Source: *Tabla!,* p8
Date: 13 January 2017

Factories of the future

MANUFACTURING is essential for sustained economic growth. Gross Domestic Product contribution of manufacturing ranges from 15 to 25 per cent of national economies. Manufacturing accounts for a quarter of worldwide employment.

Recognising the importance of the manufacturing sector, several nations launched generously funded programmes to innovate and build factories of the future. Singapore's Research, Innovation and Enterprise plan, known as RIE2020, has a major thrust on Advanced Manufacturing and Engineering. Other examples from Asia include Make in India, China Manufacturing 2025, Digital Korea, and Japan's Industrial Value Chain Iniative. Germany's Factories of the Future and the UK's Innovative Manufacturing are examples from Europe. Similarly America launched the US Advanced Manufacturing Iniative.

Worldwide total investment exceed tens of billions of dollars.

What are the opportune domains for innovation and entrepreneurship? What are the new drivers?

Digital manufacturing and zero-waste manufacturing are new popular themes. Digital manufacturing leverages advances in digital technologies to model, design, simulate and analyse machines, tooling and input materials in order to optimise the manufacturing processes and produce customised products for local markets.

The benefits of digital manufacturing include improved productivity, resource efficiency and customised mass production. Resource efficiency means optimal utilisation of materials, energy and water in the manufacturing of products, thus eliminating pollution and reducing costs. It also leads to the aspiration of zero-waste manufacturing.

According to the United Nations Environment Programme (UNEP), manufacturing is responsible for 20 per cent of global CO2 emissions. There is a growing realisation that the current trajectory of increasing resource consumption is unstainable. The UNEP advocates voluntary product declarations, which identify products according to their environmental and social attributes. Such information brings benefits across the whole value chain in terms of resource efficiency gains, reduction of production costs, manageability of the chain, trustful relationships with suppliers and credibility of the company brand.

Well-known companies are leading the way. For example, Apple requires environmental checklists to go along with new product launches. According to Frost and Sullivan, car manufacturers aim for 90 per cent of a vehicle's materials content to be recycled, reused or used for energy recovery in the US.

Zero-waste manufacturing involves designing products and processes such that no trash is sent to landfills or incinerators. The wider scope envisaged means eliminating all emissions during manufacturing to land, water or air that are a threat to planetary, human, animal or plant health.

One approach is to redesign products and materials selection suitable for reuse. Another approach is to conserve and recover resources from the used products, and use them in manufacturing new products. Another emerging trend is remanufacturing or reconditioning. A*STAR Singapore established the Advanced Remanufacturing Technology Centre to apply remanufacturing concepts to aerospace and engineering industry products. Words such as recycling, upcycling and closed-cycle manufacturing succinctly capture the motivations in terms of enhanced product life span, more efficient use of resources, easier recycling, and less pollution during the manufacturing process and life of the product.

Life Cycle Engineering (LCE) approach aims at waste prevention as opposed to the end-of-life waste management. It is a whole systems approach that aims to change the way resources flow during the full life cycle of the product, thus resulting in zero waste. It involves restructuring production and distribution systems, selection of materials, redesign of product and packaging to reduce waste. LCE enables strategies for continually working towards eliminating wastes.

Emerging new manufacturing technology, widely known as 3D Printing or Additive Manufacturing, has the attributes of zero-waste manufacturing. In this method, successive layers of materials are formed under computer control to create a product. Products are produced directly using digital model data from a 3D model.

Digital technologies such as sensors, industrial Internet of Things, big data analytics, algorithms, artificial intelligence and cloud computing are also necessary to realise zero-waste manufacturing. For example, General Electric Company has been investing billions of dollars on the Predix system for connecting millions of industrial equipment, analysing data, and delivering real-time insights so as to improve resource efficiency.

Manufacturing waste is diverse. In the near future, a web-enabled collaboration platform can be envisioned via data and knowledge about whether a particular waste is recyclable or transformable into a useful resource that can be shared among manufacturing companies, recyclers and product designers. Using such a web-based platform, manufacturing wastes or by-products are physically exchanged between different companies from within and across industries, thereby waste-to-resource matching is dynamically facilitated. Moreover, decisions can be made based on the economic and environmental viability of the exchanges.

Challenges for this development include codifying the vast and growing amount of tacit knowledge on multitude of manufacturing wastes and resources. Industrial Symbiosis, devised by International Synergies Limited, UK, is an example. It aims to capture under-utilised resources generated by industrial processes and repurpose it for use as a "new" input into another process by one or more companies, thereby yielding mutual benefit or symbiosis, and more efficient utilisation of material streams, energy, water and other assets.

Industrial Symbiosis approach has been cited as the best practice within the European Waste Framework Directive, and for systemic innovation vital for future green factories by the OECD.

Changing the way the products are made will go a long way towards mitigating manufacturing's negative environmental impact. Substantial investments are being made around the world to innovate manufacturing. Zero-waste manufacturing forms an important component of factories of the future and zero-waste smart cities. This backdrop makes zero-waste manufacturing a fertile ground for innovation and entrepreneurship.

➥ tabla@sph.com.sg

Professor Seeram Ramakrishna, is from the Department of Mechanical Engineering, National University of Singapore; Chair, Future of Manufacturing Technical Committee, Institution of Engineers Singapore and Co-Lead, Smart Manufacturing Expert Group, SPRING, Singapore

In association with

NPS

WORLD SCHOOL ib

UNIVERSITY of CAMBRIDGE
International Examinations
CAMBRIDGE INTERNATIONAL CENTRE

Source: Tabla! © Singapore Press Holdings Ltd. Permission required for reproduction.