Pearson BTEC Levels 5 Higher Nationals in Engineering (RQF)

Unit 48:
Manufacturing Systems Engineering

Unit Workbook 1

in a series of 1 for this unit

Learning Outcome LO1 to LO4

Manufacturing Systems Engineering

edexcel Approved Centre

1 CONTENTS

2 INTRODUCTION

This Workbook guides you through the learning outcomes related to:

Illustrate the principles of manufacturing systems engineering and their relevance to the design and enhancement of manufacturing systems.

Manufacturing systems elements:
Elements to be considered include quality, cost, delivery performance and optimising output.

Problem-solving and managing complexity, maintenance scheduling and planning, resource planning and productivity.

Effect of testing and data analysis on performance.

Use a range of analysis tools, including value stream mapping, to determine the effectiveness and efficiency of a manufacturing system, and then develop an appropriate future state for that system.

Analysis tools:
Introduction to value stream mapping, and the value of both current state mapping and future state mapping.

Bottle-neck analysis, by using process improvement tools and techniques e.g. value stream analysis, simulation, kanban.

Using key performance indicators to understand the performance of a manufacturing system e.g. overall equipment effectiveness, lead-time, cycle time, waiting time, yield, delivery performance, safety metrics.

Reviewing key performance indicators; methods for presenting metrics and performance e.g. balanced scorecards, performance dashboards, Andon boards, Gemba walks.

Outline the impact of different production planning approaches on the effectiveness of a manufacturing system

Production planning approaches:
Examples of production planning strategy: push vs pull factors, kanban systems, make to stock, make to order and engineer to order.

Production planning approaches such as batch and queue, pull/kanban, just-in-time, modular design, configuration at the final point, and master scheduling.

Production planning management tools:
Enterprise Resource Mapping (ERP) systems, Material Resource Planning (MRP 2) and Manufacturing Execution systems, ability to managing complexity and resourcing through information technology.

Industrial engineering issues: the importance of standard times and the impact on productivity and the costing of products. Standard work underpins the repeatability of process and quality control.

Review the functions of manufacturing systems engineering and how they enable successful organisations to remain competitive.

Effectiveness of manufacturing systems:

Plant layout design, planning and control, productivity and continuous improvement, quality control and equipment effectiveness.

Return on investment and capital expenditure, control of the cost of planned maintenance.

Manufacturing information technology: the supply of data from the process to decision-makers e.g. failure modes for both product and system, maintenance and down time data, standard times for production, material control, energy usage.

IMPORTANT NOTE:

It is recommended that in conjunction with this Workbook, that you also read "round your subject". This means accessing and reading the references and other material given in this workbook as well undertaking your own research.

3 GUIDANCE

This document is prepared to break the unit material down into bite size chunks. You will see the learning outcomes above treated in their own sections. Therein you will encounter the following structures;

Purpose

Explains *why* you need to study the current section of material. Quite often learners are put off by material which does not initially seem to be relevant to a topic or profession. Once you understand the importance of new learning or theory you will embrace the concepts more readily.

Theory

Conveys new material to you in a straightforward fashion. To support the treatments in this section you are strongly advised to follow the given hyperlinks, which may be useful documents or applications on the web.

Example

The examples/worked examples are presented in a knowledge-building order. Make sure you follow them all through. If you are feeling confident then you might like to treat an example as a question, in which case cover it up and have a go yourself. Many of the examples given resemble assignment questions which will come your way, so follow them through diligently.

Question

Questions should not be avoided if you are determined to learn. Please do take the time to tackle each of the given questions, in the order in which they are presented. The order is important, as further knowledge and confidence is built upon previous knowledge and confidence. As an Online Learner it is important that the answers to questions are immediately available to you. Contact your Unit Tutor if you need help.

Challenge

You can really cement your new knowledge by undertaking the challenges. A challenge could be to download software and perform an exercise. An alternative challenge might involve a practical activity or other form of research.

Video

Videos on the web can be very useful supplements to your distance learning efforts. Wherever an online video(s) will help you then it will be hyperlinked at the appropriate point.

4 INTRODUCTION TO MANUFACTURING SYSTEMS ENGINEERING

Manufacturing is the production of merchandise for use or sale using labour and machines, tools, chemical and biological processing, or formulation. The term may refer to a range of human activity, from handicraft to high tech, but is most commonly applied to industrial production, in which raw materials are transformed into finished goods on a large scale. Such finished goods may be sold to other manufacturers for the production of other, more complex products, or sold to wholesalers, who in turn sell them to retailers, who then sell them to end users and consumers.

Manufacturing engineering or manufacturing process are the steps through which raw materials are transformed into a final product. The manufacturing process begins with the product design, and materials specification from which the product is made. These materials are then modified through manufacturing processes to become the required part.

Modern manufacturing includes all intermediate processes required in the production and integration of a product's components. Some industries, such as semiconductor and steel manufacturers use the term fabrication instead.

4.1 Manufacturing Process Management (MPM).

Manufacturing process management (MPM) is a collection of technologies and methods used to define how products are to be manufactured. MPM differs from ERP/MRP which is used to plan the ordering of materials and other resources, set manufacturing schedules, and compile cost data.

A cornerstone of MPM is the central repository for the integration of all these tools and activities aids in the exploration of alternative production line scenarios; making assembly lines more efficient with the aim of reduced lead time to product launch, shorter product times and reduced work in progress (WIP) inventories as well as allowing rapid response to product or product changes.

1. Production process planning
    1.1. Manufacturing concept planning
    1.2. Factory layout planning and analysis
        1.2.1. work flow simulation.
        1.2.2. walk-path assembly planning
        1.2.3. plant design optimization
    1.3. Mixed model line balancing.
    1.4. Workloads on multiple stations.
    1.5. Process simulation tools e.g. die press lines, manufacturing lines
    1.6. Ergonomic simulation and assessment of production assembly tasks
    1.7. Resource planning

2. Computer-aided manufacturing (CAM)
   2.1. Numerical control CNC
   2.2. Direct numerical control (DNC)
   2.3. Tooling/equipment/fixtures development
   2.4. Tooling and Robot work-cell setup and offline programming (OLP)
3. Generation of shop floor work instructions
4. Time and cost estimates
   4.1. ABC – Manufacturing activity-based costing
   4.2. Outline of industrial organization
5. Quality computer-aided quality assurance (CAQ)
   5.1. Failure mode and effects analysis (FMEA)
   5.2. Statistical process control (SPC)
   5.3. Computer aided inspection with coordinate-measuring machine (CMM)
   5.4. Tolerance stack-up analysis using PMI models.
6. Success measurements
   6.1. Overall equipment effectiveness (OEE),
7. Communication with other systems
   7.1. Enterprise resource planning (ERP)
   7.2. Manufacturing operations management (MOM)
   7.3. Product data management (PDM)
   7.4. SCADA (supervisory control and data acquisition) real time process monitoring and control
   7.5. Human–machine interface (HMI) (or man-machine interface (MMI))
   7.6. Distributed control system (DCS)

4.2 Quality, Cost, Delivery (QCD)

Quality, cost, delivery (QCD), sometimes expanded to QCDMS (Quality, Cost, Delivery, Morale, Safety), is a management approach originally developed to help companies within the British automobile sector. QCD analysis is used to assess different components of the production process. It also provides feedback in the form of facts and figures that help managers make logical decisions. By using the gathered data, it is easier for organizations to prioritize their future goals.

QCD helps to break down one big thing into many smaller ones, which helps organize and prioritize efforts and, psychologically, prevents the feeling of being overwhelmed.

QCD is a "three-dimensional" approach. If there is a problem with even one dimension, the others will inevitably suffer as well. One dimension cannot be sacrificed for the sake of the other two.

4.2.1 Benefits of QCD

QCD offers a method of measuring processes while being applicable to both simple and complicated business processes. It also represents a basis for comparing businesses. For example, a business measuring supplier delivery performance may easily compare its findings against other businesses' performance.

4.2.2 QCDF

Flexibility is often included as a measure to QCD resulting in Quality, Cost, Delivery and Flexibility (QCDF). Flexibility relates to the capacity to adapt to changes and/or modifications. The modifications could be in;

a) input quality
b) output quality
c) product specifications
d) delivery schedules.

4.2.3 Quality

Quality is the ability of a product or service to meet and exceed customer expectations. Customers' requirements determine the quality goals. It is almost always listed first, presumably because poor quality often results in bad business. Quality is the result of the efficiency of the entire production process formed of men, material, and machinery.

Even though quality is now seen as a competitive advantage, most manufacturing outfits in the 1970s tended to focus more on cost and productivity. In the US and Europe, that approach led to a major share of the market being captured by Japanese business organizations, which once again proves that in order to be successful an organization has to focus on all three QCD dimensions together.

It was not until the late 1970s and the beginning of the 1980s that the factor “quality” drastically shifted and became a strategic approach. This approach focuses on preventing any mistakes and, also, puts a great emphasis on customer satisfaction.

4.2.4 Quality basis

4.2.4.1 Performance

Performance is a product’s primary operating characteristics. For example, for a stereo those characteristics would include sound quality, surround sound, and, perhaps, Wi-Fi connectivity.

4.2.4.2 Conformance

Conformance refers to the degree to which a certain product meets the customer’s expectations.

4.2.4.3 Special features

Those are any additional features of a product or service. In other words, extras. An example of an extra could be free meals on an airplane, or free drinks at a museum visit. And for a TV, for example, it can be split screen, internet access, embedded apps etc.

4.2.4.4 Aesthetics

Aesthetics refer to a product's looks, sound, feel, smell, or taste. When it comes to aesthetics, complete customer satisfaction is simply impossible as it is very subjective. For example, one group of customers may like the smell of a certain perfume while other may find it completely repelling.

4.2.4.5 Durability

The durability of a product is how long the product lasts before it has to be replaced. Durability can be improved by the usage of long-life materials or improved technology processes in manufacturing. Some products are expected to be more durable than others. Those often include home appliances and automobiles for which durability is a primary characteristic of quality.

4.2.4.6 Reliability

Reliability refers to the time until a product breaks down and has to be repaired, but not replaced. This feature is very important for products that have expensive maintenance.

4.2.4.7 Serviceability

"Serviceability is defined by speed, courtesy, competence and ease of repair." [8] Customers usually want products that are relatively quickly and easily serviceable.

4.2.4.8 Perceived quality

The perceived quality may be affected by the high price or the good aesthetics of a product.

4.2.4.9 Product components

The quality of a product depends almost entirely on the quality of the supplied materials. One cannot produce a high-quality end product from low-quality components. Suppliers and manufacturers must be willing to work together in order to reduce and eliminate errors and defects and achieve higher quality end products. SMEs should discuss with their suppliers how quality improvements can affect the overall performance of the supply chain. A properly implemented quality procedure can reduce testing, scrap, rework, etc. This could result in a reduction of production costs.

4.2.5 Consequences of poor quality

4.2.5.1 Business loss

Poor quality often results in unsatisfied customers which leads to business loss. In an environment where the customer can easily switch to a competitor, producing poor-quality products can be fatal to an organization.

4.2.5.2 Productivity

Poor-quality products must often be reworked or scrapped entirely, which reduces the amount of usable output.

4.3 Costs

The biggest cost in most business organizations is the manufacturing cost. Production has a direct responsibility when it comes to controlling and reducing manufacturing cost.

There are four basic types of manufacturing costs:

1. Raw materials
2. Direct labour
3. Variable overhead – production costs that increase or decrease depending on the quantity produced. For example, electricity is a variable overhead. If a company increases production, it will also increase the usage of equipment, which will result in a higher electricity bill.
4. Fixed overhead

Those are the production cost that stay the same even if the quantity produced increases or decreases. Those costs include:

1. Salaries for employees that do not work directly on the production line (e.g. security guards, safety inspectors, etc.).
2. Depreciation costs
3. Occupancy costs – property taxes, building insurance, etc.

4.3.1 Cost reduction

Businesses have been under the pressure to drive down costs in order to be more competitive for many years. There are many books and articles that suggest different ways of reducing costs, some of which are as follows:

1. Minimizing supplier costs
2. Adopting lean manufacturing
3. Eliminating waste