SUSTAINABILITY

# Adopting Circularity in the Lubricants Industry

**By Dr. James Wakiru**

Dr Wakiru (PhD-Mechanical Engineering) is a seasoned industrial engineer with work, research and training experience in the maintenance, reliability, lubrication, productivity and technical marketing field. He is also a Senior Lecturer at the Dedan Kimathi University of Technology. He can be reached on:
james.wakiru@lubesafrica.com

Circular Economy (CE) is considered an innovative approach used to increase company resource efficiency by keeping products and equipment functioning for as long as possible. Many authors concur that CE incorporates reuse, remanufacturing, recycling and maintenance of products[1]. The Circular Economy model has already been promoted for instance, in the European Union (EU) by Directive 98/2008/EC, which seeks to protect the environment and human health by preventing or reducing waste generation and its management. Moreover, it enforces the need for efficient use of goods crucial to the transition of a Circular Economy. The directive specifies the waste hierarchy: prevention, reuse, recycling, recovery for other purposes –such as energy recovery- and disposal.

The traditional business models have been based on a linear approach which is phased and brings forth the manufacturing of products which after use, are disposed of; while the circular approach provides economically viable ways to continually reuse products and materials, utilizing renewable resources where possible[2].

It is essential that organizations have to develop product design and business model strategies that will transition them from a linear to a circular or closed-loop model.

The Circular Economy model can be achieved generally in either of the three ways. First, slowing resource loops, where the product is designed for long life or life extension strategies. This is intended to extend the use or utilization period of a product. Second, closing resource loops incorporates recycling, where disposal is eliminated; hence the gap between production and after-use is closed. Lastly, resource efficiency or narrowing resource flows retains the aspect of using minimal resources per product.

Reuse encompasses life extension and reduction of waste disposal strategies. It is the process of using the component again, whether for its original use or different purpose and without carrying out any significant repair. Two options under reuse include: the use of the product in the same or other functions and the production of the new component through recycling. These activities align with the definition of CE in industrial ecology, where the economic and environmental value of the component is safeguarded for as long as possible by keeping the component in the economic system as well as by lengthening its life using maintenance or reuse.

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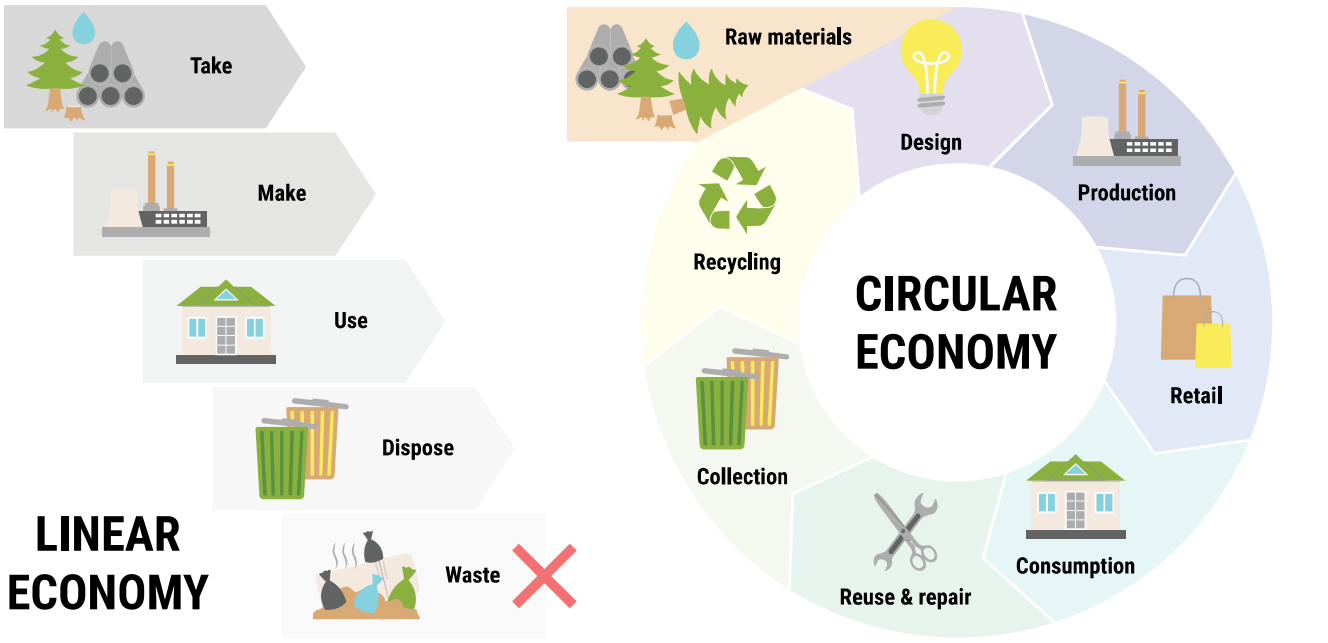
### Lubricant lifecycle and End of Life (EOL)

The lubricant lifecycle commences from the oil well for the mineral-based lubricants, where the crude is extracted, then refined in a refinery to generate base oil. Subsequently, blending produces the lubricant and the useful life commences when the lubricant is charged into a system.

In the use phase, the lubricant is exploited until its properties effect are depleted and the lubricant is replaced with a new one. The used oil waste is collected and incinerated, mixed with heavy fuel oil for burning or disposed of or refined anew.

On the flip side, used oil is categorized as hazardous waste containing harmful or toxic elements and metals. It is estimated that one litre of used oil could contaminate one million litres of fresh water. A significant amount of used oil ends up in the environment, hence the

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» need to reduce this amount which could be achieved by eliminating waste or extending the useful life of the lubricant so that reduced waste is achieved hence adapting circularity.

### Adapting to circularity

Under the traditional linear approach, used oil generated requires to be disposed of. However, with the Circular Economy approach, measures must be taken to either reduce or eliminate used oil to be disposed of to the environment, or increase the useful life of the lubricants.

The Circular Economy resource loop considers the lubricant's useful life to the disposal stage hence the loop could be closed to eliminate disposal or slowed to increase the useful life; thus, not getting to the disposal stage sooner.

The key strategies to achieve circularity as discussed in the following section includes: slowing the resource loop and closing the resource loop.

### Slowing the resource loop: Using highly durable lubricants

Slowing the resource loop entails extending a product's useful life to slow down the overall flow of resources by extending the product's life. It is said that the greenest product is usually the one that already exists as it will not exploit new resources to produce it. This CE strategy seeks the reuse of goods over time, through the design of long-life goods and product life extension. Two options are fronted to address slowing resource loop:

a) Development of long-life products
In this strategy the long-life product should ensure long utilization periods; that is, retain long durability. The product should be designed to provide physical durability (Design for durability). In this case, it can take or withstand wear and tear without breaking down. In the Lubrication field, lubricants break down when some of the critical performance properties deplete in performance and effectiveness. To adapt to circularity therefore, lubricants for instance with high oxidation resistance, optimal total base number, antiwear additives and other aspects will last longer in use. This will subsequently reduce the frequency and magnitude of a waste generation hence slowing the resource loop. In addition, the design for reliability of the product ensures that the product will operate for a specified period without failure. This could be entrenched by using high-performance lubricants such as synthetics which provide a guaranteed period of operation without failure when maintained in accordance with the manufacturer's recommendations or instructions.

b) Entrenching product life extension
This strategy includes extending the use period of a product by using various techniques to extend its life; including but not limited to: reuse of the product, maintenance, upgrading the product technically or a hybrid of the aforementioned techniques. To encapsulate this circularity strategy, a fleet operator may use high-performance lubricants or synthetic lubricants which provide an extended drain interval, for instance, change from an API SL with a drain interval of 5,000 km to an API SN with an extended drain of say 8,000 Kms.

In plant setup, the strategy may include effective maintenance of the lubricant in use; for instance, using Condition Monitoring and intervening with some partial charge and additive boosting which ultimately will extend the useful period of the lubricant. Arguably, accurate Condition Monitoring will ensure timely and

targeted maintenance intervention[3].

### Closing the resource loop: Refining used oil

Closing the resource loop entails creating a circular flow through the reuse or recycling of resources. The recycling leads to the closing of the loop between post-use and production, resulting in a circular flow of resources. This can be achieved by either technological or biological cycle design:

### Technological cycle design

In a Circular Economy, the idea is to recycle the products, or part of them, to reuse them. A product can be upcycled (reprocessed to a higher value product) or downcycled (reprocessed to a lower value product). To establish continuous flow of resources in the technological cycle, the "waste" resources are to be recycled into material having properties equivalent to those of the original material.

Adapting this circularity strategy in lubricants retains the recycling of the used lubricant which totally incorporates the philosophy of sustainable development in its daily activities. An advantage retained by re-refining the used lubricant is that not only is the waste oil reduced, but also, the use of precious resources like crude oil to produce lubricants is reduced. In addition to this strategy being feasible for waste oil management, it is possible to achieve high quality base oils with no harmful substances producing zero or minimal waste.

### Biological cycle design - Biodegradability

This is aligned to products consumed during their service or wear during use; hence, the products are designed with safe and health related materials. A plausible example is the Total Loss Lubricants, where the lubricant is partly used up at the friction point due to aging, evaporation, bleeding, and leaks. A total-loss oiling system is a lubrication system in which oil is introduced, and then either burned or ejected overboard, which can affect people's health and the environment. Potential lubricants as examples include the mist lubrication in compressors, metal cutting, drilling fluids, mould release agents which most of the times are not recycled.

Due to the inherent nature of the product leaking or bleeding or evaporating to the environment, the product should be designed to mitigate the effect to the environment and people's health.

**Circularity involves slowing the resource loop and closing the resource loop. Slowing the resource loop entails extending a product's useful life while Closing the resource loop entails reuse or recycling of resources.**

These lubricants plausibly should be designed with "recycling" in perspective. An important way of recycling these types of lubricants (in addition to the technological cycle design), includes the composting in the earth surface instead of destroying the soil. This potentially involves the designing of the lubricants to be biodegradable.

Lubricant biodegradation is the chemical breakdown of lubricants by living organisms (microorganisms such as yeast, fungi and bacteria) in the environment. Readily biodegradable test standards, indicate typically a minimum of 60% degradation of a substance must occur during a 28-day incubation period. The use of natural plant esters in lubricant design and production provides superior biodegradability over other lubricant base stocks such as mineral (petroleum) or synthetic base oils.

Embracing biodegradable lubricants will play a significant role in adapting Circularity in the lubrication field.

Summarily, in the life cycle of sustainable lubricants, used oil management is critical. Used oil which is no longer useful can still be used as a fuel in the production of cement, lime, and steel. Used oil can also be re-refined for use in the production of fuel and base oil. In addition, it is a valuable raw material as a hydrocarbon source similar to coal, crude oil, and natural gas. Base oil made from used oil (re-refined) has a privileged place in the lubricants sector due to its position in the Circular Economy. Lubricants formulated with a re-refined base oil and released to the market have a positive impact on the life cycle in the areas where they are used; thus, creating significant benefits, primarily in terms of Carbon Footprint.

Integrating Circular Economy concerns at an early stage in the product design process is important because once product specifications are made, only minor changes are usually possible – it is difficult to make changes, once resources, infrastructures, and activities have been committed to a certain product design.

Regulations could be put in place by various governments for Circular Economy to be achieved. For example, the Lubricant producers could be obligated to collect a certain percentage of the lubricants they release to the market. An example is in Turkey, the lubricant producers are required to collect 10% of the lubricants they release to the market in 2021, 15% in 2022, 20% in 2023, and 25% in 2024, while used base oil produced from used oil at a rate of 8% in 2022, 12% in 2023, 15% in 2024, and in subsequent years, at rates consistent with the Ministry's goals.

Organizations and individuals should be intentional while integrating circularity approaches in the daily operations. This will ensure the world reduces the effect of waste and optimally exploit the products in use. ■

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