain studies have questioned the standard benefits or stressed the various pitfalls associated with its implementation (Boiral, 2011; Quazi *et al.*, 2002).

First, the standard's implementation can add to internal bureaucracy and paperwork (Boiral and Amara, 2009). Thus, many organisations develop an overly

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extensive documentation by seeking to comply mechanically with the principle "say what you do, do what you say".

Second, an important obstacle in the effort of certification at ISO 9001:2008 (2008) mainly for an SME is the costs of designing, implementing and maintaining the ISO 9001:2008 (2008) quality system which can be significant (Lo *et al.*, 2001). The cost of auditors and consultants, the time and resources necessary to implement ISO 9001:2008 (2008) can represent serious barriers. The certification process can be costly, especially for SMEs (Briscoe *et al.*, 2005; Gotzamani and Tsiotras, 2001). According to certain studies, implementation costs can exceed the standard's benefits (Martinez-Costa and Martinez-Lorente, 2007a, b), especially when implemented with little employee participation and adopted just to achieve certification.

Third, the management systems lead to a disciplined, structured and effective approach to work, as long as they are aligned to business objectives (Symonds, 1998). In this regard a QMS should be incorporated with the other management systems of the organisation (e.g. environmental management, occupational health and safety management, financial management, risk management, etc.), in order to facilitate the determination of objectives, the planning, the resources' allocation and the evaluation of results. Organisations have often to implement function specific management systems which comply with several standards (ISO 9001:2008, 2008; ISO 14001:2004, 2004, OHSAS 18001, etc.) and must not only align but further integrate for practical reasons the function specific management sub-systems to a unique integrated management system (Karapetrovic, 2010; Simon *et al.*, 2011; Leopoulos *et al.*, 2010). Nevertheless it is often observed that the QMS is used separately of the other management systems, aiming at the maintenance of certification but without satisfying the real needs of the organisation. The aim of continuous improvement is not achieved. Several ISO 9001:2008 (2008) certified enterprises face the dilemma of how to change their QMS from a set of manuals that ensure the conformity with the requirements of the standard, to a tool that really supports their operations. It has been supported that internally motivated organisations experienced more improvement of their production process, more cost reduction, less customer complaints and more motivated personnel than the organisations that were externally motivated (Singels *et al.*, 2001).

A forth issue is related to the minimal requirements of the documentation of a QMS imposed by the standard as necessary for the certification of an organisation (ISO IAF, 2004). ISO 9001:2008 (2008) standard requires as essential documentation: documented statements of a quality policy and quality objectives, a quality manual, documented procedures, documents needed by the organisation to ensure the effective planning, operation and control of its processes and records. ISO 9001:2008 (2008) specifically requires the organisation to have "documented procedures" for the following six activities: 4.2.3 Control of documents 4.2.4 Control of records 8.2.2 Internal audit 8.3 Control of non-conforming product 8.5.2 Corrective action 8.5.3 Preventive action. These minimal requirements can easily lead different organisations to built practically identical QMS. The standard, however, emphasises that the extent of the QMS documentation may differ from one organisation to another due to the size of organisation and type of activities, the complexity of processes and their interactions, and the competence of personnel (ISO/TC 176/SC 2/N525R2 2008, 2008).

In order to avoid these pitfalls, the objective of this paper is to present a method for the development and implementation of QMS that will:

(1) satisfy the requirements of the standard ISO 9001:2008 (2008);

(2) satisfy the needs of the organisation to the best possible degree; and

(3) allow the consultant who undertakes the support of the development of the QMS to take advantage of the experience from similar systems (corporate knowledge).

The method results in the creation of a suitable preliminary draft of the QMS which includes processes that incorporate the best practices for each type of production system and satisfy the requirements of the standard. The QMS that is developed can be used as a tool for the daily operation of the organisation and consequently is appropriate for continuous improvement. In addition the development project is of small duration and low cost.

The method is illustrated through a case study, a company belonging to the chemical industry, producing expandable polystyrene (EPS). The enterprise, supported by a specialised consultant, developed and applied a QMS, which has been certified to ISO 9001:2008 (2008). The system is audited each year by an accredited external auditor for conformance with the requirements of the standard. Before each external audit, the consultant supports the executives in performing the internal audit and the management review. After the external audit, when all non-conformities have been resolved, the consultant adds the audited procedures to a corporate memory and develops reusable reference processes.

After the introduction, the short literature review and the presentation of the objectives, the rest of the paper is organised as follows: in the second section methods and practices for QMS development are presented. The third section describes the proposed method. In fourth section the method is illustrated through a case study from the chemical industry. The paper ends with the conclusion section where the findings and further research ideas are exposed.

QMS development

For the development of a QMS, the organisations occasionally are based only on their own staff, but, usually, they use the services of external consultants. The selection of a competent QMS consultant is frequently the first step that an organisation takes towards implementing a QMS. The basis of the relationship between the organisation, the consultant and the QMS implemented, depends on the clarity and integration of both the needs and objectives of the organisation together with the competence and professionalism of the consultant (Colferai, 2001).

In order to develop and apply a QMS the development team, usually staff from the organisation and external consultants, first identify the key processes, which are directly related to the realisation of product and/or service. Support activities that affect performance and effectiveness of the key processes are further identified.

Processes documented as a set of procedures describe the "function view" of the organisation (Ponis *et al.*, 2007). According to a usual approach, the development team identifies the existing processes, using a model that allow the review of activities according to the requirements of the standard (as – is phase). In the review step the linkage between the individual processes, as well as their combination and interaction, is determined. Further, the processes that exist and conform to the requirements of the

standard, those that exist but should be harmonised with the requirements of the standard, and finally those that do not exist and should be developed are identified (to – be phase) (Kirytopoulos *et al.*, 2008). The procedures are thus documented for the activities that every department of the organisation performs as parts of the related processes. The processes thus developed and documented in the procedure manual, satisfy the requirements of the standard and correspond to the characteristics specific to the organisation.

This approach presents the problems of business process reengineering (BPR) projects, mainly the high cost, the extended need for resources and the difficulty in the co-ordination of the functional departments of the organisation which participate in the project. The consultant often spends a lot of time recording the as-is situation of the organisation, through questionnaires and interviews with the relevant staff, and the time remaining for the re-design of the processes is limited. It should be further noted that the development of a QMS is usually a low budget project within a company.

A different approach is when the consultant quickly develops a draft of the QMS using another system already developed and audited for another organisation, taking advantage of the operational memory of his own company. Next the consultant examines every process with the representatives of the organisation and adapts it suitably. This approach is facilitated by the generic nature of the requirements of the standard ISO 9001:2008 (2008).

Disadvantage of this approach is the development and application of a QMS which is a copy of an existing one, applied already in another organisation, often taking into consideration the sector of activity but not the similarity of features of production systems. The QMS thus developed is conforming to the requirements of the standard, but is difficult to be adapted to the needs of the organisation and can rarely be used as a tool for the daily operation, is not appropriate for continuous improvement cannot lead to the necessary change of habits and the cultural change without which a QMS will not work.

Thus, the focus on alleviation of cost lead to QMS with uniformity of the structure and the documentation, but the content does not take into consideration the business objectives, the products, the activities, the size and the structure of the organisation in which they are installed. These QMSs often include processes that deviate from the daily activities of the organisation, because they are adapted copies of similar processes of other systems.

Method

In order to overcome the above problems but at the same time allow the external consultant to use the earlier developed QMS, the proposed method adopts knowledge management techniques and consists in four steps:

- step 1: knowledge acquisition;
- step 2: knowledge organisation;
- step 3: knowledge maintenance; and
- step 4: knowledge communication.

The proposed process for managing corporate knowledge regarding the QMS, is depicted in Figure 1:

- Step 1: knowledge acquisition.

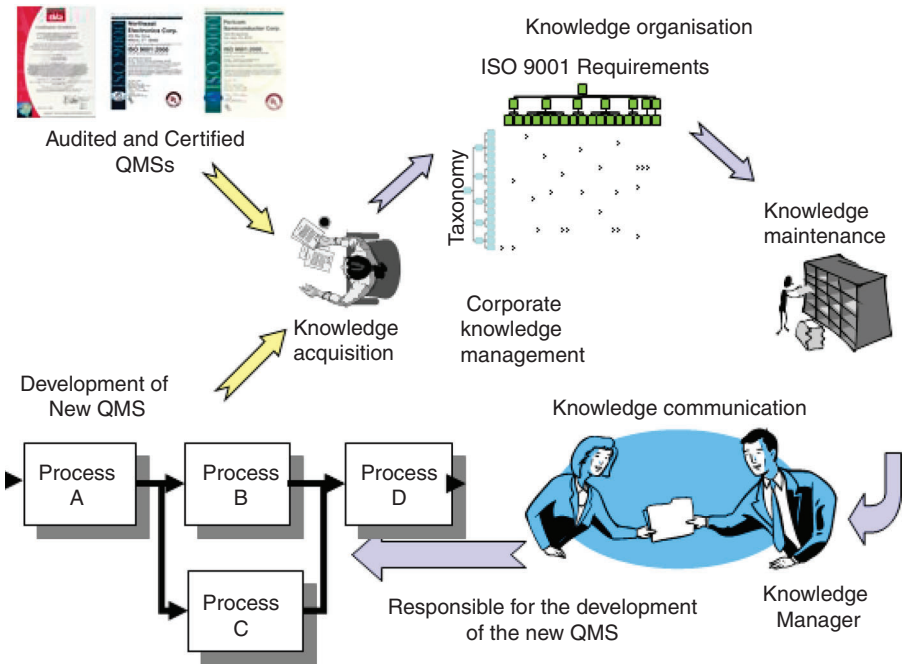

Figure 1.
Corporate knowledge management

1.1 The knowledge manager (KM) creates a library of already developed QMSs which have been audited and optimised through continuous improvement processes.

1.2 The KM checks the procedures manuals and points out processes that characterise reference processes regarding the requirements of the corresponding production system. Reference processes have been optimised through activities of continuous improvement using either or both fundamental ways: first, breakthrough projects which either lead to revision and improvement of existing processes or the implementation of new processes, second, small-step ongoing improvement activities conducted within existing processes by people (ISO 9004:2009, 2009). In addition these processes satisfy the requirements of ISO 9001:2008 (2008) because the processes come from QMS that have been audited at least once, but often several times. A library of processes is thus created that satisfy both the requirements of the standard and the particularities of the production system:

- Step 2: knowledge organisation.

2.1 For each one of the QMS of the library the KM determines the functional features of the corresponding production system. A taxonomy of production systems has been adopted based on an appropriate set of functional features.

The proposed taxonomy for the knowledge organisation is a suitable extension of the taxonomy used for the choice of modules of a production planning and control system (Leopoulos and Tatsiopoulos, 1999). This taxonomy was proposed initially for the support of production scheduling (Schomburg, 1980). Checking of the appropriateness of the taxonomy pointed out that the functional features used for production planning and scheduling purposes are not relevant to all the requirements of the ISO 9001:2008 (2008) standard and consequently cannot characterise all the

processes that are included in a QMS (e.g. the requirements of the standard related to the management responsibility are not covered). Consequently, the initial taxonomy was extended with two functional features: quality control and organisational structure. The features and their corresponding parameters are presented in Table I.

Next the functional features of the taxonomy were correlated to the requirements of the standard ISO 9001:2008 (2008) as presented in Table II. Each process that is included in a QMS can henceforth be characterised.

2.2 The KM organises the knowledge by relating each process to the functional features of the production system that influence it. Each reference process is thus characterised by one or more functional features:

- Step 3: knowledge maintenance.

3.1 The KM maintains the library and updates it taking into consideration the new QMSs that are developed by the consultant. The reference processes are updated:

(1) After every audit that has been conducted, especially when non-conformities have been detected and corrective actions planned. The KM is based on the records of the audits and their results.

(2) When a process is revised either by breakthrough projects or by small-step ongoing improvement activities.

(3) When the standard is revised and the new requirements influence the conformity of the process.

- Step 4: knowledge communication.

4.1 When the consultant undertakes the development of a new of QMS for an organisation the KM points out the functional features of the production system.

4.2 For each process of the new QMS the KM searches the library and locates a reference process that is characterised by the same features. This reference process will be used as a preliminary draft for the development of the new process.

4.3 The KM communicates the corresponding knowledge to the manager (user) responsible for the development of the new QMS.

4.4 The QMS development team adapts the draft processes to the particularities of the organisation and comes up with a set of new processes. The new processes and their interrelations are checked in order to cover all the activities of the organisation. If necessary some new processes will have to be developed from scratch through the traditional methods from the as-is towards the to-be process.

4.5 When the QMS of the customer is completed, audited, certified and improved through activities of continuous improvement, the user communicates the processes to the KM who includes them in the enriched library.

Case study

In the following case study, a reference process of Order Receiving is presented. The company under consideration belongs to the chemical industry. The Order Receiving is related to the requirements of the standard "7.2 Customer related processes". The production system is characterised according to the functional features of the taxonomy then the features related to the Order Receiving are pointed out, that is the Steps (2.1) and (2.2) of the method are presented, while the other steps are presented in brief.

Product standardisation	
a1.	Non-catalogued customised products
a2.	Catalogued products with non-standard, customised options
a3.	Catalogued products with standard options
a4.	Standard products without options
a5.	Innovative products
Product structure	
b1.	Single component products
b2.	One level bills of materials
b3.	Multi-level bills of material
b4.	Scrap recycling
b5.	Yield variability
Form of independent demand (products)	
c1.	Production to individual order
c2.	Production to blanket order
c3.	Non-seasonal production to stock
c4.	Seasonal production to stock
c5.	Assembly to order
Form of dependent demand (components, row materials)	
d1.	Dependent on customer order
d2.	Mixed – mainly dependent on customer order
d3.	Mixed – mainly independent of customer order
d4.	Independent of customer order (all materials exist in stock)
Form of purchasing	
e1.	Insignificant buy
e2.	Mixed (production of more than 50% of the parts)
e3.	Mainly buy (buy of more than 50% of the parts)
Process form (time dimension)	
f1.	One-off production with transfer
f2.	One-off production without transfer
f3.	Small batch production
f4.	Serial intermittent batch production
f5.	Machine-paced line flow
f6.	Worker paced line flow
f7.	Lot production (row material dependant)
f8.	Lot production (process dependant)
f9.	Batch flow process
f10.	Continuous flow process
f11.	Production with by-products and co-products
Shop layout (space dimension)	
g1.	Work bench production, construction shop
g2.	Functional layout, job shop
g3.	Functional layout with sequenced operations
g4.	Group technology, cellular manufacturing
g5.	Product line layout
g6.	Flexible manufacturing system
Process complexity	
h1.	One operation per component
h2.	A few operations per component ($\leqslant 3$)
h3.	Many operations per component (>3)
h4.	Sequential routing
h5.	Networked form of routing

(*continued*)

Table I.
Taxonomy of production systems

Warehouse structure	
i1.	Single warehouse
i2.	Multiple warehouses geographically adjacent
i3.	Multiple warehouses geographically distant
i4.	Receiving warehouse geographically distant
i5.	Assembly components from multiple warehouses
i6.	Tracking per customer order
i7.	Quality status tracking important (lot tracking, serial numbers)
Quality control	
j1.	Acceptance sampling.
j2.	Quality control 100%
j3.	Preventive quality control
j4.	Use of statistical control tools
Organisational structure	
k1.	Functional organisation
k2.	Projectized organisation
k3.	Matrix organisation
k4.	Strategic business unit

Table I.

The company produces EPS. Polystyrene, after the expansion is used as raw material for the production of insulation plates and packing materials. EPS is a styrenic homopolymer produced by styrene monomer polymerisation and impregnated with pentane used as blowing agent during converting process. It is in the form of spherical beads, available in various diameter ranges, which determine the type suitable for the final application. Grades are available with or without flame retardant additives.

Knowledge acquisition (Step 1 of the method)

Step (1.1): the enterprise developed and applied QMS, which has been certified according to the standard ISO 9001:2008 (2008). The system is audited each year from an external auditor for the conformance with the requirements of the standard. EPS is a standardised product, which if necessary can be modified (in standardised variants) depending on the needs of customers (functional feature a, parameter a3). The company contracts blanket annual agreements with the customers (functional feature c, parameter c2).

EPS is produced according to a batch, suspension, polymerisation process (functional feature f, parameter f9). Styrene, organic initiators, water and dissolved additives are added in an agitator reactor. This process creates a suspension resulting in styrene droplets. The droplets polymerise by free radical polymerisation to polystyrene. A blowing agent is then added to the reactor. The latter dissolves in the polymer and EPS beads are produced. After conversion of the styrene monomer droplets to EPS beads, the reactor is cooled and the expandable beads are separated from water. Then they are dried, sieved and screened in various bead size fractions and coated with suitable additives, depending on their size and application. The different EPS types are separately packed in cardboard octabins containers or big bags for delivery (functional feature b, parameter b2).

The company attributes a lot number in the final products for traceability reasons (functional feature i, parameter i7). In the event a non-conforming product reaches a customer, the non-conformance is traced to the initial cause and corrective/preventive actions are planned. The quality is controlled by acceptance sampling according to a sampling plan (functional feature j, parameter j1).

ISO 9001:2008 (2008)	Functional features														
	Product standardisation	Product structure	Form of independent demand (products)	Form of dependent demand (components, row materials)	Form of purchasing	Process form (time dimension)	Shop layout (space dimension)	Process complexity	Warehouse structure	Quality control	Organisational structure
4.1. General requirements (quality management system)											×
5.1. Management commitment											×
5.2. Customer focus											×
5.3. Quality policy											×
5.4. Planning											×
5.5. Responsibility, authority and communication											×
5.6. Management review											×
6.1. Provision of resources		×	×	×	×				×		
6.2. Human resources		×	×	×	×				×		
6.3. Infrastructure					×						
6.4. Work environment		×			×	×	×	×			
7.1. Planning of product realization	×	×						×			
7.2. Customer-related processes	×		×								
7.3. Design and development	×	×						×			
7.4. Purchasing	×			×	×						
7.5. Production and service provision		×	×	×	×	×	×	×	×	×	

(*continued*)

Table II.
Correlation of functional features with requirements the ISO 9001:2008 (2008)standard

ISO 9001:2008 (2008)		Functional features												
		Product standardisation	Product structure	Form of independent demand (products)	Form of dependent demand (components, row materials)	Form of purchasing	Process form (time dimension)	Shop layout (space dimension)	Process complexity	Wharehouse structure	Quality control	Organisational structure
7.6.	Control of monitoring and measuring equipment				×					×		
8.1.	General (Measurement, analysis and improvement)		×								×	×
8.2.	Monitoring and measurement		×	×	×					×	×	
8.3.	Control of nonconforming product		×								×	
8.4.	Analysis of data		×								×	
8.5.	Improvement		×								×	×

Note: ×, Functional feature related to ISO 9001:2008 requirement

Table II.

The raw material stock is important, particularly styrene, which is a commodity and is bought in big quantities (functional feature d, parameter d4). The enterprise employs about 60 people and the factory operates three shifts.

Step (1.2): the process of Order Receiving has been developed, in the initial form, during a BPR project, which the enterprise carried out supported by specialised consultants. The processes that were developed were optimised according to the needs of the enterprise and they are supported by an Enterprise Resource Planning (ERP) software which has been installed in the frame of the reengineering.

Each year the certification organisation dedicates one man-day in order to audit the QMS. Since the reference process has been created, it had been audited five times during the initial and the surveillance audits. The audits have been conducted by trained auditors under the direction of a chief auditor, with expertise of the standard and in the chemical industry. Thus applied and certified against the standard, the QMS has been repeatedly audited by the certification organisation so that all the non-conformities have been spotted and corrected through corrective and preventive actions.

Knowledge organisation (Step 2 of the method)

Step (2.1): the KM characterises the production system of the enterprise. That means he/she attributes values to the parameters of the functional features as presented in Table III.

Step (2.2): the KM examines the process of Order Receiving of the enterprise. The process is related to the requirements of the standard "7.2 Customer related processes" and is influenced by two functional features: a "product standardisation" and c "form of independent demand" (cf. Table II). The values of the parameters are a3 (catalogued products with standard options) and c2 (production to blanket order). The KM checks the parameters against every activity of the process. In Table IV the check of the process regarding the parameter a3 is presented.

Activity 1 is influenced by the feature a3, as the customer is asked to specify the additives that he wishes in the final product. These additives lead to the standardised variants of the basic product.

In Activity 2 the form of the standardised electronic document (ERP) that it is used is influenced by the same feature.

Activities 3 and 4 are formal steps of credit control and communication with customers and are not influenced by the feature.

Activity 5 is influenced by the feature a3 as the company does not need to verify the ability of the equipment to produce the required product, and checks only the ability to provide the product in the required deadline (capacity control).

Activities 6-9 are typical for production planning to customer order (individual or blanket), and are not influenced by a feature relative to the product standardisation.

In the same way are characterised the activities regarding the other feature, considering the form of independent demand (production to blanket order). The KM henceforth has completed the characterisation of the process and he/she can include it in the corporate memory.

Knowledge maintenance (Step 3 of the method)

The registered process will be modified in the case of changes in the QMS of the enterprise that influences it.

	Functional feature	Characterisation	Parameter
(a)	Product standardisation	The company produces catalogued products with standard options. Products are standard but additives may vary based on the needs of specific customers	(a3)
(b)	Product structure	The products have one level bill of materials. The production process consists of the mixture of raw materials in a reactor where the polymerisation takes place and packing of the produced grains	(b2)
(c)	Form of independent demand (products)	The company produces upon blanket customer orders	(c2)
(d)	Form of dependent demand (components, row materials)	The company maintains the raw materials in stock, independent of customer orders. In particular styrene is a commodity and the stock level is often high. There exist specific reorder levels for the raw materials	(d4)
(e)	Form of purchasing	The company has a relatively small depth of productive process as more than 50% of the materials are purchased	(e2)
(f)	Process form (time dimension)	Batch flow process. The materials are first mixed in the reactors (batches) and then the product packed	(f9)
(g)	Shop layout (space dimension)	The equipment is arranged in the factory as a product line layout. The industrial facility consists of two sequential departments of mixture and packing	(g3)
(h)	Process complexity	Small process complexity. A few operations per component ($\leqslant 3$) and sequential routing (operations of mixture and packing)	(h2 and h4)
(i)	Warehouse structure	There exist several warehouses all geographically adjacent as all the materials and products are stored in the factory. The company tracks the quality status of the lots	(i2 and i7)
(j)	Quality control	The quality control releases each lot to the next operation and the final product to the customer using acceptance sampling	(j1)
(k)	Organisational structure	The company is structured as a functional organisation	(k1)

Table III.
Characterization of production system

Knowledge communication (Step 4 of the method)
In the case that the consultant is called to develop a QMS for an organisation with production features (a3, c2) the person responsible for the development of the new QMS can use the aforementioned reference process as a preliminary draft which will be further adapted.

Conclusions – further research

The development of a QMS should focus on achieving certification to the standard ISO 9001:2008 (2008), and to support the management functions. The QMS should be integrated with the other management systems, in order to facilitate the planning, the provision of resources and the total evaluation of effectiveness.

	Activities	Dependence on the parameter a3
Activity 1	The customer contacts the sales department of the company (the responsible of sales) and places the order. The customer specifies: the standardised specification (quality) of the polystyrenes the additives if applicable quantity the delivery date, the place of delivery, and economic terms of collaboration. The order is confirmed by fax (external document).	Yes
Activity 2	The responsible of sales, based on the customer demand, updates the appropriate fields of the enterprise resource planning (ERP) system of the company (electronic document): product specifications, quantity, delivery date, and additives. The place of the order delivery is also given if different from the customer's facilities. For every ambiguity the responsible of sales communicates with the customer to clarify the requirements	Yes
Activity 3	The responsible of sales checks the ERP system for the credit situation of the customer. The responsible of sales informs the sales manager for the results of the checking and the payment terms that the customer proposes. In the event of a problem the sales manager decides for the acceptance of the order, or contacts the customer for solving the problem. If an arrangement is achieved follows Activity 5	No
Activity 4	If an arrangement is not achieved the customer is briefed by fax (controlled document) about the rejection. Follows Activity 8	No
Activity 5	The production planner inserts the order in the production plan (electronic document) and verifies the possibility to respect the due date. If the plan is feasible follows Activity 9	Yes
Activity 6	In the event of an infeasible plan, the responsible of sales informs immediately the customer by fax (controlled document) for the problem and proposes an alternative date. In case of agreement follows Activity 9	No
Activity 7	If an arrangement is not achieved the customer is briefed by fax (controlled document) about the rejection. Follows Activity 8	No
Activity 8	The responsible of sales updates the ERP system for the cancellation of the customers' order	No
Activity 9	The customer's order is then characterised in the production plan as frozen and is confirmed to the customer by fax (controlled document)	No
Activity 10	Beginning of process "production set up"	

Table IV.
Characterization of the process "Order Receiving"

The proposed method supports the fast development and easy application of a QMS that satisfies the requirements of the ISO 9001:2008 (2008) standard, and supports the daily operation of the organisation. The method adopts a taxonomy of production systems, based on a set of features and creates a library of reference processes that satisfy the requirements of the standard and are suitable for each specific type of production system. The consultant develops a new QMS based on a preliminary draft that is created using suitable reference processes from the library, selected according to the functional features of the organisation's production system.

Further research aims the analysis of the reference processes in detailed activities and the mapping of each activity with the corresponding features. The user (KM) does not deal with reference processes but creates the initial processes out of the detailed

activities. The process thus created could be immediately checked for conformity with the requirements of the standard.

References

Boiral, O. (2011), "Managing with ISO systems: lessons from practice", *Long Range Planning*, Vol. 44 No. 3, pp. 197-220.

Boiral, O. and Amara, N. 2009, "Paradoxes of ISO 9000 performance: a configurational approach", *The Quality Management Journal*, Vol. 16 No. 3, pp. 36-60.

Briscoe, J.A., Fawcett, S.E. and Todd, R.H. (2005), "The implementation and impact of ISO 9000 among small manufacturing enterprises", *Journal of Small Business Management*, Vol. 43 No. 3, pp. 309-330.

Colferai, G. (2001), "How to choose a competent quality management system consultant", *ISO Management Systems (IMS)*, December, pp. 10-12.

Gotzamani, K.D. and Tsiotras, G. (2001), "An empirical study of the ISO 9000 standards' contribution towards total quality management", *International Journal of Operations & Production Management*, Vol. 21 Nos 9/10, pp. 1326-1342.

ISO IAF (2004), *ISO 9001 Auditing Practices Group Guidance On: Auditing a QMS Which has Minimum Documentation*, ISO IAF, Geneva and Cherrybrook, NSW.

ISO/TC 176/SC 2/N525R2 2008 (2008), *Guidance on the Documentation Requirements of ISO 9001:2008*, ISO, Geneva, October.

ISO 9001:2008 (2008), *International Standard, Quality Management Systems – Requirements*, ISO, Geneva.

ISO 9004:2009 (2009), *International Standard, Managing for the Sustained Success of an Organization – A Quality Management Approach*, ISO, Geneva.

ISO 14001:2004 (2004), *International Standard: Environmental Management Systems – Requirements with Guidance for Use*, International Organization for Standardization, Geneva.

Karapetrovic, S. (2010), "Special issue of the TQM journal: 'integrated management systems' guest editorial", *The TQM Journal*, Vol. 22 No. 6, p. 569.

Kirytopoulos, K., Leopoulos, V. and Voulgaridou, D. (2008), "Supplier selection in pharmaceutical industry: an analytic network process approach", *Benchmarking: An International Journal*, Vol. 15 No. 4, pp. 494-516.

Leopoulos, V., Voulgaridou, D., Bellos, E. and Kirytopoulos, K. (2010), "Integrated management systems: moving from function to decision view", *The TQM Journal*, Vol. 22 No. 6, pp. 594-628.

Leopoulos, V.I.N. and Tatsiopoulos, I.P. (1999), "Evaluation of a taxonomy for SMEs' production systems using cluster analysis", in Stephen J. Childe (Ed.), *Simulating Manufacturing Excellence in Small and Medium Enterprises, Proceedings of the Second International SMESME Conference*, University of Plymouth, Plymouth, pp. 295-303.

Lo, V.H.Y., Humphreys, P. and Sculli, D. (2001), "The definition method zero applied to ISO 9000 quality manuals", *The TQM Magazine*, Vol. 13 No. 2, pp. 105-111.

Martinez-Costa, M. and Martinez-Lorente, A.R. (2007a), "A triple analysis of ISO 9000 effects on company performance", *Journal of Productivity and Performance Management*, Vol. 56 Nos 5-6, pp. 484-499.

Martinez-Costa, M. and Martinez-Lorente, A.R. (2007b), "ISO 9000:2000: the key to quality? An exploratory study", *The Quality Management Journal*, Vol. 14 No. 1, pp. 7-18.

Ponis, S., Tatsiopoulos, I., Vagenas, G. and Koronis, E. (2007), "A process-based knowledge management framework supported by ARIS enterprise modelling architecture", *International Journal of Applied Systemic Studies*, Vol. 1 No. 2, pp. 168-187.

Quazi, H.A., Hong, C.W. and Meng, C.T. 2002, "Impact of ISO 9000 certification on quality management practices: a comparative study", *Total Quality Management*, Vol. 13 No. 1, pp. 53-67.

Schomburg, E. (1980), "Entwicklung eines betriebstypologischen instrumentariums zur systematischen ermittlung der anforderungen an EDV-gestuetzte produktionsplanungs-und-steuerungssysteme im maschinenbau", dissertation, TH Aachen, Aachen.

Simon, A., Bernardo, M., Karapetrovic, S. and Casadesús, M. (2011), "Integration of standardized environmental and quality management systems audits", *Journal of Cleaner Production*, Vol. 19 Nos 17-18, pp. 2057-2065.

Singels, J., Ruel, G. and van de Water, H. (2001), "Certification and performance ISO 9000 series", *International Journal of Quality & Reliability Management*, Vol. 18 No. 1, pp. 62-75.

Symonds, J (1998), "ISO 9000 – case sensitive", ISO 9000 News, available at: www.iso.org/iso/en/iso9000-14000/addresources/articles/pdf/viewpoint_6-98.pdf (accessed 30 June 2006).

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