THE NEED FOR AGILE MANUFACTURING IMPLEMENTATION IN MOULD MAKING BUSINESS

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Abstract

Several industrial sectors, in which value chains mould making is involved, are actually subjected to a huge demand towards the reduction of their product innovation cycles. This fact induces a strong pressure on mould manufacturing lead times and a clear need to accommodate a growing number of product modifications during mould manufacturing cycle without deteriorate mould final cost and final due date. Implementing management strategies able to cope with a one-of-a-kind production type, with changeable specifications set where delivery date is a critical issue, assuring a continuously improved performance, is the only way to guarantee business excellence and market leadership. In this paper the management strategies and the methodologies to be used on the pathway to fully implement lean manufacturing will be discussed, taking into account mould making companies classical constraints.

Keywords: agile_manufacturing, lean_manufacturing, mould_industry, productivity, competitiveness.

INTRODUCTION

During last years the moulds industry has been in front of innumerous challenges at a global scale. But, as generally happens, companies can take the advantage of the challenges and transform them in real opportunities. The increasing number of moulded components in the majority of current commercial products has placed the moulds sector in a key position in the global manufacturing industry[1].

The pressure carry out by the clients (automotive industry, aeronautics, electronics, house-ware, etc.) has been growing as regards to costs and total manufacturing time[2]. Moreover the growing speed in the introduction of innovative products and the constant evolution in the engineering analysis tools (modelling, numerical and graphical simulation), determine the need for new technological and functional requirements in highly complex moulds[2]. In addition to these pressures, which are external to the sector, the internal ones related to the concurrency between mould-makers must be considered. In a global economy/market, the capacity to provide a mould has acquired planetary dimensions. The concurrency may be in the same street or in the opposite side of the planet.

In this context, European and North American mould companies have been largely affected by the competitive capacity of Asian mould-makers in supplying the market with low cost moulds[3]. The superior quality of the moulds produced in the West has been presented as a minimizing factor of the damage caused by the growing productive capacity in Asian[3]. However, the future points out to a rapid reduction of this quality gap.

To answer to these threats, particularly strong in North America, several mould European associations point out trends of sector evolution to avoid the collapse risks. The incorporation of product development activities and of final parts manufacturing, through the injection moulding technology, are some directions frequently pointed to include new engineering services provided to achieve a sustainable position in the European industry. The strategy of vertical integration will allow the increase of the added value of the provided services and the collaboration and partnership with the clients, which are really receptive to outsourcing strategies[3][4].

New short-term business strategies ask for immediate and consequent preparation actions. In that sense, several authors have pointed out the introduction of Lean Manufacturing (LM) in moulds industry[5][6][7]. In accordance to LM definition, “systematic approach in identifying and eliminating waste (non-value-added activities) through continuous improvement by following the product at the pull of the costumer in the pursuit of the perfection”[8], the approach is a present answer to the real needs of moulds companies, in particular for the European ones. Through the systematic elimination of waste all along the manufacturing
process, LM allows the reduction of cost and cycle time, increases the overall quality and efficiency and sustains a more competitive, agile and market-responsive company[5][9].

Although some authors enhanced the importance of LM in moulds sector, the literature only presents a general approach to the action lines and potential benefits[7][8], evidenced through the parallelism with other industrial sectors[5], and a description of the specific benefits of one technology to the LM promotion[6]. The omission of concrete and specific methods and actions towards LM implementation in moulds companies has difficult its adoption. The opinion emitted by general mould-makers about LM reveals a dominant scepticism: “Lean doesn’t apply to mould making, we are different”; “we don’t churn out 1000 automobiles a day”; “Our costumers are really, really difficult”[4][5].

This paper is about the LM application to the moulds industry and the operational procedures to promote significant competitive benefits.

MOULDS INDUSTRY & COMPETITIVENESS

Besides having to deal with cost and lead time pressures, moulds industry has to tackle the additional complexity of the one–of-a-kind production type. Each mould is a unique product, where a 3D complex geometry with a high dimensional accuracy must be design and fabricated within a compressed lead-time[10].

Being a traditional sector, moulds industry has positively dealt with the adversities through the constant incorporation of innovative production technologies that have driven to the integration of high engineering levels[4][10]. In parallel, the relatively rapid incorporation of communication and information technologies, has allowed a more and more responsive answer to the market. The pressure for the permanent technological upgrade is so strong that a study on the sector, done by CimData[2], detected a well-balanced technological level between mould-makers in different geographical regions.

This idea is stressed with the example from a small country like Portugal, where the moulds industry has a technological incorporation similar (and in some cases superior) to the current level in countries with a larger industrial power[1][4].

The qualities shown by the sector and the responsiveness of the majority of the companies have led to the increase of client requirements and expectations. Thus a technological innovation introduced by one company is momentarily a competitive advantage: when a mould-maker reaches a new technological performance degree, this degree becomes rapidly the demanded standard reference all over the industry[4].

Considering that technological innovations are frequently developed by the equipment manufacturers and assimilated by mould makers, it becomes more and more evident that the technology, being a fundamental factor for the presence in the market, does not constitute a differentiation factor. This aspect is currently addressed by mould-makers, which pointed out the cost and the total manufacturing lead-time as the major competitive factors (Fig. 1).

So far, it is understandable why quality appears as the third competitive factor. Quality, resulting essentially from the “best” use of technology, is a fundamental requirement to stay in the business but it is not a differentiation factor. The service providing appears in the forth position, being an evidence that the partnership with the client has a growing weight in moulds industry.

Portuguese case can be pointed out as a paradigm of this situation. The Portuguese moulds industry presents unique competences in the design and manufacturing of moulds of high complexity within a high productive flexibility, where the experience and a smooth and long-term relation with clients are crucial competitive advantages, within a service providing perspective.

The synergies within the mould sector, with the involvement of different actors, are schemed in Fig. 2. Due to the large focus on production, mould-makers try to expand their competitiveness essentially through the technological surveillance and exploitation[4][6]. The automation of the processes is more and more a reality in several companies in particular in North America and in Japan[6][11][12]. The information, knowledge and competencies management are development vectors where the difficulties of exploitation have been larger.
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Fig. 2. Synergies in the moulds sector.

From this context, it results that the adoption of productive strategies aiming the efficacy maximization of the resources and competencies in moulds industry will create a background support to the medium-term challenges. According to Alukal et al.[8], Womack[9] and Drucker[13] the reasons why LM is especially important as winning strategies can be summarised: (1) to compete effectively in the global economy; (2) to face the pressure from the customers for price reductions; (3) to fast-pace the technological changes; (4) to continuously focus the market on-time delivery, cost and quality; (5) to hold on the core competencies and outsource the rest; (6) to meet the market high expectations. Those drivers to LM implementation are proposed to the industry in general, so one can expect their applicability to the mould industry.

LEAN MANUFACTURING FOR MOULD MAKING

LM is a Western adaptation of the Toyota Production System developed after the Second World War by T. Ohno, S. Shingo and K. Toyoda[5][9]. Since its birth it has been related to the automotive industry and the most successful cases rely on high production rate companies. Indeed this is the fundamental reason why LM has been considered as non-applicable in the mould industry.

Alukal et al.[8] mention that about 70% of the manufacturing throughput time is spent in non added value activities, 25% is spent in tasks related to regulations, standards and legal requirements and only 5% is spent in real value added activities. It is the enormous impact of such wastes that justifies the demand for a LM strategy. Womack[9] proposed a waste classification in 8 different classes. Several current situations in mould companies within each waste class are presented in the following points:

1. Over-production waste: Frequently in moulds industry it occurs in the form of redundant tasks, which are excess of work in comparison to the necessary. An example is the NC programmes generated in the process-planning department and modified later by the machine operator.

2. Inventory waste: The acquisition of large volumes of electrode material and of large number of tools represents excess in face to the strict needs.

3. Defective product waste: Human errors, information non-robust and low technological knowledge are at the origin of most defective components and moulds. Inaccuracies in the manual finishing, causing the lost of tolerances and the elimination of small geometric details, determine the need of reworking tasks[10].

4. Over-processing waste: Over dimension of mould design and manufacturing solutions as regards to the strict client requirements[14].

5. Waiting waste: Non-efficiency as regards to production planning and control is one of the reasons for a throughput flow with long waiting phases[14].

6. People waste: It happens on every company when the skills and competences of people are not fully used.

7. Motion and 8. Transportation waste: The unnecessary movements of people and materials around the plant due to inappropriate location of tools and equipments and to the unavailability of information on time and on site.

Since the 8 wastes are daily generated in the mould-makers shop-floor, the implementation of a strategy focussed on LM is essential. Several authors have presented the implementation of LM strategies[9][13], summarised in Fig. 3. The moulds industry scepticism to the LM is reinforced as far as they note that the proposed operational methodologies (SMED, Kanban, Cellular Flow, etc.) do not seem to have correspondence with the mould-making activities. The sporadic introduction of those operational methodologies has resulted in a limited success and did not contribute to the LM dissemination in the sector[5].

However, the approach to LM is based on theoretical and strategic concepts. If these concepts are well thought-out to the particularities of the sector, their applicability to the moulds industry will be a success.

In fact, the difficulty and the unsuccessful of LM in moulds industry are related to the proposed methodologies and operational procedures: 5S, visual control, error proofing, etc. However, the essential foundations of these methodologies are
related to their objectives and not with the way they achieve the objectives. And the global objectives are the total manufacturing time and waiting time reduction, the elimination of non-quality, the rework avoiding, etc.. In the following paragraphs methodologies, which in moulds industry will allow the achievement of these objectives, are identified.

Putnik et al.[15] and Oliveira et al.[16] indicate a reduction on time to market between 25% and 40% with the application of SE work methods and tools. The parallelism with the model shown in Fig. 3, demonstrates that the objectives of SE are similar to the Quality at the Source, Standardized Work, Teams, Cellular Flow and Pull/Kanban operational procedures.

Internet–based manufacturing: The production monitoring, the in-time availability of specific information, which flows in the moulds value chain (suppliers and clients), and the remote access to that information, supports the collaboration and the efficacy of the resources use. The model schemed in Fig. 5 is supported in the current needs of mould-makers as regards to communication and interaction with clients, suppliers and partners, to consolidate the SE practices[15][16].

The access in real time to the progression status of each job will allow the definition of Pull/Kanban production flows and will support principles of point-of-use storage, visual control, error-proofing and 5S.

Best Practices of Planning: Zawila[14] had listed a systematic approach to the mould making planning. First, planning should not fully begin until mould concept design is completed and approved. The link between this attitude and SE is crucial. Second, lead times for all the mould’s purchased components must be known and taken into consideration. Third, the individual scheduling and various skill levels of each worker must be known.

![Fig. 3. Scheme of the LM Model [9][13]](image)

Simultaneous Engineering: An effective implementation of Simultaneous Engineering (SE) in mould companies supports a high interaction with the client, and improves the agility in what concerns the introduction of modifications during the mould manufacturing cycle with a minimal impact framework. Simultaneously, it promotes the involvement of extended teams in development phases (Fig. 4).

![Fig. 4. Mould project and manufacturing in a SE Framework.](image)
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The existence of written procedures and their classification by client and mould type and by production similarities has large benefits. These benefits can increase if the performance indicators are registered through the manufacturing process and used within continuous improvement objectives. The treatment of this information in an organized way will facilitate the easy access to previous plans and procedures, and also to performance indicators, contributing directly to the improvement and agility of future plans. Indirectly, it will contribute to the reduction of the probability of similar errors occurrence and to the continuous improvement of planning tasks.

The integration of the planning best practices with the company information system and with teamwork culture extended to clients and suppliers in a SE context, will contribute towards the waste reduction (over-production, defective products, over-processing, people waste and waiting waste).

Autonomation: Far over the equipments automation, the autonomation concept includes the technology itself and requires an analysis in several vectors.

Obviously the equipments must be automated as regards the CAD/CAM systems, the tools/electrodes changeover and the parts replace. But the process must develop itself in an autonomous way. Arnane[18] suggests the adaptive control systems (based on constraint algorithms-ACC or optimisation algorithms-ACO) for EDM technology. He suggests also adaptive control systems for milling technology to allow the on-line automatic parameters compensation during the process. The objective is to guarantee the increase of robustness and process capability and to support the machining performance with lower operator assistance. Simultaneously, the guarantee of quality is improved, the standardization (Standardized work) and workplace organization and discipline is promoted (5S), and the probability of errors occurrence is reduced (Error-proofing).

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Fig. 6. Relations between the methodologies proposed by traditional models and the ones proposed to moulds industry.
Another aspect involving automation is the palletization[11][12]. It consists on a tooling system and featuring chucks for unmanned operation avoiding parts/tools unclamping between machining operations. The introduction of such systems will reduce the setup time (SMED) and will increase the dimensional accuracy, repeatability and reliability (Quality at the Source).

The analysis of the potentially evitable wastes, which are the aim of the four methodologies presented, allows relating them with the ones traditionally applied in LM (Fig. 6). In fact, both groups of methodologies cover similar objectives (Fig. 7).

Entrusting the operational requirements, these methodologies allow the elaboration of a specific LM model to the moulds industry (Fig. 8). If information / knowledge / technology management capabilities are added and implemented, mould companies will become agile enterprises – companies rapidly responsive to the market requirements, with low cost/high quality products/services.

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<td>• Concurrent engineering</td>
<td>• Lean thinking</td>
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Fig. 8. Scheme of the LM Model purposed to moulds industry.

CONCLUSIONS

Investing strongly on design/production up-to-date technologies, mould-makers usually forget the continuous improve of the manufacturing procedures, perpetrating the mistake of just rest on the technology performance. In order to change this attitude, management must focus on service and flexibility, waste minimization, empowerment of human resources, training and technological surveillance. Indeed, combining a lean attitude with methodologies intended for the particularities of the sector (particularly the one-of-a-kind production) and continuous improvement procedures (of means and knowledge) it is possible to achieve a lean and agile mould sector positioned as a structural element of the European industry.

REFERENCES

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