Virtual Trading System For Rapid Manufactured products

Conference or Workshop Item

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ABSTRACT
Rapid Manufacturing (RM) has the potential to have an impact on a number of industry sectors. This paper presents research into a dynamic business model for the RM industry, where the supply and demand is matched over a Virtual Trading System (VTS). This is necessary because at present, the RM supply chain for many sectors is still in its infancy. In order to exploit the potential benefits of RM, the industry needs a supply chain model and this is where the VTS can be employed. The VTS is proposed as a platform where the entire RM industry can function in a competitive and mutually beneficial environment. It is based on the concept of an e-business mechanism. This paper introduces some core features of the model such as *E-Catalogue* and *Reverse Auction,* both being part of a *Trade Engine*.

KEYWORDS: Rapid Manufacturing, Supply Chain, Virtual Trading System, E-business, Reverse Auction

1. INTRODUCTION

Rapid Manufacturing (RM) has evolved from Rapid Prototyping (RP) technologies that have been successfully used to physically create designs and concepts. RM is concerned with the direct manufacture of parts and components using additive manufacturing techniques [1]. RM differs from traditional production technology in that the *modus operandi* is not subtractive or formative (machining and moulding respectively), but rather, is additive in the way it layers up parts during manufacture. One of its particular advantages over these traditional techniques is that no tooling is required to manufacture a component [2].

The use of RM could possibly solve some long standing supply chain problems. According to the Pareto rule [3], 20% of items make up 80% of sales, whereas 80% of items are not in high demand. These are parts where inventory holding logistical costs are high in relation to production costs [4]. The expense of repairable spares for aircraft engines and avionics contributes greatly to the financial outlay of airline operators. These parts, though low in demand, are critical to operation and their unavailability could lead to excessive down time costs. The situation is significantly similar in the case of spare parts manufacturers other than in the aerospace industry, e.g. automobile spare parts sellers. It is possible that RM could be utilised to manufacture some of these parts.

However, RM is still thought by some people as a mere extension of RP [5]. In practice, the major difference between the two is in the supply chain where RM products are intended for end use, not just as a prototype. However, a number of companies are undoubtedly performing RM with RP methods [1]. In order to take advantage of the vast benefits of RM, a comprehensive business model needs to be in place. A business interested in utilising RM could choose to outsource the technology use, install their own RM facility or even could

alternate between them. Whatever the scenario, it is certain a business model is needed where all components of the supply chain including the network of suppliers, original equipment manufacturers, designers, engineers or even customers who are all geographically apart, have to communicate. In addition there is need for supply chain intelligence. Supply chain intelligence is the coupling of business knowledge and technical knowledge [6]. This paper presents research into a dynamic business model where supply and demand for RM products can be settled electronically.

2. ICT TECHNOLOGY

In the course of this research, the objective has been to identify different solutions to the existing supply chain problems in the RM industry. In this venture, a literature review was conducted to identify developments in other fields that could have a beneficial impact on the RM industry. It is important to note that Information Communication Technology (ICT) has grown in maturity such that it has had a profound impact on the spectrum of a whole range of industries. According to the Economist Intelligence Unit UK [7], the UK is one of the top ten global locations for doing e-business. The UK has a particular strength in the key aspects of the ICT infrastructure typically required by international companies, including: the e-business environment, availability of broadband, availability of Wi-Fi and provision for secure servers [8]. It is due to these factors that the UK has a very high e-readiness ranking as can be seen in Table 1. Therefore, it is no wonder that the UK is a very lucrative place for doing electronic commerce. Electronic commerce or e-business can be defined as any electronic communication that facilitates the exchange of goods, services or other assets between suppliers and buyers. It is also termed as Business-to-Business or B2B, which can be classified as including sell-side (e-catalogues), e-marketplaces, trading partner agreements and buy-side (e-procurement) [9].

Country	**Rank**	**Score (out of 10)**
Denmark	1	8.88
USA	2	8.85
Sweden	2	8.85
Hong Kong	4	8.72
Switzerland	5	8.61
Singapore	6	8.60
United Kingdom	7	8.59
Netherlands	8	8.50
Australia	9	8.46
Canada	13	8.30
China	56	4.43
Indonesia	67	3.39
Iran	69	3.08

Table 1: E-readiness rankings (Source: Economist Intelligence Unit, 2007 [7])

3. VIRTUAL TRADING SYSTEM (VTS)

This paper argues that an e-business platform could potentially provide an alternative to the RM industry, in terms of supply chain functionality. The VTS is a proposed e-business model for electronically settling the demand and supply for RM made products. It is important to note that the VTS is proposed as a work environment for RM products, but it could possibly have a proportional impact on the number of products that could be manufactured using RM. A process diagram of the VTS is provided in Figure 1.

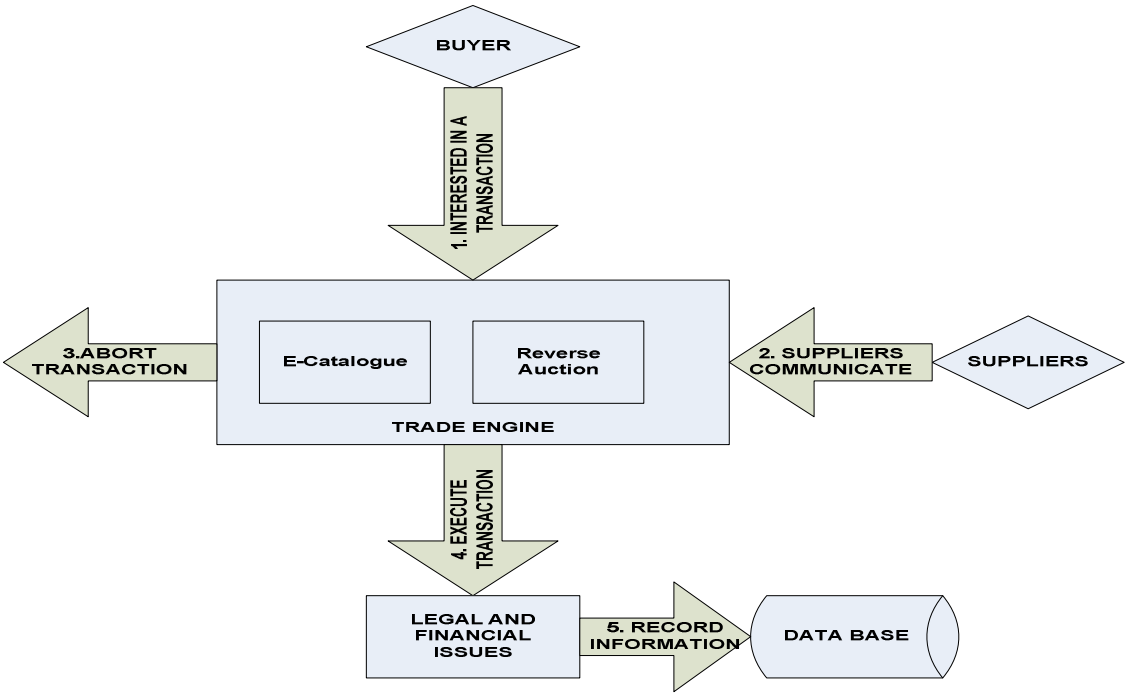

Figure 1: A process diagram of the VTS

3.1 Trade Engine

The trade engine is the mechanism through which the VTS is expected to support the trading of RM products. The trade engine can offer buyers two separate processes to communicate with potential suppliers. The processes are reverse auction and e-catalogue, described further below.

3.1.1 Reverse Auction

This paper proposes reverse auction as a method for settling the demand of RM products online. At the heart of any auction model is the concept of personal price elasticity. That is, customers will determine the price depending upon the price/value trade-off [10]. Reverse auction can be defined as a process where buyers set up an auction to receive bids from suppliers. Suppliers bid down the price for fulfilling that order [11]. One leading online commerce company, Freemarkets, claims that customers buying through it should be able to save around 20% on their supplies. Freemarkets says that it ran auctions valued at €5.2 billion in Europe alone in 2001, saving customers €860 million. Worldwide auction turnover has

reached $30 billion with savings of $6.4 billion [12]. These numbers suggest that there is a significant justification for utilising online auctions to conduct purchases. The format of a possible reverse auction process is tabulated in Table 2.

1. Prepare detailed electronic product specification. This includes the digital CAD data of the intended product.
2. It is important to produce a clear requirements specification as it will help suppliers in bidding and also make post-auction evaluation more straightforward.
3. The platform is notified of the potential bid sought.
4. The suppliers express their primary interest to participate in the bidding process.
5. The buyer can potentially restrict suppliers, who could participate in the auction.
6. Start of the reverse auction event. Buyer and suppliers access the event through the internet. They can log in and out of the event to view and place bids. Suppliers bid anonymously against each other. There is no limit to the number of individual bids and the event can last any timescale as determined by the buyer.
7. Reverse auction closes. The bids are analysed according to preset criteria available. The buyer can use bid evaluation tools and assessment engines in this regard.
8. The buyer decides on awarding contracts.

Table 2: Reverse auction process

3.1.2 E-Catalogue

E-catalogue is another proposed method to buy and sale RM products through the VTS. Online catalogues, as a means of selling products, are firmly established in the market (Sweets, AEC info, Barbour Index) [13]. 3D ContentCentral [14] is another example of a web based catalogue, where designers can host their 3D data. The catalogue proposed in this research is a digital database or pool of parts that can be manufactured using RM. A product in the catalogue will have the supplier's information sheet as well as the 3D CAD data. The selection of a catalogue can be described in a three step process which is tabulated in Table 3.

1. Browse the catalogue.
2. Select a product to purchase.
3. Contact the appropriate supplier.

Table 3: E-catalogue selection process

3.2 Legal Framework, Monetary Channel and Database

After a buyer is satisfied and when they decide to place a purchase order (the agreement between the buyer and seller), logistic partners and the financial mechanism have to be

covered by a legal framework. The legal framework should be governed by international, national and platform protocols.

All the monetary transactions are proposed to be performed through the existing banking mechanism, such as remittance (bank to bank transfers), electronic fund transfers or other suitable alternative means.

The database is used to keep a record of all the transaction history including financial and technical details. This is to ensure traceability of parts and would exist as evidence for any future legal matters.

3.3 Potential Services

There are potentially five services that the VTS can offer and these are as follows:

Sourcing or discovery - giving buyers an easy access to a pool of suppliers, a process that can save time and offer buyers better prices due to the increase in competition amongst suppliers.

Demand identification - suppliers can identify customers and their demands in a free market economy.

Transaction - the actual exchange of procurement information, such as purchase orders, between the buyer and supplier.

Content - through the e-catalogue that could contain a vast volume of products, the buyer can acquire the required product.

Promotion - advertisement for suppliers through the e-catalogue.

3.4 RM Versus Tooling

To put the use of RM in context, a short case study example follows which highlights how the effectiveness of a VTS might be capitalised on. The top moulding of a hand-held electronic device about the size of a telephone handset was tooled in China in 2007 for €3,000, with each part costing €0.43 based on an order of 1,000 units. The same part presumed suitable for RM, using Selective Laser Sintering, would cost around €45.00 each. This means that the first 1000 parts would cost a total of €3,430 produced conventionally, or €45,000 produced using RM. The 'break even' production point, below which RM would be cheaper than injection moulding, would be 67 parts [15]. The above analogy is bound to raise the question "*Why use RM then?*" The answer lies in two of the most important benefits of RM: that is, (i) making complex geometries possible with apparently no additional cost; and (ii) customisation. The fact is that there is an increasing market for such products across economies and the break even batch size of 67 or less as it is in the above analogy is not a factor anymore. The VTS can thus capture the market for such exclusive products across different economies and could essentially support the demand and production for such products to flourish.

4. A CASE ANALYSIS: THE CLASSIC BIKE INDUSTRY

The following case analysis is taken as an example to illustrate how the increase in market size induced by the VTS could pay dividend. Classic Suzuki bikes dating from 1960's are extremely popular and demand for spare parts has created a multi-million (sterling) niche market. It is expected that sooner or later, bike manufacturers, including Suzuki, will render many parts from older bikes obsolete. Before going further, it is important to have a look at the market size of the classic spares industry. Table 4 provides a distribution of motorcycles in the Organisation of economic co-operation and development (OECD) countries.

Country	Population	1987	1997	Change +/-
Austria	8,169,929	14.1	25	78%
Belgium	10,274,595	13.3	22.1	67%
Czech Republic	10,256,760	44.9	42.6	-5%
Denmark	5,368,854	8.2	10.6	30%
Finland	5,183,545	9.7	12.8	32%
France	60,765,983	14.9	16.9	14%
Germany	83,251,851	24.2	33.1	37%
Greece	10,645,343	18.3	54.4	197%
Hungary	10,075,034	37.6	14.8	-60%
Italy	59,715,625	38.5	45.5	18%
Netherlands	16,491,461	8.6	23.1	168%
Norway	4,525,116	6.0	11.6	94%
Poland	38,625,478	35.5	21.8	-39%
Portugal	10,084,245	11.6	25.5	120%
Spain	45,061,274	21.2	33.7	59%
Sweden	8,876,744	12.0	13.8	14%
Switzerland	7,301,994	36.8	58.0	58%
United Kingdom	59,778,002	13.3	11.3	-15%
Australia	20,434,176	21.6	16.9	-22%
Japan	127,433,494	32.0	35.6	11%
Korea	49,044,790	19.7	53.5	171%
USA	301,139,947	20.2	14.3	-29%
OECD Median		18.3	22.1	21.0%

Table 4: Number of motorcycles per 1000 population OECD nations 1987 and 1997, (Source: Organisation for Economic Co-operation and Development (OECD))

Now considering that classic bikes represented 2% of the motorcycle population in 1987, it is estimated that the market has a global value of £134.3 Billion divided into three main regions [16]:

USA	£42.5 Million
European	£64 Million
Asia and Australia	£27.8 Million

There is definite potential that RM could be used to make some of these spare parts due to their complex geometry and exclusive nature of the demand. A situation where parts could be manufactured on demand is more ideal than to have them on the shelf. The VTS can potentially ensure that the global demand and proportionate supply of RM products for the industry is captured.

4.1 Manufacture of an Impeller

A typical spare part is considered to be manufactured for experimental purposes. The part shown in Figure 2 is an impeller for a water pump in a motorcycle. Research was conducted and quotations were sought from different RP/RM bureaus. The results were found to be quite interesting. One of the bureaus quoted a single unit production using the 17-4 PH SS material to be £383.00 whereas a 15 unit production with the same material would be £186.00. This result seems to support the analogy that the increase in market size brought about by the VTS would ensure that economy of scale is taking affect. However, other results would give a different picture. A bureau quoted the production of the same part to be £633.56 in stainless steel whereas another manufacturer quoted £450 excluding other charges as their base price. The important thing to note is that these manufacturers would charge the same respective unit price as the number production unit increases. The argument for these manufacturers is that they calculate their cost on the build time and for certain units of production they therefore charge the same unit cost. The above mentioned argument can be associated with the RP philosophy. RM is concerned with repeated manufacturing and more than one unit of production can be made in the same build volume which is perhaps not required in RP. It is hoped that the increase in RM production due to using a VTS would eventually lead to a revamp of the pricing structure used by the manufacturers.

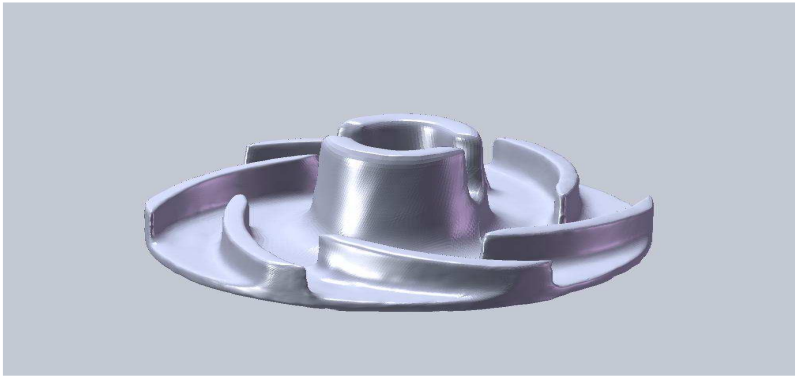

Figure 2: An impeller for a water pump in a motor cycle

5. CONCLUSION

The discussions that have been put forward in this paper are concepts resulting from current research on formulating supply chain and implementation strategies for RM technologies. The paper has essentially put forward a plan for an online trading system for RM products and has identified two mechanisms through which trading of RM products can be conducted, namely, reverse auction and e-catalogue. The latter half of the paper describes the market and scope of the classic motorcycle industry, as it is a potential area for RM application; and price quotations from market research on production of an impeller is provided to illustrate the existing anomaly in a cost analysis of manufacturers. It is expected that the potential services of the VTS as mentioned in this paper could provide an alternative option for the supply and demand of RM products to function. However, the biggest impact the VTS could have is perhaps to increase the existing market size for RM products. This is because the VTS in theory could accommodate different components of the supply chain located globally to execute trade and thus, result in a potential world wide operation.

ACKNOWLEDGEMENTS

This research is part-funded by the European Regional Development Fund *Rapid Manufacturing North West Project* and the Higher Education Innovation Fund. Additionally, the authors wish to acknowledge the input of Dr Phil Reeves of Econolyst Ltd in the support of this Project and its activities. Additional thanks are also extended to Mr Martin Crooks of Crooks Motorcycles Ltd for his participation in this research.

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