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Casting Lean 'Make in India' Products

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ABSTRACT

Having faced ineffectiveness of the 'Make in India' paradigm, duly launched to rejuvenate Indian manufacturing, there is a need to investigate as to why such unsatisfactory and erratic performance may have resulted? One issue was to review the lack of accent on right product development. Possible constraints were probably the need for lowering the costs of a component? Hence for improving the global competitiveness of Indian manufacturing the 'Make in India' policy'ing must additionally be supported by concrete strategies and tools. Separately, to improve profitability and reduce wastages a 'Lean' thinking has been employed by various practitioners.

Various rubrics that are used to define lean include use of tools/ philosophy etc., which have been reviewed as to how they determine its exquisite scope. I further investigate as to why and How the manufacturing of 'make in India' Products be dictated using Lean thinking and how options for achieving Leanness could be further driven to product development? Further how should manufacturing competence become worthy of casting a scenario for Lean - 'Make in India' – Value flow systems? Moreover, how may the Cast in India scheme be invigorated so that the products are competitively made, sold globally and be able to serve the needs of customers and satisfy them? Through this paper a systematic approach to chart achievement of 'Lean - Make in India' objectives is advised.

The lean product development is exemplified using a case study.

Keywords: "Cast in India", Manufacturing success, Lean Thinking, Transformation, Production, Weight Reduction

The Scope of this paper in Essence

Theoretically, scope means "to look out or around" the extent of the area/ subject matter.[1] More specifically, assessing or investigating through a programmer,[2] to see where the action is, and how it is applied in the business initiative planning process.[3] The context here in this case is 'Manufacturing in post 'Make in India' scenario', which was flagged off by the reverend Prime Minister, Narendra Damodardas Modi on 25th Sept 2014.

The context of scope of present paper: i.e. to understand the context of Lean thinking, and applying it to Manufacturing of Cast Products in 'Make in India' scenario. It warrants that we define the various elements - 'Casting',' Lean',' Make in India' and 'Product' first.

'Casting' is:

- Distinguished as a manufacturing process that adds value to raw materials to transform them into products.[4] Alternatively said, it works as valuing agent that provides the liquid metal a permanent set of physical, structural and mechanical attributes.

Additionally, as Merriam Webster[5] explores, it includes **Tasks as:**

- 'the throwing of a fishing line by means of a rod and reel' to catch fish (call it a bait towards the product)
- The assignment of duties to actors or performers (to produce service as product)

In the present context of manufacturing system, a casting of the operator (i.e. a Tool - say Lean), by means of a Bait (read – say make in India), to make more of products (castings); or to woo workers (skilling India) so as to make them efficient.

'Lean', implies an 'inclination' - incentivised to shed waste so as to become more fit. "Waste" is defined as anything that interferes with the smooth flow of production (Macduffie and Helper, 1997).[6] In Industrial parlance, it involves a way of thinking about an activity and visualizes the inadvertent origination of waste, in the way the process has been organized, through the process flow. It requires both the competence and attitude (Compettitude).[7] Lean (yhu), when defined in Hindi language focuses rather as 'involution'-Inner Evolution of one's competencies (mind, heart and soul)[8] (read people and processes, information, and transformation) as a transformative strengthening.[9]

'Make in India' a core policy initiative, launched so as to invigourate manufacturing in India, outlines a set of objectives which should provide for a manufacturing infrastructure in India indigenously or with foreign assistance, which could produce products which carry 'Made in India' label. The policy initiative was necessitated to rescue not only the ailing manufacturing sector, which especially catered to ICT (Information and Communication Technology) for public at large, and high technology areas for defence, railways etc. and also for capital goods sector for manufacturing sector itself.

Product is a good, service, or idea, as the result of an action or process, consisting of a bundle of tangible and intangible attributes, say a good, idea, method, information, object (physical or in virtual or cyber form) or service created[10] and serves a need of a customer that satisfies them.[11]

The integration of above definitions, so as to determine the full scope of this paper implies the following: (of which only (ii) and (iii) have formed the scope of this paper):

- Evaluation as to how well Manufactured products encompassed under 'Made in India' label will serve the policy mandates of 'Make in India' policy
- Why and how the manufacturing of 'make in India' Products be dictated by Lean thinking and/or products be made Lean?
- How the Lean 'Make in India' systems may invigourated so that the products are globally sold, serving the need of a customer and satisfying them.
- The importance of design towards 'Make in India' policy is reiterated, while it is also used towards enriching the manufacturing technologies with autonomation, cyber systems, etc. in the IIOT era[12]/ industry 4.0 scenario.

The rejuvenation of manufacturing industry of tomorrow however cannot happen only with motivation (as the bait of sops @ 'make in India' thrown into the sea of competition to catch fish), but it also requires both provision and adaptation of technology. Akin to the parable in order to be able to swim, one must first jump into the water; use of new technology will first necessitate indulgence into either indigenous or adopted technology. Since the latest in technology is the integration of cyber physical systems in manufacturing, in line with industry 4.0/ or Foundry 4.0 [13] technologies, the development or adaptation of such systems to comply with future manufacturing requirements requires integration of indigenous advancement of softer products of virtual/ cyber types with local manufacturing.

To sum up, the integration of the various components as defined in aforesaid leads to a promise (i) by way of policing, and at the same time (ii) by way of meeting various challenges of implementation, which require continual learning, demonstration of competencies, finance, resources, infrastructure etc.

The objective of this paper drives down to evaluating the potency of core policy initiative 'Make in India' for its realization of promises. These include improvement in design competencies/ production technology, facilitation of high tech 'Made in India' products, and improvement in people competencies. For the success of meeting the objectives, what and how products of manufacturing may be improved/ made lean, so that it can demonstrate achievement of allow flexibility, feedback, predictability, and control.[14] Also, that the principles of lean manufacturing applied to product development significantly decrease product development wastes.[15] which would ultimately contribute to leaner process planning, strengthening business process. Further we need to evaluate the various set of goals for a success, and if there may be deficiencies, the implementation of necessary corrective action.

The Role of Intangible Products

The transformation of manufacturing through 'Make in India' initiatives calls for not only investment for improvement of design competencies and/or improvement in production technology, as stated above, but also in people competencies. All these factors are full of challenges, because India is a poor country in view of investible capital resources, technology, design competencies, availability

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of skilled workforce and employable engineers (who are inclined to work in India and who possess the due culture to devote to improvements and value addition). The realization of Make in India initiatives are, therefore, likely to be easier if more manufacturing is consummated @ least cost and dedication of resources.

In order to increase productivity, at lowest cost, one will need to minimize inputs. Its elements (of Productivity) include financial productivity, labour productivity, machine productivity, and so on. To maximize output, in each of these elements, the coveted option is to reduce inputs, which can be affected by improving quality, yield, effectiveness, and/or other options viz recycling, choosing lower grade products etc. by applying innovations.

Evaluating in case of labour productivity, advantages can be achieved by various means reduction of wastages (not wages), improving effectiveness and efficiencies of people such that they increase value, apply innovations etc. The operator should be able to identify customer-defined value to separate value-added from waste. Viz to reduce the content of labour input, one option is to deploy mechanization and automation which can produce large volumes with large product variety. However, since the speeds are faster, and subject to vagaries of set up and continual monitoring by the operator, due culture for 'Aim for perfection' is solicited to ensure the value addition is maximized. The current ambition is to 'pull making products which the customer has ordered'.[16] To clarify, this customer is the individual customer, who is in focus. It is not 'mass' but 'one at a time'.

The philosophy descends from the 'upside' of the production method which requires 'half the human effort, half the manufacturing space, half the investment and half the engineering hours to develop a new product in half the time.'[17] There is 70% reduction in engineering effort, and 50% reduction in engineering rework[18] besides displaying dramatic improvements in profitability and customer satisfaction. Significant improvements also occur in the retention of engineering knowledge. If such competency gets embedded in our manufacturing men, then only the governmental support through 'Make in India' policy can bring significant results, not otherwise.Provided our engineers or entrepreneurs identify business units/ products, determine key functions and include all relevant activities of each function.

In essence it needs a culture to align processes to focus on customer requirements, especially where customer assigns value to the product. It may be noted that whatever customer does not pay for is considered waste. Value, then, is an elusive commodity and one that must be continually adapted and refined.[19] The operator's culture to separate value-added from waste is the mantra for efficient manufacturing. Thus the competent operator fortifies which method of manufacturing may be used, and how wastes may be isolated and removed from the system, through design and operation. Former (design) is a component of Manufacturing, and latter (operation) is an attribute exploited in Production which includes more focus on acceptance of product by customer, quality, cost etc including the intangible components. Thematically, Production paradigm involves use of some intangible functions, which invoke upstream functions so as to improve responsiveness and thereby ensure better utility. Additionally these cater to improving efficiencies and effectiveness. The Manufacturing and Production are differentiated in table 1.

One of the major differences in Manufacturing and Production is design, which when applied to the domain of casting thoroughly gets underestimated in former. This is due to criticality of 'Methoding', a competency which most manufacturing / Foundry books are seen to ignore. The virtues it ('Methoding') imparts to the foundry man regarding production process are colossal, and no short of acrobatics.[20] In addition, the Methoding, apart from its

Table 1. Making a distinction between Manufacturing and Production

Basis for comparison	Manufacturing	Production
definition	The process of producing merchandise by using resources like labour, machines, raw materials, tools, etc.	Process of creating an output, a good or service which has value and used for consumption, contributes to the utility
Characteristic of output	Usefulness (product or object centric)	Utility (satisfaction or consumer centric)
Concept	A process that uses raw materials to generate output	A process of converting inputs into outputs
Compulsory resources	Men and Machine	Men
Form of Input	Tangible	Tangible and Intangible
Form of Output	Goods only	Goods and services

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design functions, targets serving the intangible requirements at the next stage of operation from a customer's angle. But unless there is a smooth and efficient mediation between methoding engineers on one side and production processes on the other, the casting may not have both usefulness and utility. Thus as a nomenclature between manufacturing and production, casting is considered as more of a production activity, rather than the claim otherwise. To its validity (of claim), the result of google search of manufacturing versus production of castings are reported in table 2.

From table 2 and aforementioned discussion, it can be deduced that the 'Make in India' paradigm can be strengthened with design and the Value addition for success. For both, the policy needs to 'Center on the People Who Add Value' either way. Thus the objective of 'Make in India' extends much beyond the mere provision of jobs to one that where the skills get honed. However for achieving breakthrough success, in a 'Make in India' initiative, the people need to be the center of knowledge, Process Design Authority, Decision Making Authority, and Organizational Energy. For this a dedicated and oriented integration of humans in the production process should be continual. A clarity on processes with understanding as to what activities and resources may be necessary to create maximum value, and how to maximize value, with due cultural alignment for value addition will only promise success. Given if something does not directly add value, it is termed as waste. Wastes can result from over design, Design for not 'X' (DFNX) where 'X' is the customer needed attribute[21] –the inevitable component or of the highest excellence, activities which do not add value, etc. The various authors have identified 8 types of wastes which form a part of this kitty.

Table 2.Citation count in favour of Castings - Produced over Manufactured

Manufacture	Production	Remarks
Manufacturing of casting 7,01,00,000	Production of castings 23,70,00,000	Production of Castings has more than 3X acceptance
Manufacture Castings 52,80,000	Produce castings 95,20,000	As a verb also 'Produce' is preferred for castings
Manufacture forgings 7,84,000	Produce Forgings 9,23,000	As a verb also 'Produce' is slightly preferred for forgings too,
Manufacturing of forgings 31,50,000	Production of Forgings 29,80,000	Manufacturing of forgings is more popular,

The ideology of Lean for 'Make in India' Success

The aim of lean thinking is to create a lean enterprise by managing Flow (of information, materials etc.), using concepts of Pull (demand) so as to offer innovative products or services to customers, suppliers and the environment and by strategically aligning customer satisfaction with employee satisfaction. The intent is to avoid over-costs to ensure profitability. The pathway for successful manufacturing competence lies in value addition in each stage of product development (called value chain),- the resources (i.e. machinery), the raw materials, people, inbound logistics and production processes (on supply side), and outbound logistics, marketing, and sales (on demand side). The worthiness in analysis of value chain enables redesigning of internal and external processes to improve efficiencies and effectiveness.[22]

Creating value in any stage of a virtual value chain involves a sequence of five activities: gathering, organizing, selecting, synthesizing, and distributing information. It is important to comprehend as to how we develop the initial product and the respective process design and/or methoding as it were a case product. It encompasses as to how we assure compliance to how we design to operate a completed facility. However, to be truly effective and efficient, we have to link all these elements within a robust supply chain.

While Lean methodologies help add value for the customer, in lean product development it allows efficient use of resources, facilitating the reduction of time-to-market. It additionally helps counter the challenges of product development, notably: Lack of innovative solutions, Long development cycle times, Multi redevelopment cycles, High development costs, long production cycle times, High production costs etc.

Lean methodology is successfully deployed in both physical and virtual systems (physical world of resources and virtual world of information) to add value for successful product development. The onus is however driven to the various people competencies, both in physical and the virtual world, who are the agents of requisite value addition in each component of the chain. In each of the two cases the bundle of tangible and intangible attributes may be required in view of satisfying needs of end customer. The methodology of Lean, as it underwrites a manufacturing process serves as a vehicle to assure value to a customer. As a tool, it can be applied to manage pull in production. Through a system approach it can help improve the production processes by identifying wastes. Or, as a philosophy that enables graduation of operators to equip themselves with the wherewithal to meet challenges at lowest cost.

It is worthwhile to explore the questions whether Lean is a methodology, a philosophy or simply a metaphor? Is it a system, method, school of thought, and even a way of life?[23] While all are focused on reducing waste, yet the question is at what level of involution? Does it have fixed dimensions, a purpose, or it involves exploration? Lean thinking targets people for both organizational learning and also optimize exploitation of say plant and machinery versus the environment? In short 'Lean' needs to be better understood. Concurs Jon Miller[24] "Definitions aside, I

Table 3.The exploration of various attributes of Lean Thinking from literature

Context	Specific Character	Target/ application	Reference
Lean manufacturing... the buzzword in manufacturing.	buzzword	Indicates Popularity	Gershen(2003)[15]
The lean production metaphor	metaphor	Representative or symbolic of something else.	Poppendieck (2011)[25]
Defined lean as "the elimination of waste from the production cycle".	purposeful	eliminate waste	Cooke and Williams (2009)[26]
Lean is to view it as a (proven) approach to dispense	approach		Bicheno and Holweg 2000[19]
Roadmap of lean …impart…wherewithal for Green and environment-friendly planning of … system.	Road map	Planning go Lean, Green, environmentally friendly system	Chahal and Thareja[27]
Effective way to reduce waste and boost profits.	effective way	Reduce waste and boost profits.	
systematic method for waste	systematic method		Wikipedia[28]
Lean is the set of "tools" that assist in the identification and steady elimination of waste.	set of "tools"		
Lean Manufacturing System as a great management tool	Important tool	Tool of implementation	
LM is a systematic approach to identifying and eliminating waste (all non-value-added activities) through continuous improvement by flowing the product at the pull of the customer	systematic approach	in pursuit of (achieve) perfection	NIST (1998)[29]
Lean Manufacturing has been the best manufacturing practice	best practice	eliminate waste	Holweg (2007)[30]
strategy for achieving significant continuous improvement	strategy	continuous improvement	Quoted in Sharma, Neha et al.[31]
Lean is defined as "a strategy for Operational Excellence based on Clearly Defined Values to Engage People in Continuously Improving Safety, Morale, Quality, Cost and Productivity."	strategy based on Clearly Defined Values @ People Engagement	Operational Excellence thru	Liker(2014)[32]
'Lean Management' is an intellectual approach consisting of a system of measures and methods	intellectual approach	Thru system of measures and methods	Warnecke and Hüser (1995)[3]

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promotes a new way of thinking and acting,	new way of thinking and acting	implementation	Womack J et al.[34]
Lean manufacturing is plethora of principles	principles		Quoted in Sharma, Neha et al.[31]
lean principals drive efficiencies	principles		FE Manga no.[35]
The science of lean.	science		PAVNASKAR S. J. (2003)[36]
Lean is perhaps the most important concept	Concept		[31]
"Lean is a philosophy, a way of thinking about the management of work in projects."	Philosophy/ way of thinking	project management	Mossman (2014)[37]
Lean is a philosophy of continuously simplifying processes and eliminating waste.[7]	philosophy	eliminating waste + simplifying processes	Womack and Jones E.(1996)[38] Bhasin and Burcher(2006)[39]
"Lean is a management philosophy supported by a coherent set of conceptual foundations, basic principles, fundamental practices and a common language".	management philosophy	(Knowledge Infrastructure)	Howell (2014)[40] Ugochukwu et al. (2012),[41]
Lean manufacturing is the aggregate of many waste reduction tools and philosophies in manufacturing.	aggregate of tools and philosophies		Gershenson(2003)[15]
Lean is a paradigm which helps processes become environment friendly	paradigm	Process improvement for environment friendliness	Thareja[42]
lean thinking is a non-zero-sum (win-win) paradigm,		non-zero-sum (win-win)	Thareja & kaushik (2010)[43]
Lean concerns a production system that is oriented on learning of organization through continuous improvements.	'Learning' through continuous improvements.	learning organization	Appelbaum & Gallagher[44]
Lean thinking is a concept to activate the paradigm non only to better competitiveness, but also a superior focus	Learning	Customer focus with productivity gains	Thareja P, Sharma A. (2011).[45] Thareja P, Sharma DD. 2011[46]
attain and realize improved outputs with reduced consumption of resource as a systems.	System	improved outputs with reduced consumption	Rajender Kumar et al 2015 ()[47] Taleghani (2010)[48]
Non-traditional definition to lean. Lean is about pull and standardisation and about all those good things about building the capability and capacity of people and processes using good practice."	a non-traditional definition - about pull and standardization	People Focus (building the capability and capacity of people and processes) & good practice	Keegan (2014)[49]
"Lean is simple: fix what bugs you."	[Multifunctional - Adaptable]	Need based	Akers (2012)[50]

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Lean is an evolving concept[11] with rapidly increasing popularity	evolving concept	evolved from the operational level to the strategic level	Hines et al.(2004)[51]
	a multi-faceted concept		Teich, S. T., & Faddoul, F. F. (2013)[52]
"a transformation in the way you approach and think … deliver[ing] … not just about eliminating waste or just about creating value, but it's a mind shift,	Transformation in approach a mind shift	eliminating waste, creating value	Umstot (2014)[53]
Add value to achieve targeted objectives, through transformation precluding society's overall interests.	Paradigm, Alignment	People Metamorphosis / Process Transformation	Thareja P 2005[54]

wonder how many people really understand what this lean philosophy truly means".

A quick survey of literature delivered following information, as compiled, is listed in table 3.

Defining lean is thus a difficult exercise, as Pettersen assigns any of four approaches could be there viz. practical and philosophical versus operational and strategic. However " any 'definition' of the concept will only be a 'still image' of a moving target, only being valid in a certain point in time."[55]

Lean sure has worked as a buzzword, and there are a plethora of users. Whilst the: "number of tools, techniques and technologies available to improve operational performance is growing rapidly, most efforts to use them fail to produce significant results". It is because, Lean "is constantly evolving", and is beyond the 'proverbial provision of a shoulder to fire the gun'. In fact one must learn to apply one's own strategy to follow the path to target. As Repining and Sterman (2001)[56] observe, the emulation of the competitors successes@ lean has been used by new practitioners as a passing style and resulted in no big success. Sohal and Eggleston (2004)[57] confirm only 10 per cent users have the philosophy properly instituted. Unless the right tenets are ingrained in people, the Leaning will deliver no success. Hence is the need for higher level consideration, like a paradigm, and change of mindset. The game plan of Lean is to transform people with a knowhow to flow through the value assuring that each activity leads to lean success.[58]

Casting Lean 4.0 Production

As most industry view the lean approach seeks ways to utilize assets more effectively vis-à-vis as in traditional systems[51], the adopters of lean philosophy can hope to secure the big step towards becoming a global competitor.[15] The attempt to add value to the customer, which will spruce up the manufacturing business in accordance with 'Make in India' policy in a lean environment is schematically proposed as in figure 1.[59] Given, "The context of providing right value to the customer begins with a holistic objective and a broad vision"[27], the casting of a"Lean Make in India" paradigm deserves to be appropriately designed.[28] It is also because casting is the mother of manufacturing, and the Foundries remain a key link in the value chain for most

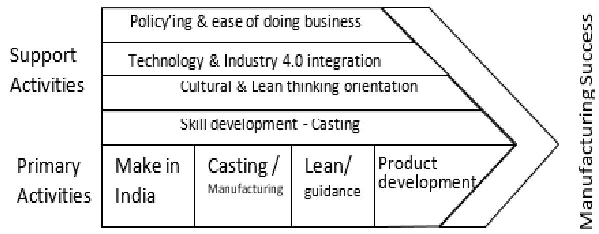

Figure 1.The Make in India Lean Cast Product development Value Chain [after]

metals related manufacturing processes and are closing due to lack of business opportunities.[60] The connect between 'Lean' and 'Make in India' is though philosophical, is also practical and strategic. Hence the perception to make it operational to make the latter succeed.

There is, albeit, a distinct interconnectedness of 'Make in India' Policy'ing, with production (including methoding), lean thinking, and product development. Since there are many linkages and interdependencies among these, the ability to coordinate interrelationship is critical to achieving success. Good integration can facilitate implementing right strategies, responsiveness to customer needs and market forces and also additionally reduce costs. Thereby they help achieve over all competitiveness.[61]

Evidently as seen in table 3 that Lean success is aided by transformed people who chase value,[62] the modus operandi of maintaining value flow through the chain makes them potent to ensure the focus on the outcomes sustains. The following steps are followed:[63]

- Define the outcome or scope on which the value chain will focus.
- Identify a requirements elicitation methodology that focuses on the identification of the high-level processes

within the application domain.
- Identify the high-level processes within the application domain.
- Use the high-level process model developed to derive the sequence of processes needed, to achieve a predefined outcome.

To implement such steps the operators need specific competencies for which not only the employees are properly trained around ‘what to do and how to do’, but they need be taught ‘how to learn’. The organization must become people centric. By putting people first rather than systems, lean thinking radically gears up organizational innovation. The goal of Lean thinking is to develop each person’s autonomy in problem solving, along the value flow, by supporting them in their continuous improvement activities. The various tools and their purposes/ principles[64] are listed in table 4.

Table 4.Lean Principles with Corresponding Practices and Techniques

Principles	Practices	Tools and techniques
Specify value from the end customer view	Source information on customer need	customer involvement
	Value chain analysis and end customer focus	Value stream mapping (VSM)
Map value to expose and eliminate waste	Value chain analysis	VSM
	Waste reduction	JIT, TPM, small lot size, 5S, SMED
Establish flow	System organisation	5S, cellular manufacturing
	Strong and effective relationship	Supplier integration
	Waste reduction	JIT, small lot size, TPM, and 5S, SMED
Let the customer pull the products	Production of exact customer needs only when needed	JIT, pull/kanban system
	Strong and effective relationship	Supplier integration
Strive for perfection	Problem search	VSM, 5Whys, employee involvement
	Problem solving	Training, 5Whys, employee involvement

It is a fact that most methods and tools for identifying product or process requirements including their design have been developed and tested in a western context. Given, “all the value in product development is embodied in the essential deliverables”[65], the collation of all needs [read domestic needs] are vital so as to maintain leanness in local context.

Since expertise in collation of Design requirements that must originate from various kinds of inputs is vital for synthesizing a solution[66], any deficiency in this documentation (collation of all needs) will lead to the waste of resources and even failure. Though an appreciation of differences and adaptation to local needs is still problematic[67] due application of local innovation to needed valuation is essential, especially within the ‘Make in India’ perspective.[12]

Further, as future the factories are likely to be automated, and use ICT to exploit resources, competencies, customer choices and markets, the resulting complexity is already driving operators crazy. Hence for effective process management, the input, processing and use of information must be right to generate new, valuable information that increases the confidence at every stage. In order to maximize value, it is thus essential to get the right information in the right place at the right time.

The future transition into say Industry 4.0 will be governed by three paradigms: the Smart Product, the Smart Machine and the Augmented Operator. The Smart Product is destined to change the role of the work piece from a passive to an active part of the system, for which integration of say methoding software’s to dynamically assist product development shall become the norm. In such a system the products will have a memory (as today’s based on RFID technology), and beyond to store operational data and requirements individually, which can request for the required resources and coordinates the production processes for its completion.[68] In a paradigm of the Smart Machine the traditional production hierarchy is replaced by decentralized self-organization which is realized by CPS (Cyber Physical Systems). The adaptation into foundry industry is discussed in a previous paper by the author.[13]

Following directions will have to be pursued viz (i) humans should be the conductor of dynamically allocated production resources. (ii) focus on the use of information about processes, equipment, functions, etc., It is viewed that even work instructions for manual work could be generated dynamically on the basis of context-based dynamic orchestration placing the human worker into the center of the value creation process.[69] The solution in the new scenario will be to take steps to decrease technical complexity and put the humans back into the center of factories[34]

The use of Industries 4.0 system offers potential as under:[70]

- Better planning for "pull from the customer" individualized understanding of customers and offering them specialized industry-specific solutions.
- Increase competitiveness and flexibility resulting from dynamic structure of business processes (i.e. quality, time, risk, robustness, price and eco-friendliness)
- Increasing resource productivity (providing the highest output of products from a given volume of resources) and efficiency (using the lowest possible amount of resources to deliver a particular output)
- Optimized decision making due to end-to-end visibility in real time and adjustment to changes in demand or breakdowns in the value chain
- Value opportunities (innovative services, new forms of employment,)
- Promote high-wage economy with tied-up capital cost, cut energy costs and reduced personal cost.

Leaning by Product Engineering

Lighter components are preferred provided they exhibit the same set of properties, specifications, dimensions, features and so on. There are economical, technological, and engineering considerations that determine the choice of components, whether lighter or heavy. Economically, lighter materials have lower per case transportation costs and so they have dead weight, which is a preferred requirement in aircraft/ automobile and other transport industry. As a component of manufacturing, the relative cost of materials used in component, influence the costs. "Both weight reduction (of individual piece), and the successful deployment of 'methods' can be addressed thus to assure greener [Manufacturing]".[27]

Given the constitution of the material or product may be characteristic of the production process, its attendant engineering considerations are most important to determine as these are requisites to deliver the satisfaction as per design @ ultimate functions. Viz the forged product may exhibit flow lines. Both the specifications and material deployment must match with product characteristics. Cast materials have dendrites inside and impression of sand/ shot blasting on the unfinished surfaces. Sintered materials may exhibit isolated porosity, which imparts its lightness, as the metal component is lower than that of conventionally made components.[71] If the principles of lean manufacturing can be extended here with the objective of decreasing product development waste, the value can be further enhanced.[15]

To summarise following strategies may be deployed to develop lighter components[71] (their examples are collated in table 2):

- Use of lighter materials and/ or materials with high strength to weight ratios

Table 2.The strategies deployed for lighter components with examples

Option	Example	Concept
Use of lighter materials	Aluminium in engines of automobiles (sheets in railway bogies)	Use of inherently lighter materials in value added applications
Materials with high strength to weight ratios	Titanium alloys in aircrafts Composite materials in spacecraft's	Value added alloys for high performance applications
Use of hollow forms	Tubes in steering rod in automobiles	Structured shapes/ shape modification for enhancing strength.
Material reduction by Stiffness design	Viz by corrugation of sheets	
near net shaping	To Obviate excess materials in manufacturing, which needs to be scraped	Ensuring cost and material saving through pull and perfection
miniaturisation and structural/ alloy redesigning	To Obviate excess materials in manufacturing, by reducing size for giving same performance	Reduction in redundancy
Use of porous components and related designs		Material and fabrication technology
(high tech material) technologies	Nano technologies	

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- Use of hollow forms or porous material designs to maintain strength and stiffness requirements
- Use of near net shaping technologies
- Use of the concept of miniaturisation and structural/ alloy redesigning
- Using exquisite (high) technologies for causing multi fold improvements in materials
- Reduction in use of components through multifunction's

A Material Reduction Case Study (Automotive Products)

Final cost of any product is the mix of direct costs (raw materials, operators, energy) and indirect costs. Former are generally variable, and latter fixed. To specify the contributors to cost are the quantity and cost of raw materials, resources of various types (like Men, Machines, Energy), auxiliaries (like graphite electrodes, tooling's), material handling equipment, and the equipment for control of environment (wastes, scraps, pollutants liquids, solids and gasses). This includes both basic costs of provisions and for

Figure 2(a)

their continued operations. The cost is further dependent influenced by cycle time, cost of handling, transportation and of complexity.

The challenge was to secure a differentiation of product which could be affected by applying engineered solutions to improve the metal's yield (thru' say, improve the process flows and the availability of materials) to achieve both natural and competitive advantages.

To affect cost cutting each and every cost component as above could be carefully considered for reduction, by way or reduction through design, reduction of redundancies, and all wastages. The processes can also be simplified, materials made lighter, cheaper, lowering of quantities/ weight of component and reshaping by improved design.

One way of understanding Lean is to view it as a (proven) approach to dispense with increasingly inappropriate 'economies of scale' and to adopt 'economies of time'[19]. Suggests Ohno:[19]

- Mentally force yourself into tight spots.
- Think hard; systematically observe reality.
- Generate ideas; find and implement simple, ingenious, low cost solutions.
- Derive personal pleasure from accomplishing Kaizen

For an illustration let us review the deployment of Innovation and Technology improvements for Improvement of Competitiveness together with reduction of Metals Scrap.[72] Say, in a case study for production of tubular component as in figure 2 (a), the savings in raw materials, operating costs, tools etc. can be reduced by a significant measure. In the case study it is demonstrated as to how two main constraints - high percentages of excess materials to be scraped, and the complexity of tooling was managed that led to both high quality and obviated complexity.

Following options were considered to form the part of scope for product/ process in this case for possible improvements in local/ competitive & global scenario viz.

Local

- Avenues of changes in core manufacturing
- Engineering design and innovation
- Culture of continuous improvement
- Upliftment of skills
- New Job Creation

Competitive

- Cost competitive products
- High volumes of locally cast products

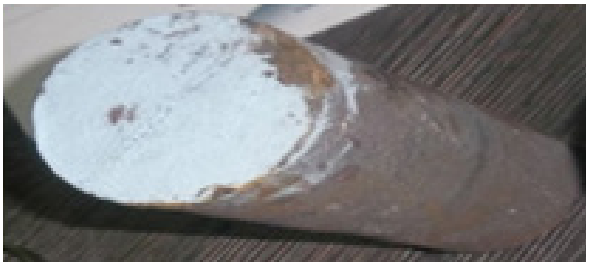

Figure 2(b)

Global Scenario

- Economies of manufacturing scale
- New Entrepreneurial Enterprise
- Export opportunities exploited

The Competitive Improvement interventions included: Product development from solid (figure 2 b) to hollow bar

Figure 2(c)

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castings (figure 2 c) for production of specialised automotive products.

Improvement in tooling from say drilling (of solid component) to boring (of hollow bar castings) and subsequent simplification of tooling (from complex tooling earlier used in this automotive products necessary for specialised surface features). The Change to the use of hollow pre-form lowered scrap and machining times (33%), to lower machining times, cost of tooling and saving in consumables.

Table 4.(a) Raw Material Savings

Material Saving	Mass	Cost
Solid component after fettling,	4.026 Kg	
Hollow component after fettling,	2.55 Kg	
Saving	1.476	
% reduction	37%	

The Outcomes/ net Returns On Investment (ROI), was total Savings in Material (37%), Machine times (33%) and saving in Consumables @ 40%. The details are classified as in table 4 (a).

There are attendant advantages of thinner casting w.r.t thicker ones. As the wall thickness of a tubular casting is lower, (because of its faster cooling that produces relatively much finer grains w.r.t that in solid one) the properties per unit area are superior. In a thicker piece the center may be subject to open grain, shrinkage, and inverse segregation, all with a high probability, threatening strength. On the other hand a hollow component may suffer of sand inclusions, duly separated from core sand, if coring practice is defective. In an otherwise sound casting free of discontinuities and inclusions, the one that is characterized by uniformly fine grains, exhibits better mechanical properties. Hence a hollow perform as a starting material yields more promise in terms of properties @ lower materials and risks. The gains in labour and overheads are reported in table 4 b.

Table 4.(b) Labour and Overheads

Savings in Machining	Cycle Time (labour)
Solid (Machining Times)	4.5
Hollow (Machining Times)	3
saving	1.5
Solid % reduction (time and cost)	33%

This gain is better than the theoretically one. To compute, the volume of a solid bar of diameter 'D' given by π. D^2.H/4 and of a hollow bar π. (D^2-d^2). H/4 for a thickness at half of the radius (the 'D' will be double than 'd'), then the weight of hollow bar would be $3d^2$ /$4d^2$ or 75% of the solid bar. The 25% scrap reduction not only leads to benefits as listed above, but also in handling of that material for melting/ or in raw material costs, inventory and transport etc. More optimization of thickness of hollow bar will lead to more of saving in machining, and also attendant improvement in as cast properties. This compliments with the time saving, energy saving, lower work relating heating of material and consequently higher life of tool because of reduction in work load. The reductions in costs of consumables are shown in table 4 (c).

Table 4.(c) Labour and Overheads

Consumables Saving
Solid (U- drill and other machining operations)
Hollow (no U- drill and some machining operations duly reduced)
Total cost reduction as % of solid castings machining cost)

The change in the state of starting material and simplification has led to advantages like faster and more reliable supply chain with high customer satisfaction, since process consistency was improved. Because of improved properties of cast tubular perform and simplicity in tooling, the probability of internal defects was also reduced. Such system advantage was instrumental in implementation of pull production. Of the approximate saving of higher than 30%, some cost advantage could be passed on to the customer, and thus there has been an increase in order book too.

Conclusion

As the experiences of implementation of make in India initiative, started in September 2014, have been mixed, more rigorous initiatives need be devised for the realization of actual objectives as lined up for this initiative. While the deceleration in contribution of manufacturing in GDP has though abated, yet it sustains to be erratic. There is therefore a dire need to proverbially sharpen the 'manufacturing axe' so that the scheduled make in India objectives are realized, as also the journey to strengthen India remains sustained.

The scope of this paper was lined up to look forward, beyond these above stated apprehensions to imbibe a schema that imparts it stability and surety. The new scenario of stability after analysis is expected to incorporate lean thinking. Lean implies being free of flab or wastages, which could be applied to both manufacturing and the context of

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lean product development. In context with former, that is in processes that cuts on wastages, the monitoring of flow calls for the need of creating a cultural change in people, as also in 'Make in India' initiative, where skilling India is duly accented. For applicability of Lean thinking in product development, the modus operandi and success has been evaluated citing a case study where multifarious advantages are demonstrated.

The theoretical understanding of Lean thinking is differentiated w.r.t the several styles of approach used with many assigning it a lower potency viz. some term it as buzzword or metaphor; more called it a tool; ranging to a concept, brainwave, mindset, a philosophy and so on. The understanding is expected in turn in, to control the motivation of implementation of lean, and also the commitment to accelerate the realization of pre- stipulated objectives.

References

1. Google Search https://www.google.com/search?q=scope+definition&oq=scope+definition&aqs=chrome..69i57.9579j0j7&sourceid=chrome&ie=UTF-8
2. What is a scope? Definition and meaning - Business Dictionary.com, www.businessdictionary.com/definition/scope.html
3. What is project scope? - Definition from WhatIs.com - SearchCIO https://searchcio.techtarget.com/definition/project-scope
4. Unit Manufacturing Processes: Issues and Opportunities in Research (1995), National Academic Press, https://www.nap.edu/read/4827/chapter/5
5. https://www.merriam-webster.com/dictionary/casting
6. McDuffie JP, Helper S. Creating lean suppliers: diffusing lean production through the supply Chain. FY'97 IMVP working papers, International Motor Vehicle Program (IMVP) 1997.
7. Thareja P. Zero Waste Processing – Competitive to Success (2012). Quality World, November 2012. Available at SSRN: https://ssrn.com/abstract=2262426
8. Aletheia Luna, What Is The Spiritual Meaning Of Involution? https://lonerwolf.com/involution/
9. Thareja P. A Total Quality Organization Thru' People (Part 21: Lean People, Mean People, Green People), FOUNDRY, An Indian Journal For Progressive Metal Casters 21(2, Issue 123): 41-48, May/June 2009. Available at SSRN: https://ssrn.com/abstract=1633896
10. What is a product? Definition and meaning - Business Dictionary.com www.businessdictionary.com/definition/product.html
11. Marketing 91 https://www.marketing91.com/what-is-a-product/
12. Thareja P et al, Inn valuation - The skill set for Make-in India initiative in IoT era, Trends in Mechanical Engineering & Technology *STM Journals* 2016.
13. Thareja P. Foundry 4.0 – With its Set-a-light Goal? FOUNDRY. *An Indian Journal for Progressive Metal Casters* 2017; 29(1): 27-34.
14. Thareja P. Directions in Production Engineering Research. *Journal of Advanced Research in Production and Industrial Engineering* 2014; 1(1): 12-24.
15. Gershenson JK, Pavnaskar SJ. Eight Basic Lean Product Development Tools, International Conference on Engineering Design, Iced 03 Stockholm, August 19-21, 2003.
16. Hopp WJ, Spearman ML. To Pull or Not to Pull: What Is the Question? Manufacturing & Service Operations Management 2004; 6(2):133-148. https://doi.org/10.1287/msom.1030.0028
17. Lean - Lean Manufacturing and Six Sigma Definitions leansixsigmadefinition.com/glossary/lean/
18. Shingo S. The Shingo Prize Production Management System: Improving, Process Functions. Productivity Press, Portland, Oregon 1992.
19. John Bicheno and Matthias Holweg, the Lean Toolbox, A Handbook For Lean Transformation Fifth Edition, Production and Inventory Control, Systems and Industrial Engineering (Picsie) Books Buckingham, 2016
20. Thareja Priyavrat (1998), Holes in Methoding, Souvenir, 46 th Indian Foundry Congress and International Foundry Exhibition, New Delhi.
21. Thareja P. Use of 'Not' In Dfx For Tomorrow's Most Competitive Manufacturing, Proceedings of National Conference on Trends in Mechanical Engineering, TME 2007, Aeronautical Society of India and CIET, Distt Patiala, Jan 19, 2007.
22. Rayport JF, Sviokla JJ. Harvard Business Review - Exploiting The Virtual Value Chain, Harvard Business Review, Sep–Dec, 1995; 3.
23. Ben Mulholland, 9 Lean Manufacturing Principles to Kill the Jargon and Get Quality Results, 2018, https://www.process.st/lean-manufacturing-principles/
24. Pereira R, Genchi Genbutsu: Do You Really Understand It? February 13, 2009. Available https://blog.gembaacademy.com/2009/02/13/genchi-genbutsu-do-you-really-understand-it/
25. Poppendieck M. Principles of lean thinking. IT Management Select. 2011; 18(1): 1-7.
26. Cooke B, Williams P. Construction Planning, Programming & Control, Oxford, *UK*, Wiley Blackwell.
27. Chahal AS, Thareja P. Green Foundry Development Through Casting Simulation and QFD (August 6, 2011). *Indian Foundry* 2009; 57(8): 57-62. Available at SSRN: https://ssrn.com/abstract=1931485
28. https://en.wikipedia.org/wiki/Lean_manufacturing
29. NIST. 1998. Principles of lean manufacturing with live simulation users manual. Gaithersburg, MD: NIST

Manufacturing Extension Partnership.
30. Holweg M. The genealogy of lean production. *Journal of Operations Management* 2007; 25: 420-437.
31. Sharma N et al. Lean Manufacturing Tool and Techniques in Process Industry. *International Journal of Scientific Research and Reviews*. 2013; 2(1): 54-63
32. Liker JK. 2014b. Developing Lean Leaders on All Levels – a practical guide. Winnipeg, Canada: Lean Leadership Institute Publications.
33. Warnecke HJ, M.Hüser. Lean production. *International Journal of Production Economics* 1995; 41(1&3): 37-43.
34. Womack JP, Jones DT, Roos D. The Machine that Changed the World: The Story of Lean Production, New York, Harper Perennial, 1990.
35. FE Mangano Modernization of Manufacturing with Cybersecurity at the Forefront M Sc. Theis, University of Michigan-Dearborn 2018 available https://deepblue.lib.umich.edu/.../49698122_CIS699%20-%20Mangano%20Thesis%2...
36. Pavnaskar SJ, JK. Gershenson, Jambekar AB. Classifi cation scheme for lean manufacturing tools. *int j prod res* 2003; 41(13): 3075–3090.
37. Mossman AP. Managing Director, The Change Business Ltd. United Kingdom. Telephone interview 9th January 2014.
38. Womack J, Jones E. Lean Thinking. Simon & Schuster. 1996.
39. Bhasin S, Burcher P. Lean viewed as a philosophy. *Journal of manufacturing technology management* 2006; 17(1): 56-72.
40. Ebbs PJ, Sexton P, Green smith DG et al. *In: Proc. 23rd Ann. Conf. of the Int'l. Group for Lean Construction*, Perth, Australia, 28-31 July, 2015: 496-506, available at www.iglc.net
41. Ugochukwu P etal. Lean in The Supply Chain: A Literature Review. *Management and Production Engineering Review* 2012; 3(4): 87–96.
42. Thareja P. Inculcating the Necessary Wisdom About Environment Through Quality Pedagogy. Proceedings of National Seminar on Environmental Management in Metallurgical Industries, 2011. Available at SSRN: https://ssrn.com/abstract=2015246
43. Thareja P, Kaushik SK. Vsm in Aid Of Lean Production In Automotive Industry-A Case Study' Proceedings of the 8th International Conference on Manufacturing Research ICMR 2010- Advances in Manufacturing Technology XXIV (Ed Professor V I Vitanov and Prof D Harrison) 2010.
44. Appelbaum SH, Gallagher J. The competitive advantage of organizational learning, *Journal of Workplace Learning* 2000: 12(2): 40-56.
45. Thareja P, Sharma A. Leaning Pizza to Value Production for Competence (Visualizing Value in Pizza to Profit) *Journal of Production Research & Management* 2011; 1(1): 1-18. Available at SSRN: https://ssrn.com/abstract=1830070 or http://dx.doi.org/10.2139/ssrn.1830070
46. Thareja P, Sharma DD, Mahapatra PB. Holean Education-The Paradigm for Thee. *Omniscience: A Multi-disciplinary Journal* 2011: 1 (1): 1-21.
47. Kumar R, Kumar V, Singh S etal. Managing the utility of manufacturing process facilities through Lean Supply Chain. *Journal of Advance Research in Production and Industrial Engineering* 2015; 2(1): 13-23.
48. Taleghani M. Key factors for implementing the lean manufacturing system. *Journal of American Science* 2010; 6(7): 287-91.
49. Keegan R. Becoming Lean – Practical steps to build competitiveness. Cork, Ireland: Oak Tree Press 2014.
50. Akers P, 2 second lean – How to Grow People and Build a Fun Lean Culture at Work & At Home. 2nd Ed. Bellingham, WA: Fastcap Press 2012.
51. Hines P, Holweg M, Rich N. Learning to evolve: A review of contemporary lean thinking. *International Journal of Operations & Production Management* 2004; 24(10): 994-1011.
52. Teich ST, Faddoul FF. Lean Management-The Journey from Toyota to Healthcare. *RMMJ* 2013: 4(2): 1-9.
53. Umstot D. President, Umstot Project and Facility Solutions, LLC. United States. Telephone interview 9th January 2014.
54. Thareja P. Manufacturing Paradigms in 2010. Proceedings of National Conference on Emerging trends in Manufacturing Systems, JMIT, Radaur, Mar 2005.
55. Pettersen J, Defining Lean Production: Some conceptual and practical issues, 11th QMOD Conference. (Quality Management and Organizational Development Attaining Sustainability From Organizational Excellence to Sustainable Excellence); 20-22 August; 2008 in Helsingborg; Sweden.
56. Repenning, Sterman. Creating and sustaining process improvement, California Management Review, Summere 2001; 1-8.
57. Sohal A, Eggleston A. Lean production Management. 2004; 14: 1-17.
58. Thareja P. Each One is Capable (A Total Quality Organisation Thru' People). FOUNDRY, *Journal For Progressive Metal Casters*, 2008; 20(4): 1-13. Available at SSRN: https://ssrn.com/abstract=1488690
59. What is Value Chain Analysis? Definition, Model & Example supplychainopz https://www.supplychainopz.com/2013/06/what-is-value-chain-analysis.html
60. (NFTN) presentation, National Foundry Technology Network. https://pmg.org.za/files/150811NFTN.ppt
61. Mrugalska B, Magdalena K. Wyrwicka Towards Lean Production in Industry 4.0, 7th International Conference

on Engineering, Project and Production Management, Procedia Engineering 2017; 182: 466-473.

62. Thareja P, Kaushik SK. VSM in Aid of Automotive Industry's Lean Operations: A Case Study. *Journal of Advanced Research in Production and Industrial Engineering* 2015; 1(2): 13-24.
63. Sutcliffe AG. The Encyclopedia of HumanComputer Interaction, Requirements Engineering, 2nd Edition. M. Soegaard and R. F. Dam, Eds. Aarhus, Denmark 2014.
64. Womack J, Jones D. The Machine that Changed the World: The Story of Lean Production; Harper Perennial: New York, NY, USA, 1991.
65. Mascitelli R. The Lean Product Development Guidebook, Technology Perspectives, Northridge, CA, 2007.
66. Darlington M, Culley S. A model of factors influencing the design requirement. *Des Stud* 2004; 25(4): 329–350.
67. Li X, Ahmed-Kristensen S, Daalhuizen J. Identifying design requirements for emerging markets. In 11th International symposium on tools and methods of competitive engineering (TMCE 2016) 2016.
68. Beata Mrugalska and Magdalena K. Wyrwicka / Procedia Engineering 2017; 182: 466 - 473.
69. Matthias Loskyll et. al. Context-Based Orchestration for Control of Resource-Efficient Manufacturing Processes, Future Internet 2012; 4: 737-761.
70. Mrugalska B, Magdalena K. Wyrwicka, Towards Lean Production in Industry 4.0, 7th International Conference on Engineering, Project and Production Management, Procedia Engineering 2017; 182: 466 – 473.
71. Thareja P. Exploring Qualte-k-nology for a breakthrough tomorrow (quality of, say, particulate technology knowledge), *OmniScience: A Multi-disciplinary Journal* 2019; 3(2): 12-26.
72. Thareja P. Green Manufacturing with Steel Swarf, WHY WASTE BE AXED, Journal of Materials and Metallurgical Engineering, 2014; 4(3): 21-31.

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