WHITE PAPER

ACHIEVING SUSTAINABILITY WITH CIRCULAR ECONOMY FOR INDUSTRIAL MANUFACTURERS

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Theme

Building a smart circular economy by integrating ERP, blockchain and IoT for remanufacturers and making it pandemic-proof. This will set the pace for a Live Remanufacturing enterprise.

Abstract

Remanufacturing is a globally accepted phenomenon today with its own ways of measurement through 'material circularity indicators'. This paper provides an overview of the current supply chain and manufacturing processes, and exposes the challenges in reconditioning and remanufacturing from a process and technology viewpoint. It further proposes a solution and process flow as integrated architecture of enterprise resource planning (ERP), blockchain and Internet-of-Things (IoT). It details the benefits of technology adoption in the overall industry scenario and how it can help create a digital eco-system. The paper looks at the benefits in individual areas of supply chain like demand and supply planning, inbound logistics and remanufacturing. It takes readers through the enabling factors for remanufacturing and technology adoption like product characteristics and business drivers. It ends with a summary of the benefits achieved by adopting technology, thereby enabling digitalized, transparent and touchless supply chains, the hallmark of post pandemic preparedness towards a live enterprise.

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Introduction

A 'circular economy' promotes responsible usage of materials, reusing them as much as possible instead of a use-and-throw approach. It is aimed at eliminating waste and the continual use of resources. In other words, it espouses "make, use, return, remake, and use". In simple terms, circular economy promotes remanufacturing, thereby reducing the burden on natural resources, with a positive impact on climate while reducing landfills. Above all, it also offers a competitive product at a reduced price. A study by Ellen MacArthur Foundation with McKinsey & Company in 2015 determined that this model of remanufacturing could generate US $1 trillion worth of new business for the global economy. Neverthless, only 9% of the overall global economy is circular today [10, 12].

Companies like Timberland are making shoes out of recycled tires [14]. Nike recycles end-of-life athletic shoes into other shoes, thereby enabling the circular economy [15]. Today, the circular economy and remanufacturing are gradually gaining traction around the world. Ellen MacArthur Foundation (a leading global organization) works to accelerate the transition to a circular economy. The Foundation has initiated the Material Circularity Indicators Project to estimate the amount of circularity practiced in products and businesses [2]. Though the Material Circularity Indicators are vital, these do not include the method or technology to improve it. Remanufacturing in an industrial scenario is more complex and needs detailed analysis. This paper specifically focuses on industrial remanufacturers, their processes and challenges. It provides a technology-driven roadmap to solve and improve on these bottlenecks.

In order to improve the Material Circularity Indicators for industrial manufacturers, we recommend a holistic view of the process from a system and technology perspective. A systematic approach connects remanufacturnig, demand/supply planning and supply chain operations in ERP systems with the processes and networks used by manuafcturing partners to acquire used materials. This helps recreate an effective supply chain map that acts as the stepping-stone for improvement. Figure 1 shows a high-level representation of the concept and how different systems come together to enable a circular economy. Such a view brings out the dependencies and challenges.

This paper analyzes processes, partners and their dependencies. We also identify the key challenges and problems that hinder visibility of demand and supply among trading partners, which reduces trust, thwarts seamless operations and impedes the adoption of a circular economy. The paper then provides a solution to the problem through the mature use of the latest technology and best practices. The solution takes into account the current pandemic problem and is designed and tuned for a post-pandemic world.

Business problem

Business process

As per Ostlin [1], any re-manufacturing process comprises three subprocesses, namely, collection, remanufacturing, and redistribution. For a manufacturer, collection and redistribution are externally focused while remanufacturing is internally focused. Together, collection, remanufacturing, and redistribution enables the circular economy for the product.

Fig 1 shows a topographical map of remanufacturing. It indicates the collection, remanufacturing, and redistribution subprocesses. The red boxed zone is the internal focus area of the manufacturer dedicated to manufacturing. This area comprises material analysis, disassembly, cleaning, inspection, reusing, replacing, and reassembly. The red box processes are mostly done in ERP systems. The external focus is on acquiring used products (used materials) for the remanufacturing facility. This is what connects the green and red boxes. Re-distribution is represented in the green box.

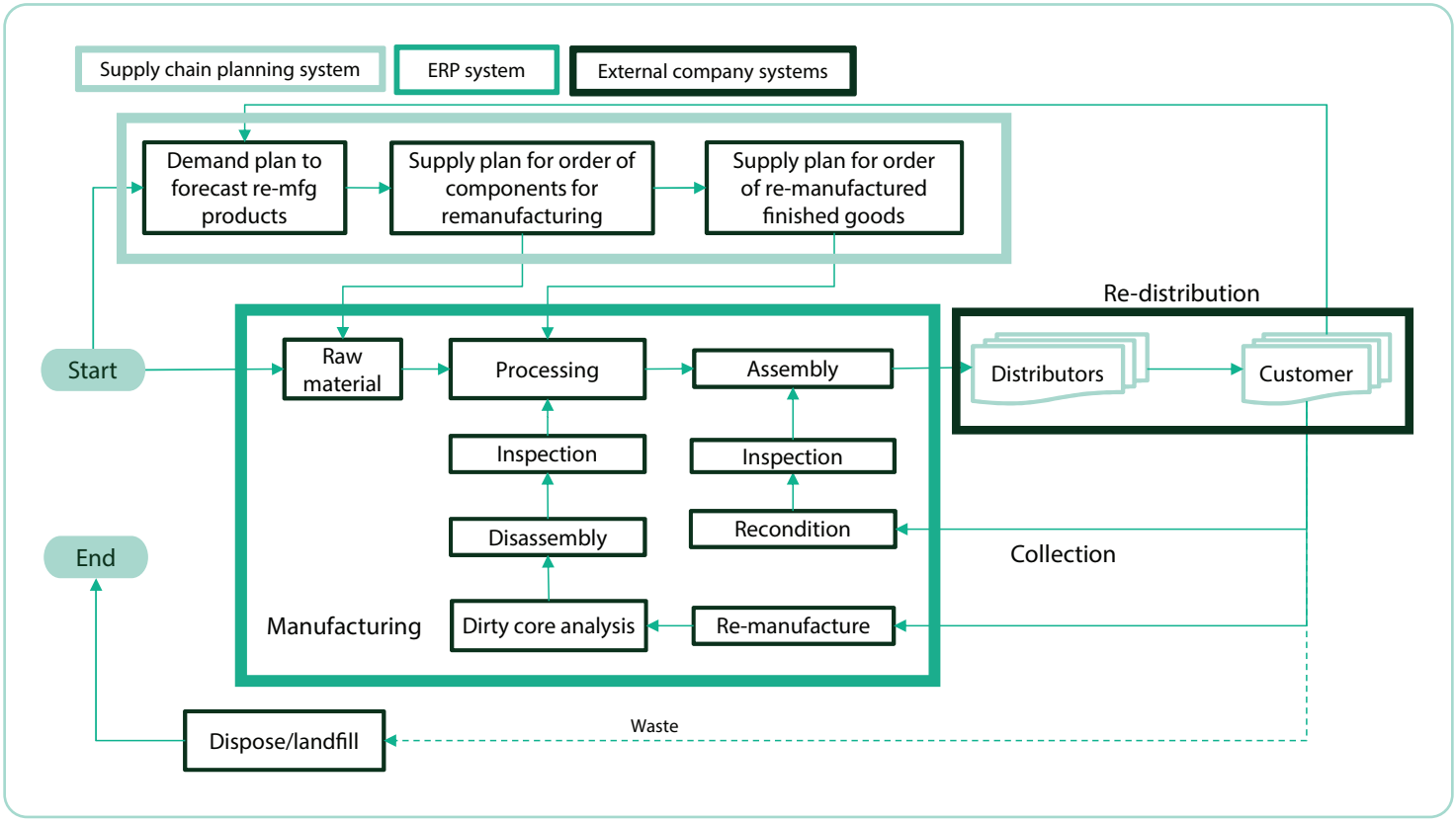

Fig 1: Overview of remanufacturing supply chain with identified systems

Problem description

There is no standardized process or defined system to reclaim used materials from customers. Every company has its own established recovery channels that are highly people dependent. This makes the used material recovery process unpredictable and prone to variability. It causes process disruption. Further, matching demand with the right supply is very challenging. Due to lack of processes and systems, the returned products suffer from quality, timing and availability issues. Thus, for remanufacturers, collection is a people-dependent labor-intensive task. The COVID-19 situation has further magnified this problem due to reduced availability of manpower and lack of systems.

Most remanufacturers depend on suppliers to source used materials through deposit-based, credit-based, and buy-back mechanisms [3]. This leads to many suppliers and the consequent challenge of managing them. A greater number of suppliers/intermediaries also increases the chances of loss of IP of the original product. But remanufacturers have no visibility of the end customer from where the product is being salvaged or even the intermediaries. There is no system to support such sourcing and it often completely depends on the relationship with the supplier. Most manufacturers never include reverse logistics as a focus area to recover end-of-life products. They assign the task of returns to their channel partner/supplier and lose visibility into returns [4]. Another challenge is the arrival of unnecessary parts along with the used materials (needed product). This leads to storage constraints in warehouses along with issues of disposal and additional processing. This causes time delays and increases processing cost and overheads. Similarly, damages during dismounting, transportation and reckless handling is another problem for lower remanufacturability.

1. No systematic and transparent way to trace back-end customers who are salvaging the product. This leads to:
   a. *Lack of visibility on returns*
   b. *Unpredictable returns.*
   c. *IP losses from intermediaries*
2. Challenging demand-supply scenario for remanufacturing due to:
   a. *Unpredictable quantity from used material suppliers*
   b. *Unpredictable quality of used material as received*
3. The sourcing of used materials for remanufacturing is human-driven and relationship-based. This involves many suppliers [3].
4. Logistics planning is another challenging aspect of sourcing the cores [4]
5. A COVID19-like pandemic can complicate the problem due to dearth of manpower
6. Arrival of unwanted/unknown parts along with the used materials causes space constraints in warehouses, disposal issues and additional processing time and cost
7. Reckless handling during transportation causes parts damage

Fig 2 summarizes all the above problems faced by remanufacturers and represents it figuratively. It is to be noted that these limiting factors also impact the Material Circularity Indicators of the product as its reuse becomes restricted. Solving these problems will not only improve the Material Circularity Indicators but increase overall business benefits.

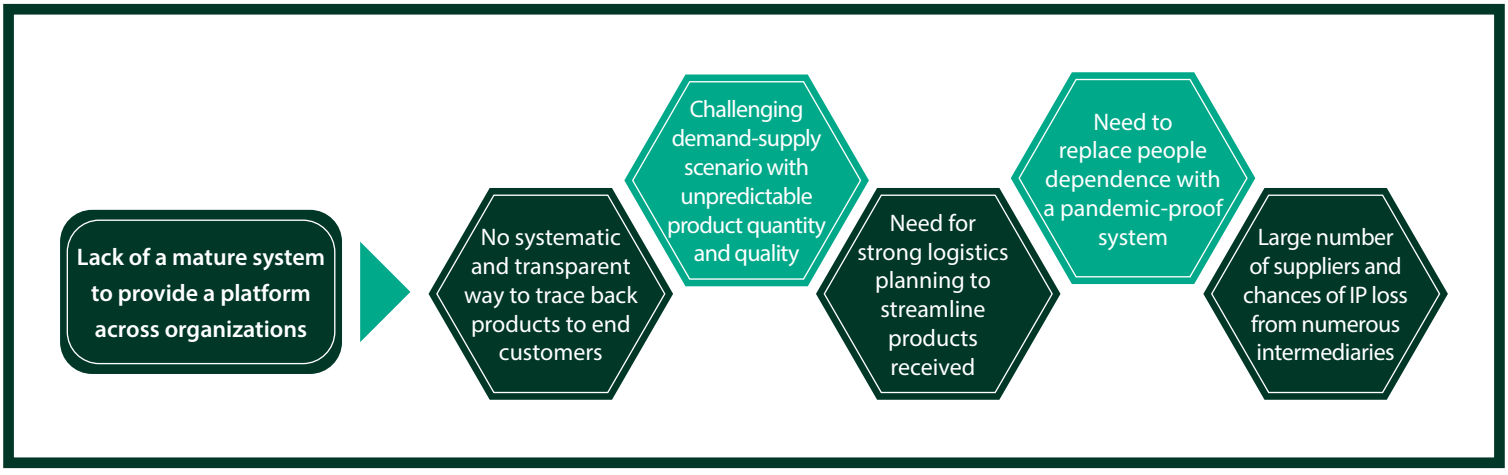

Fig 2: Summary of the problem

Solution - Blockchain and IoT for a circular economy

The typical flow of materials in a supply chain begins from the supplier ecosystem to the manufacturer for parts, systems and subsystems. In a circular economy, the thrust is to get the products back from the customer and recondition or remanufacture them as shown in Fig 1. The problem, as highlighted in Fig 2, points to a disparate system for recovery, leading to lack of visibility, predictability and traceability. It is also believed that the lack of traceability and transparency can lead to product damages. Moreover, without the right systems, this entire process is mostly manual.

Solution overview

For a problem of this scale, a mature integrated ERP-blockchain system can be a game changer. This can be enriched with IoT systems design and configuration, which can be very useful for remanufacturers. When a finished product from an OEM completes its forward supply chain journey to the end customer, it should be registered in a blockchain network along with the transfer of ownership. This would be similar to the installed base of the ERP system but with enriched features and complete traceability of transfer of ownerships across all intermediate partners. The blockchain network will help the remanufacturer trace the actual owner salvaging the product, thereby removing intermediaries. This will speed up the recovery process and bring in efficiency, transparency and cost benefits. The blockchain network will have smart contracts that can trigger maintenance and end-of-life actions. This will remove human dependence, making it a touchless and digital process. Having IoT in this process design will enable appropriate parties (remanufacturers or distributors) to receive data directly from the installed product directed with warranted action. The data can include status of operation, anomalies or problems and can be sent via the blockchain to the relevant party. It is important to note that not every product can be installed with IoT sensors; so, this design must be optional.

Fig 3 shows the value chain of the remanufacturer. The high-level process flow shows how IoT, blockchain and ERP will integrate and enable material and information flow seamlessly. The figure shows the forward supply chain and how the blockchain system will register the transfer of ownerships. As the product nears end-of-life, the reverse flow begins and the IoT-blockchain system informs the distributors to start the collection process and send it to the manufacturer. This drastically reduces intermediaries and brings in time and cost efficiencies along with predictability.

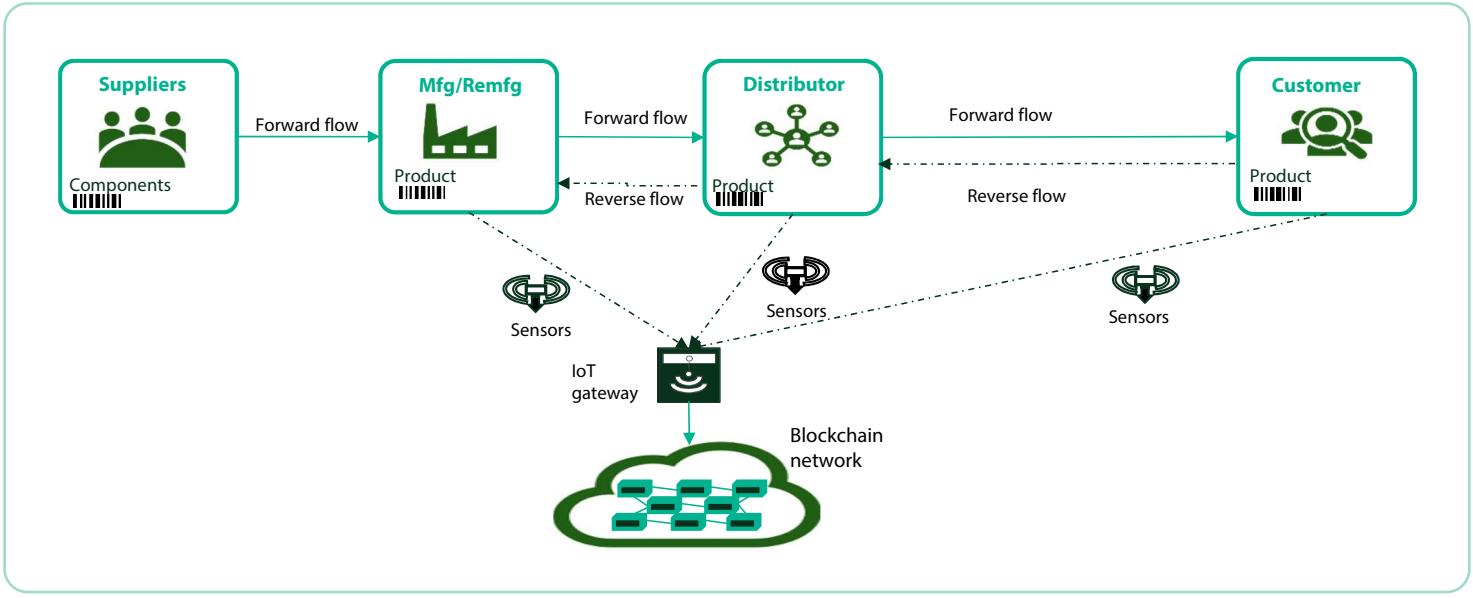

Fig 3: A value chain with manufacturing and remanufacturing depicting forward and reverse flows with IoT and blockchain

Detailed design with ERP-blockchain and IoT

Today, there is no mechanism for remanufacturers to track a product back to the end customer and retrieve it. They depend on the distributor or supplier to provide the used materials. This is why it is unpredictable in quality and quantity. With the high-level solution described in the previous section, Fig 4 provides the detailed flow of the process. It depicts the different systems involved and the complexity of the architecture to sell and retrieve products from different entities. Fig 4 depicts both forward and reverse supply chain flows. It illustrates a process flow that integrates ERP systems of different trading partners along with the blockchain network (with smart contracts). It also demonstrates how all of this comes together to provide a seamless, transparent, and predictable mechanism for used material returns. The uniqueness of the solution is the blockchain network's ability to act as a platform. It brings all partners together, thereby improving transparency, predictability and cohesiveness towards a common goal.

In Fig 4, the supplier provides components to manufacturers who build the product and ship it to the distributor who then sends it to the customer. A blockchain system will register the transfer of ownership. IoT systems can also remotely send data on product status and problems, if any. This data can be reposited in blockchain network so that it can be accessed by the required partner. Smart contracts on blockchain can trigger the approval mechanism for a return process to the distributor in their integrated ERP system. Upon approval, this will trigger the return process with appropriate partners. IoT is not depicted in the process flow in Fig 4. However, IoT sensor information can help distributors assess whether the product should be reconditioned or returned for remanufacturing.

The following sections explain how blockchain will impact individual processes:

Demand planning: Blockchain provides visibility into end customers and how long they are using the product. This information can be used by manufacturers for demand planning, thereby improving accuracy. IoT sensors can optionally provide data on product condition to the manufacturer, thereby improving demand planning confidence. Besides improving visibility and accuracy, this reduces the unpredictability of product quantity. Today, without any system, the demand plan is blind and relies only on historical data. The return forecast can also positively impact the manufacturer's forward selling plan, thereby driving revenue.

Blockchain smart contracts can trigger the approval mechanism, bringing visibility into the return process from customers to manufacturer. This has tremendous value for manufacturers as they can now logistically schedule the return process, negotiate rates for truck usage, and drive cost savings. The visibility will also help manufacturers monitor those partners handling the return products, thereby ensuring better handling and reducing damage. Further, IoT devices and smart contracts together can provide insights on the conditions of the return, thereby addressing the challenge of unpredictable quality. Finally, this will help the distributor to forward plan the replacements, thereby driving revenue and providing cross-sell opportunities.

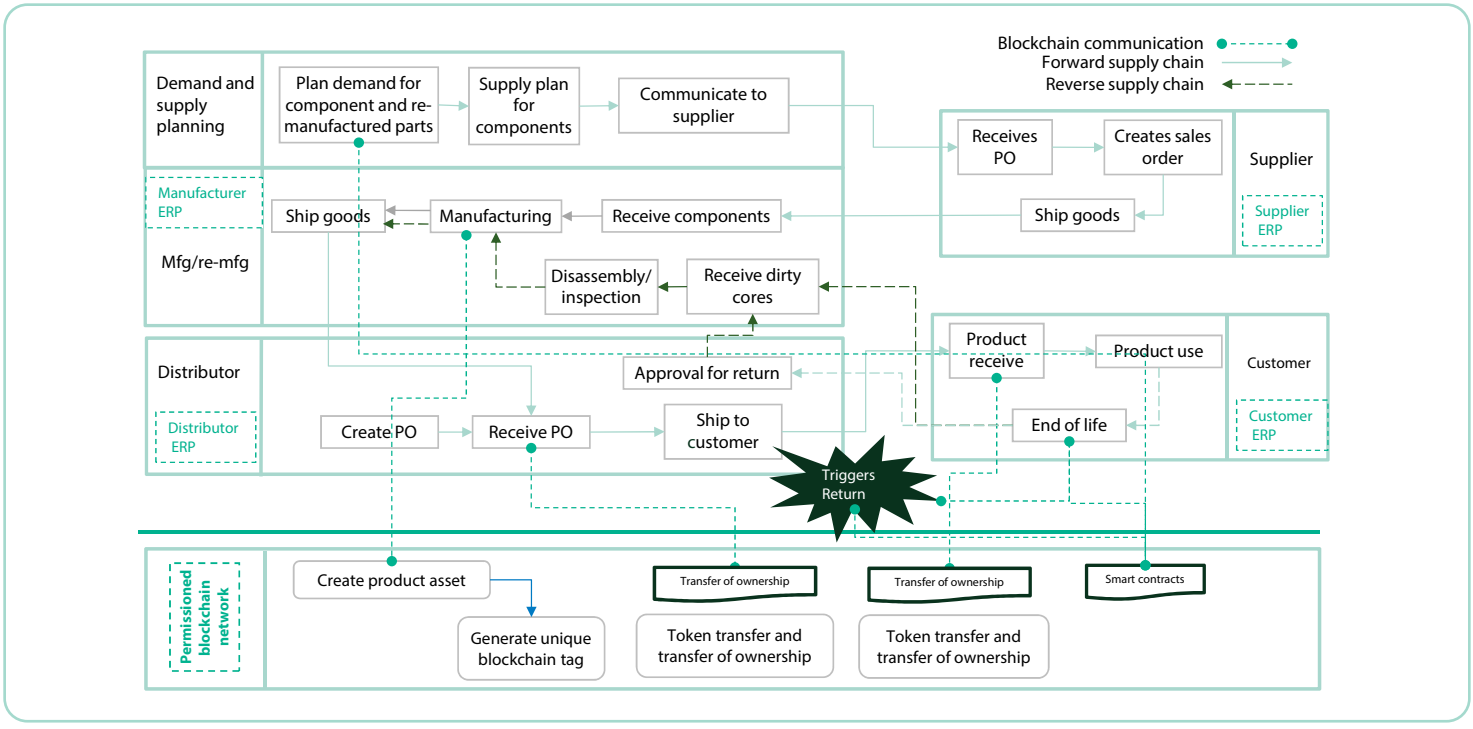

Fig 4: Detailed design of process flow with blockchain for circular economy

Remanufacturing: With more predictable quantity and quality, the disassembly, inspection and manufacturing processes can be streamlined. The problem of getting additional parts along with the core is solved as the distributor filters parts from the customer before sending for reconditioning / remanufacturing. Since the distributor and / or manufacturer has visibility into end customers and the status of operations, this will greatly improve the customer connect and maintenance mechanism, thereby extending the lifespan of the product. This will serve the overall brand value of the product.

With blockchain, the sourcing of the used materials will be a system-driven, touchless and transparent process. Such system architecture will reduce dependence on humans, greatly benefiting the post COVID-19 world. It will permit environment-friendly and better remanufacturing processes, thereby driving cost efficiency and customer satisfaction. These systems and processes will improve the Material Circularity Indicators of the product as more products are returned and reused, thereby reducing the landfills.

Connected Live Remanufacturing Enterprise: Having a connected ERP with other digital capabilities like IOT, Blockchain paves the way for other capabilities like cloud technology adoption, analytics on cloud to name a few. All of these can together transform to a live enterprise. Having a real time visibility of end customers and its product usage, visibility of logistics for returning products, reducing unpredictability, improving quality and IT enabling a disassembly, inspection and manufacturing process are all a hallmark of a connected, live and vibrant enterprise. Having a next-gen IT landscape, architecture, and technology driven processes are the cornerstones of an efficient live enterprise.

Adoption of remanufacturing in industries–A brief walk-through

There are companies that have remanufacturing as one of their major business lines or initiatives. This section looks at the business aspect of remanufacturing and the adoptability of IoT and blockchain. Overall, the adoption of IoT and blockchain must be done with a strategic perspective.

Manufacturers will need to provide a convincing story to bring together distributors and customers in a way that delivers efficiency and benefits as described in earlier sections. The cases highlighted in Table 1 demonstrate that blockchain for circular economy is a reality with valid, viable and doable use cases. Table 1 summarizes different scenarios possible in the circular economy.

Scenario	Enabling circular economy	Product characteristics	Business case for blockchain
Recycle	Sourcing batteries and recycling Cobalt and Lithium [5].	Rare materials that are limited in supply, ethical sourcing, and reuse of rare materials.	• Shortage of materials • Traceability needs for rare metals *Blockchain is implemented but customers should be integrated into the network for greater benefit.*
Refurbish or Remanufacture	Honeywell used an aircraft component marketplace for hot gas path components in aircraft engines and gas turbines [6].	Costly product, critical in performance, and intellectual property protection.	• Regulatory requirement • Margins • IP protection *Blockchain will help reclaim the proprietary product and protect IP.*
Refurbish, remanufacture or redistribute	Diesel engines, fuel pumps, injectors, and actuators from Cummins [7]. Through remanufacturing Cummins Inc. claims it uses 85% less energy compared to the manufacturing of new products [9].	Commoditized parts but with reliability, durability and performance.	• Cost effective • Environment friendly • Warranty • Conserving energy and resources *Blockchain will increase predictability of product availability from customers.*
Regular return/ recall	Consumer goods, electronic items, and Apple's Daisy robot [8].	Minerals and mines dependent products, environmentally degrading products, and high usage rate of products.	• Reduce impact on climate change • Conserve resources • Energy efficiency *Blockchain will enforce a system of return and make product availability more predictable.*
Recycle/ clean-up	Global plastic recycling ecosystem driven by blockchain technology [11,12].	Reduce plastic waste, basic recycling system, and cost-efficient waste management.	Every minute 15 metric tons of plastic reaches the ocean from land-based sources. Empower, a Norwegian company is creating a plastic recycling system using blockchain technology. The system is being tested in 10 countries. BASF has launched reciChain to improve circularity of plastic in the supply chain.

Table 1: Examples of products and their typical characteristics for circularity scenarios

These use cases highlight that companies are adopting remanufacturing and refurbishing to help conserve energy, resources and environment. Blockchain and IoT will integrate with the ERP system and bring in process efficiency, transparency and traceability to onboard customers and distributors. It will also enable IP protection, cost effectiveness, predictability, and faster time to market.

Discussion and conclusion with benefits

By listing examples on reuse of products in everyday life, this paper emphasizes industrial remanufacturing and points to a growing global acceptance of the circular economy. It introduces the concept of Material Circularity Indicators and focuses on the business process for remanufacturing. It also highlights the challenges faced by manufacturers that have adopted remanufacturing and how these impact growth and Material Circularity Indicators of products.

The integrated solution proposed in this paper brings together the business process flow with the blockchain network and multiple ERP systems. It highlights how IoT will bring in more efficiency into the network, thereby solving the challenges faced by industrial remanufacturers. The paper addresses these problems with an inclusive and integrated architecture of ERP-IoT-blockchain that will be open for any satellite system integration in future. Blockchain with IoT acts as a platform to bring all partners together with seamless data integration.

Such an approach holds multiple benefits including:

(1) Reduced cost of remanufactured product due to lower input cost

(2) Reduced cost of sourcing the product as it will need fewer sourcing personnel and lower departmental load on sourcing and tracking. This will also reduce reverse supply chain cost through fewer intermediaries like agents, suppliers, etc.

(3) Reduced burden on landfills, thereby helping the environment

(4) Wider variety as companies can offer more recycled products to customers

(5) Improved predictability of return, thereby stabilizing the reverse supply chain and reducing cost of operations

(6) Traceability of intermediaries, thereby protecting IP

(7) Traceability and information on end customer that will improve longevity of product, performance, and efficiency through better maintenance

(8) A digital, touchless and transparent supply chain, which is the hallmark of post-pandemic preparedness.

Appendix

Details on smart contracts for blockchain design for industrial remanufacturers. There will be multiple smart contracts used in this scenario such as:

- Blockchain integrated and enabled with IoT can set reminders to the distributor ERP system for regular maintenance schedules
- The same system can trigger an approval mechanism on the distributor ERP system from blockchain to inspect whether the product has reached end of life and needs to be returned or not
- There can be smart contracts that can send relevant data to manufacturers like usage/maintenance record details for consideration during inspection
- Upon shipment for remanufacturing, the blockchain system can trigger replacement parts to the distributor
- Smart contracts can provide an estimated end-of-life time to the manufacturer for forecasting purposes
- Smart contracts can validate the manufacturer of the product to the returning manufacturer, thereby reducing chances of error

References

[1] Ostlin, J. Analysis and Managing Material Flow and re-manufacturing Process. Ph.D. Thesis, Linköping University, Linköping, Sweden, 2008. Available online: https://www.diva-portal.org/smash/get/diva2:18334/FULLTEXT01.pdf (accessed on 10 May 2020).

[2] Material Circularity Indicators An Approach to Measuring Circularity, Available online: https://www.ellenmacarthurfoundation.org/assets/downloads/insight/Circularity-Indicators_Project-Overview_May2015.pdf (accessed on 10 May 2020).

[3] Sundin, E. and Dunbäck, O., 2013, Reverse logistics challenges in re-manufacturing of automotive mechatronics and electronic systems. Available online: https://www.diva-portal.org/smash/get/diva2:611763/FULLTEXT01.pdf (accessed on 13 May 2020).

[4] Krishnan, R., 2013, The Rise Of re-manufacturing, Available online: https://www.manufacturing.net/industry40/article/13057345/the-rise-of-re-manufacturing. (accessed on 13 May 2020).

[5] Sasha Banks-Louie, Jan 2020, Available online: https://www.forbes.com/sites/oracle/2020/01/27/volvo-mines-blockchain-to-keep-ethical-sourcing-promise/#19eb1077eb60. (accessed on 19 May 2020).

[6] Shah, A., 2019, Available online: https://www.wsj.com/articles/honeywell-brings-blockchain-to-used-aircraft-parts-market-11559072819. (accessed on 19 May 2020).

[7] Cummins, Available online: https://www.cummins.com/components/electronics-fuel-systems/aftermarket-reman (accessed on 20 May 2020).

[8] Scheyder, E., and Nellis, S., 2020, Available online: https://in.reuters.com/article/us-usa-minerals-recycling/apple-pushes-recycling-of-iphone-with-daisy-robot-idINKBN1Z925S (accessed on 20 May 2020).

[9] Cummins Inc. Sustainability Progress Report 2016. 2016. Available online: https://www.cummins.com/sites/default/files/files/reports/2017_cummins_sustainability_progress_report_1017.pdf (accessed on 10 May 2020).

[10] Ellen Macarthur Foundation, 2015, Available online: https://www.ellenmacarthurfoundation.org/news/the-ellen-macarthur-foundation-publishes-a-new-executive-summary-report, (accessed on 22 May 2020).

[11] The Explorer, Available online: https://www.theexplorer.no/solutions/empower-blockchain-powered-plastic-waste-collection/. (accessed on 22 May 2020).

[12] Morais, M., 2022, Available online: https://www.the-future-of-commerce.com/2020/01/08/circular-economy-examples/. (accessed on 22 May 2020).

[13] BASF, Canada, Available online: https://www.basf.com/ca/en/who-we-are/sustainability/Sustainability-in-Canada/reciChain.html. (accessed on 22 May 2020).

[14] Hower, M., 2015, Timberland, Omni United Launch First Tire-to-Shoe Lifecycle Brand. Available at https://sustainablebrands.com/read/products-and-design/timberland-omni-united-launch-first-tire-to-shoe-lifecycle-brand, Access on 12-May-2020.

[15] Reuse-a-shoe program of Nike, Available at https://purpose.nike.com/reuse-a-shoe, Access on 12-May-2020.

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