KNOWLEDGE MANAGEMENT AND ECO-DESIGN SCOPES

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Abstract: The eco-protection acts imply reorganising the manufacture business, towards product-service supply chains. The innovation can be tackled at two ranges: - the presetting of the knowledge management surroundings, to deal with the extended producers' responsibility; - the incorporation of the entrepreneurial facility/function assembly, to accomplish the product-service delivery. The paper surveys the knowledge management frame, specifying the standard PLM aids, with account of the PLM-SE and PLM-RL requirements, giving especial attention on the alternative net-concern options, from virtual, to extended enterprises infra-structures.

1 INTRODUCTION

The industrialised societies face greater challenges than ever, to keep the growth pace, due to globalisation (competition of lower wage countries, etc.) and to sustainable growth (exacting regulations to preserve eco-conservativeness, etc.). For higher effectiveness, several major changes in product design are needed, with focus on lifelong properties and on recovery opportunities. These paradigm shifts modify the relative weigh of the design phase, compared to the production phase, as, in the past, return on investment was mostly won by manufacture *internalities*, once pre-set optimal off-process choices.

The trend leads to expand manufacturers' liability, from the *point-of-sale*, to the *point-of-service*, to support the conformance assessment duties, as for safety and environment protection acts, and to the *point-of-disposal*, to comply the enacted recovery, recycling and reclamation duties. This means to deal with the provision of *products-services*, where the *additions* correspond to the intangible frames, going together with the (material) supply chains, to warranty scopes feat, at clients' satisfaction and environmental safeguard.

The design steps become critical: to optimise the lifecycle performance, to increase the profitability, to enhance the delivery quality, to respond to the regulatory drivers, to satisfy customers and third parties, up to embed the producers' responsibility on the all supply chain. This requires reconsidering the design duties, by exploiting proper decision skills that cut across the manufacture business, to concentrate the efforts on the *additions* appearing after the *point-of-sale*, and to integrate prospects on the items' life, taking in on-duty service and reverse logistic views, with full business coherence.

2 ECO-DRIVING KNOWLEDGE

The knowledge management is fine way to improve the enterprise value chain awareness, achieving the unified accountability of the on-duty and end-of-life marks. The provision, manufacture, operation, maintenance, disposal and recovery steps are tested and assessed by virtual prototypes. As compared to early trade habits, when competition is won by off-process presetting the optimal production plans, today, the decision support is required to run on-process, aiming at:

- features-customised products, with warranted lifelong performance and acknowledged call-back;
- total-quality manufacturing efficiency and robustness, with minimal environment impact;
- standard servicing for conformance-to-use, provided by voluntary agreement integration;
- recovery duties, as soon as prescribed by the enacted eco-consistency regulations.

The conventional manufacturing business requires the full rethinking of the engineering paradigms, forcedly obliged to look at the on-duty performance and at the end-of-life requirements, as main features guaranteeing competitiveness, based on the service *externalities*, as compared with the old process *internalities*. The need to look at the all supply chain follows the established trends of the

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economy of scope. The vertical flow-shops are replaced by adaptive job-shops, incorporating non proprietary facilities and technologies, with resort to out-sourcing and productive break-up. The firms' functions (strategic positioning, market assessment, risk management, resource planning, quality deployment, engineering trimming, work-flow scheduling, factory management, shop running, throughput monitoring, performance evaluation, finance/cost managing, etc.) become interlaced, with commitment and liability distributed among the associated partners. The suited set-up is forcedly achieved dynamically, through co-operative efforts, and after facility updating.

The business competitiveness turns from the capability of offering products (fit-for-purpose to the *individual* necessities), to the ability of providing added services, granting functions to the buyers' satisfaction and better tangibles efficiency (fit-for-purpose to *general* guard). The emerging knowledge management aids, now, are:

- the presetting of *product lifecycle management*, PLM, tools, offered as standard design out-fit;
- the provision of *service engineering*, SE, aids, as diagnosis, decision and maintenance support;
- the execution of *reverse logistics*, RL, duties, when requested at the items' end-of-life.

The business lifelong widening is sought with resort to enhanced PLM tools, having *federated* architecture, assuring unified access to the value chain issues. The integration of the lifecycle *view* (structure layout, making process, quality guarantee, up-keeping policy, disposal duties, etc.) into a *super-model* is competitive advantage, to upgrade the manufacture activity. These PLM tools are attractive, to fix the divide, favouring value added deliveries of high technology countries.

The paper directly deals with the eco-design knowledge management tools, in view to develop right lifestyle information surroundings. Indirectly, the underling entrepreneurial settings are appraised, based on assembly the needed facilities/functions, timely adapted to the current product-service provision. The net-concern help is the winning knowledge management support, distinguishing dissimilar infra-organisational options, from the *virtual* enterprise lay-out, where independent partners collaborate to the common project, to the *extended* enterprise set-up, where the leader manufacturer establishes and co-ordinates the actual supply contract. The co-operating structures are motivated by the extended producers' responsibility. The former situation is apt answer, when the eco-regulations are ruled on voluntary base. When compulsory eco-targets are required, the latter allows reaching better performance, when the design-for-service or the design-for-recovery is standard manufacturer's option, ruled by the resource manager, as current internal duty. In general, however, the two *virtual* either *extended* organisations, today, depend on how the single enterprise is aware of the changes, and is capable to incorporate the *externalities*, as necessary completion of the traditional *internalities*.

3 ENGINEERING FUNCTIONS

The market of manufactured goods aims at knowledge-intensive deliveries, with large intangible value added. Companies' fight begins at the ideation/development stage, to conceive buyers' tailored offers with comparatively effective performance, reached along the lifelong operation and call-back stages. The business profitability requires lifestyle knowledge orientation:

- off-process decision support instruments, assuring the design and development of the deliveries;
- on-process monitoring and managing aids, assuring the lifecycle and recovery prescribed charges.

Organisations, based on co-operative networked infrastructures, are the chief instrumental aids to rule and manage the business to manufacture and to trade *products-services*, at on-duty and end-of-life coverage. Suitable modelling and simulation tools need to be available, backing the on-process information flow, to provide the assessment means for the operation testing, accomplished on virtual prototypes. Addressing the product conception and acknowledgement tools as off-process decision support, we distinguish four domains, Fig. 1, in progress tackled by the integration steps.

The eco-driven innovation requires lifestyle knowledge orientation, grounded on design supports allowing the supply chain transparency, through considerably up-dated business paradigms. The engineering paradigms do not establish as self-

- product specification, leading to proper performance, selecting, by CAD, CAM, etc. tools, the producibility figures, operation constraints, disposal requirements, etc., of the forecast *product-service* delivery;
- process specification, leading to improve the manufacturing effectiveness by the simultaneous engineering practice of the product-and-process mutual betterment, through pace-wise up-grading;
- eco-consistency specification, leading to establish regulation, maintenance, restoring, etc. plans, for on-duty conformance-to-use, and to call-back and recovery plans in keeping with the enacted rules;
- enterprise specification, leading to adapt the productive infrastructure, which support the supply chain with resort to the facility/function integration, matching the in-progress requested *externalities*.

Figure 1: Knowledge manager: basic integration steps.

reference proposals, rather they develop to face current demands. The EU eco-policy, to foster more eco-conservative behaviours, is enacting Directives, requiring conformance-for-use assessment at the point-of-service, and mandatory recovery targets at the end-of-life. These acts, moreover, joined to producers' *responsibility* for the free take-back of mass-produced durables (such as household appliances and cars), lead to restructuring the industrial businesses, as competition is ruled by the *externalities*, depending on the supply chain lifecycle performance, rather than on production technology conventional *internalities*. The modelling is still hampered by severe limits, such as:

- creation of tools requires sophisticated skill and domain practice, mainly aiming at specific purposes;
- technical aids are dealt with as problem-solving skill (with negligible cost/benefit economic concern);
- the issues are not openly shared, rather protected as proprietary assets (out of limited side-views);
- the modelling addresses one domain, and knowledge transfer requests engineer's intermediation;
- complex products requires multiple models, mostly not combining together to yield integrated views;
- the capture and reuse of a product knowledge and data require high ingenuity and oriented training;

thus, in general, little capability exists to exploit the product models to investigate the lifecycle interactions, unless for single constraints, separately acknowledged through special purpose descriptions.

3.1 The Lifestyle Design Knowledge

The lifestyle design is critical because of the lack of univocal technical leading strings, due to the relevance of the *externalities*, having socio-political spurs. This distinguishes the concept, by respect to the traditional process- or product-innovation, when higher efficiency is achieved by scope economy grounded on technical expertise. The engineering paradigms, leading to eco-design issues, are motivated by the *externalities*, i.e., demands fixed by the environmental acts, and managed by the original manufacturers, after up-grading their business organisation, to incorporate every facility and function, required by the in-progress supply chain. The driving motivation, out of the *process*- or *product*-innovation, happens to be fostered by *enterprise*- or *environment*-innovation, meaning that new industrial settings are needed.

The engineering design functions are sketched in the full paper. To give a bird-eye view on the tackled ideas, we should distinguish the final issues, namely the **2P2E** *product-process-environment-enterprise* mixing, from the instrumental aids, namely the ***M&SF*** *modelling* and *simulation features*. The details starts to become shared engineering practice only at advanced entrepreneurial levels and reference is deferred to the quoted references and the there included technical bibliography. Especial emphasis should be given to the *environment* and to the *enterprise* integration steps, to transfer the economy of scope requirements (cooperative processing, piece-wise improving, lean engineering and proactive up-keeping) into eco-achievements through the suited inclusion of facilities/functions provided by the entrepreneurial set-up choice.

3.2 The PLM, PLM-SE, PLM-RL Aids

The swap from the lifestyle design, to the supply chain management is necessary challenge, requesting series of critical accomplishments, originally sketched in the full paper, for which we again defer to the references. They, mainly, move from a set of information tools:

- PLM, *product lifecycle management*;
- PLM-SE, *service engineering* oriented PLM;
- PLM-RL, *reverse logistic* oriented PLM;

and contain the network enablers, to build the business partnership effectiveness.

To achieve the concern federation ability, research has to be undertaken in the model build-up, interfacing techniques and programming schemes. The challenge is clear, listing the crucial goals and requirements, Fig. 2, each time tackled by the knowledge management tools.

The **2P2E** design means moving two steps further the simultaneous engineering *product-process* coverage, to include the supply chain specification, as prerequisite for the business competition. The steps mean to include the value chain *externalities*, to deal with on-duty behaviour and end-of-life recovery, thus,

- flexible complex product representation: to build standards and procedures that enable creating a reference model to yield complete descriptions by simple modules addition and interoperability methods;
- robust performance simulation environment: to fashion procedures translating customers needs and wants, and tracking the cost sensitivity along the value chains, by means of plug-and-play blocks;
- flexible complex process representation: to specify the production capacity/capability layout, including options, such as productive break-up and out-sourcing;
- conformance assessment simulation environment: to verify the on-process functional requirements, impact prescriptions, amount of material reclamation, etc.;
- flexible complex lifecycle representation: to describe the supplier responsibility and the service sold with the product (reprocessing and recycling included);
- eco-consistency assessment environment: to define the third-party certification bodies and the reference metrics, related with the supply chain eco-impact;
- distributed supply chain collaboration environment: to provide the features of the networked organisation, linking suppliers, consumers and controllers.

Figure 2: Knowledge manager: goals and requirements.

to face demands out of the traditional manufacturers core competences. At the design phase, the innovation shows that the existing integration aids, such as *product lifecycle management*, PLM, need to evolve, to link the operation account and to cover the lifelong on-duty picture.

In the value chain knowledge management, the real-time, on-process duties play relevant role, provided by the specialised operators/facilities, timely involved for the running and disposal duties. The technical details of the *product-service*, nonetheless, need to be already established at the design stage. In different words, the lifestyle delivering distinguishes from the earlier supply chains, due to the information content, covering the operation responsibility span up to the points-of-service and of call-back.

The PLM technicality develops, accordingly. The basic PLM, *product lifecycle management*, is the tool to handle the product data, through the lifecycle, from materials provision, to on-duty requirements and end-of-life disposal. It includes functions such as the organization of engineering and processing data, of operation maintenance and conformance assessment, and of take-back recovery, recycling and reclamation tasks. Its completion requires embedding:

- the *reverse logistics*, RL, the business opportunity (possibly subject to compulsory rules), for the recovery (reuse, recycle) of end-of-life items, in compliance of the enacted bylaws, with the related data monitoring and vaulting accomplishments;
- the *service engineering*, SE, the business opportunity (mainly driven by voluntary agreements), along the product life-span, to guarantee the item enjoyment, with conformance-to-use certification, and related data monitoring and vaulting accomplishments.

4 CONCLUSIONS

The eco-protection acts are challenge to reorganise the manufacture market by knowledge entrepreneurship schemes. The new market leaders will move within this technical-scientific framework, replacing the economy of *scale*, by the economy of *scope*, with two options:

- functions delivery and artefacts life-extension policy, with the profitability in the business of supplying *products-services*, incorporating the *externalities* of the lifestyle provisioning;
- increased recycling efficiency, with profitability in the new businesses aiming at *reverse* logistics (from waste, to secondary 'raw' materials), according to the already enacted targets.

The two domains develop outside the factories, and the knowledge contents of the required PLM aids shall, accordingly, expand to deal with the set of scopes, with critical weigh, aiming at on-duty performance or on-duty reliability, and at pollution precepts or recovery effectiveness. Moreover, the PLM prerequisites (e.g., model *total connectedness*) are critical challenge, when dealing with net-concern, built by independent partners that focus on their core competencies and join, each other, the efforts for co-design, co-manufacture, co-marketing, co-maintain, co-servicing and co-recycle, in view to fulfil the requirement of supplying *products-services* at the clients' benefit and the environment safety.

The full paper outlines the expected evolution in the manufacture business, focusing on two example cases, one considering SMSs' clusters working in the *service engineering* business by voluntary agreements schemes; one covering the *reverse logistics* mandatory duties by authority ruled net concerns.

The **2P2E** integration through suited ***M&S*F** tools is the necessary innovation, still very little understood by old-fashioned enterprises. The example developments given by the full paper are especially relevant, when, e.g., the reverse logistics of *end-of-life vehicles* ELV or of *waste electrical-electronic equipment* WEEE are presented, while dealing with already enacted EU bylaws. The few remarks sketched by the present overview can only say that the problems exist and that the solutions are as well available for the people properly involved in effective innovation.

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