Module 3P10: Contemporary Issues in Manufacturing May 2015 CRIBS

Question 1

1 A UK-based clothing retailer has suffered some adverse publicity relating to its environmental performance in an article in the popular press. The specific criticisms related to wasteful factory operations both in the UK and in their factory in Sri Lanka.

(a) Describe how you would plan and execute a project to reduce the environmental impact of the UK factory, looking at energy, water and waste. What aspects would you prioritise, and why? Divide your proposals into changes that could be put into immediate practice over the next 6 months, and changes for the medium term (up to 5 years). What are the financial implications of your proposals? You may wish to make reference to McKinsey abatement curves. [60%]

(b) How would your proposals for the factory in Sri Lanka differ from those for the UK? [15%]

(c) What advice would you offer the company to improve their medium and long-term environmental performance and also reduce their vulnerability to future attacks by the press? [25%]

(a) The question states that the focus is on energy, water, waste. Energy is likely to be the biggest factor, followed by waste and finally water.

For energy use, McKinsey Abatement Curves show the cost or financial benefit (vertical axis) against the environmental benefit (abatement potential, typically measured as $GTCO_2e$ per year). Biggest hits can be identified from these curves and these are the areas on which to focus.

For light manufacturing operation such as clothing, space heating of the factory is likely to be one of the biggest energy-consuming factors. Short-term measures will be: improving building insulation; full control of heating/cooling systems. Longer term could involve construction of a new eco-efficient building (e.g. Adnams Distribution Centre). Financial implications: reduction in energy costs; very beneficial. Payback period for roof insulation less than a year.

Lighting: Factories likely to be lit by fluorescent sources; replace with LED. Payback period less than a year. Automatic light sensors to switch off when not needed.

Other factors: aim for 'no production, no energy use': all production and office machines to low-energy standby or preferably to switch-off; saves money. Should mainly be achievable in short term; if new low-energy production equipment is needed this will be longer-term and expensive.

Local 'green' energy generation may be considered. Solar panels: photovoltaic most commonly, but solar thermal may be worth considering for heating water. Short or medium term. Wind energy can be useful in some areas, but note that most of the trendy turbines on buildings don't fulfil the energy-generation expectations.

Waste: Improved process control gives reduced waste from off-spec goods manufacture. Production waste can often be reduced by design changes. There can be waste from having a long and slow (typically sea) supply chain: the need for the fashion changes before the goods reach UK.

Include also waste treatment: reduction in landfill; more recycling.

Not strictly a factory operation, but minimizing packaging waste (up and down the supply chain) may be worth looking at - it may have PR implications, as well as being of some environmental significance (relatively low, compared with the factory operations). Measures may include re-usable packaging (for transferring goods between factories), and minimum packaging for retail goods.

Water: textile production can require a lot of water. Not currently a problem in much of UK, though recirculating water supplies can be built (medium term).

To ensure successful implementation, there must be education both of the senior management and the factory workforce.

(b) Sri Lanka is hot and humid, so factory cooling (rather than heating) is the concern.

Install efficient modern building management system. Other measures include replacing tarred roads round factory with paving blocks and increasing the amount of green areas to reduce heat build-up, so air coming into the factory is cooler.

Lighting: increased natural light reduces energy costs and reduces heating from lights. Again, as in UK, residual lighting should be LED.

Water: Rainwater harvesting to provide ‘grey’ water for non-potable purposes. Also build water collection and recirculation plant, incorporating purification.

Waste: As in UK, but with local variation for appropriate technologies.

(c) A mixture of window-dressing and actually important measures. Window-dressing: make a fuss about metrics such as ‘zero waste to landfill’; energy reduction. Somewhere between the two categories is going for ISO 140001 compliance, which provides some protection against the press. More profound measures: look for ways to anticipate legislation changes, such as moving away from hazardous chemicals before they are made illegal. M&S has focused on end-of-life with its ‘take-back’ scheme, where customers get some M&S spending credit for clothing donated to charity. Paradigm shifts: could look at leasing clothing rather than buying (hire companies). IS possibilities may be limited in reality, but could be investigated.

Question 2

2 (a) You are the materials expert in a company manufacturing components for Total Hip Replacement. One component manufactured by your company is the acetabular cup, made from ultra high molecular weight polyethylene (UHMWPE). A new supplier of the raw material needs to be evaluated.

What are the properties of this polymeric biomaterial that you would need to examine to ensure that this supply is suitable? Divide your answer into:

(i) physical, chemical and mechanical considerations; and [30%]

(ii) biological considerations. [20%]

Where appropriate, include examples of relevant case studies, test techniques and standards.

2 (a) (i) Physical, chemical or mechanical considerations:

1. With a change in raw materials, the mechanical properties of the final piece need to be considered due to the load-bearing nature of the component. Typical properties measured include (a) bulk modulus, (b) strength, (b) elongation at break.
2. The mechanical behaviour should also be observed during clinical evaluation. This may be through simulation and would enable an understanding of the wear behaviour.

   Other parameters that should be considered include:

3. The glass transition temperature
4. The molecular weight (and especially the polydispersity index)
5. The level of crystallinity
6. The level of cross-linking achieved and the presence of free-radicals need to be considered as they all have an influence on the life-cycle of the component.

   The techniques needed to measure these properties are not expected but it should be noted that these parameters are important to understand the behaviour of the final polymeric component.
   [2/3 of the marks for this question are allocated to providing a very brief description of four or more of these considerations. The final 1/3 of marks for this question are allocated for good descriptions that clearly link the considerations to the suitability of supply. (e.g. Check the crystallinity of the polymer: the proportion of crystalline polymer to amorphous polymer is important to have the correct balance of flexibility and strength) and also the inclusion of appropriate test techniques, case study examples, standards or showing an understanding of the influence of the class of the component on the rigorousness of the testing.]

2 (a) (ii) Biological considerations:

1. It may be noted that changes to the material supply could require re-validation of the chosen sterilisation technique.
2. Biocompatibility studies should be noted with an emphasis on (i) biofunctionality and (ii) biosafety.
3. Additional tests, such as cytotoxicity, hemocompatibility, etc. may be noted.
4. Specific cytotoxicity tests would include a direct contact test, diffusion test and elution test.

5. Microparticles released during wear of the cup would also need to be studied for any possible inflammation response.

   [There are fewer considerations covered in the course so half of the marks for this question are allocated for noting briefly 2 separate considerations. Again, half of the marks are then allocated to providing good descriptions that clearly link the considerations to the suitability of supply and inclusion of appropriate test techniques, case study examples, standards or showing an understanding of the influence of the class of the component on the rigorousness of the testing.]

2 (b) (i) Describe briefly four trends shaping the development of the medical technology business sector. Identify clearly if your examples are trends in technology, markets, management, regulations, etc. [20%]

Any of the 5 following trends identified in lectures are acceptable:
1. Changing decision-makers
2. Influential new entities
3. Price pressure.
4. Complex regulations.
5. Commoditisation.

Alternative trends may include identifying the key growth sectors in the markets:
1. Structural Heart
2. Robotic Assistance
3. Infection Control Tools
4. Home Care
5. Neuro-devices

Or specifically the technology trends:
1. Interoperability
2. Multi-functional
3. Big Data
4. Low-cost Alternates
5. Nanotechnology

Alternative trends may include the key growth markets, such as the BRIC countries, harmonisation of standards or a range of other topics covered in the course. These will all be considered upon correction but it is critical that a brief description is provided of any identified trend and not just a list.
[The marks for this question are divided equally with a quarter of the marks awarded for each of 4 trends identified and described clearly].

(ii) Tissue engineering is one key approach to regenerative medicine. Describe what is meant by *tissue engineering*. Include in your description a note on its potential applications as well as the key steps and components required to manufacture a replacement tissue for implantation into the human body. Use examples to illustrate your answer, where appropriate. [30%]

Tissues are groups of cells that are specialised to carry out a common function. It should be noted that these are a combination of cells and extracellular matrix and the examples can include 2 of only four types of tissue, (i) Epithelial, (ii) Muscle, (iii) Nervous, (iv) Connective.

A very general overview definition of tissue engineering can be given, e.g. "Instead of replacing defective tissues with manmade devices, try to re-grow healthy tissues by making living implants with active cells". However the initial description or definition of tissue engineering and other applications should capture at least 2 more general points, such as:

1. providing cellular prosthesis or replacement parts for the human body;
2. providing formed acellular replacement parts capable of inducing regeneration;
3. providing tissue or organ-like model systems populated with cells for basic research and for many applied uses such as the study of disease states;
4. providing vehicles for delivering engineered cells to the organism; and
5. surfacing non biological devices.

The brief notes on key components required should include a description of the two possible cell sources (autologous or allogeneic), a note about the scaffolds, their role in providing a porous framework and stable structure as well as noting possible materials to ensure the scaffold can degrade over time. The final component is a bioreactor to provide a controlled sterile environment.

[Half of the marks for this question are for a good definition, including applications. Half of the marks are allocated to describing the key components and any examples or case-studies used to illustrate the definitions.]

Question 3

3 During the factory visits this academic year to companies in the automotive sector (McLaren Automotive and Jaguar Land Rover), a variety of practices was observed under the following categories:

(i) operations management;

(ii) quality control.

(a) Describe the practices observed under these categories in these two companies, commenting on similarities and differences between the companies. [70%]

(b) Discuss the reasons behind the differences in the practices observed. [30%]

(a)

Example points to include as practices observed are summarised below:

Operations Management	
JLR	McLaren
Assembly line operation ○ High levels of automation throughout ○ Cars spend 3hrs on the assembly line **Lean manufacturing** ○ Line system- stops when one thing held up ○ hold 4h worth of stock (assembly line), or 3 weeks worth of stock (press) **Performance measurement** ○ Feedback to managers every 1h on stock and car output ○ Control panels monitoring expected, planned and current output as well as failures **Cost reduction** ○ Selling scrap metal (95% of purchase price) ○ Cars produced only once ordered ○ Minimised welding (savings on technology & safety)	**Assembly line operation** ○ Entire production line is by hand; no automation - includes painting by hand ○ All equipment is on wheels, so room is easily configurable ○ Production process is labour intensive - not capital intensive. ○ 45 minute advance time - If a job is not finished in the allotted 45 mins, the car can usually still proceed and a reserve technician will come to finish the job when the car is at the next station. In extreme cases the car could be taken out of the production line to be worked on. ○ Areas for fixing issues without stopping line **Lean manufacturing** ○ Every car made to order so no issues ○ Some components take a long time to make - challenge to coordinate with rest of production line ○ Production seemingly not very lean **Cost reduction** ○ Continuous improvement with suppliers to source components cheaply and reliably ○ No huge focus on cost reduction:

	customers 'not interested' o McLaren do not think of themselves as a 'cost-driven company' o However, McLaren uses a lot of innovative technology as it is part of their business model. For instance, P1 is made from just 5 panels: saving weight and improving stiffness **Performance measurement** o Main performance measure seems to be cars produced per day o High performance and quality takes priority over efficiency and throughput
Quality control	
JLR	McLaren
• Unique tune for every line to rise manager's attention • Bar coded 'build sheet' specifying customisable aspects and checking overall assembly • Shakedown process to ensure no loose parts left in the car • inventory not held in store rooms for a very long time (no damages)	• Various testing facilities throughout production centre: rolling roads, monsoon testing etc. • Multiple engineers test e.g. brakes are torqued correctly in attachment. • Lots of talk about general attitude to quality. • Quality key, each car ridden with slave parts to test car. • Extensive process of checking each part of car after assembly line so no mistakes when car handed over. • Extensive shakedown process of every vehicle produced • Automated and sophisticated metrology • Continuous improvement process

[85% of the marks for this question are assigned to detailing points on quality control and operations management. It is important that a comparison is attempted and a brief description is provided. The remaining 15% of the marks are allocated for responses that include facts and figures to support the points made]

(b)

Candidates are expected to explore issues relating to the following influencing factors:

- Volume of production
    - JLR: Output of 42 cars/hr
    - McLaren: Currently produce 8 cars/day
    - Low volume of production at McLaren results in low level of automation

- Variety of products
    - JLR: 4 types of vehicles with some customisability
    - McLaren: Current production of 2 cars (650S and P1), but with a very high level of personalisation
    - McLaren Special Operations (MSO) do completely one-off chassis parts, allowing very

unique cars
  - High level of variety at McLaren also results in low level of automation as it adds to their flexibility

- Exclusivity of products
  - Although both target the luxury market, McLaren targets an exclusive market (£1M vehicles compared to £80-150K for JLR).
  - Large order backlog for McLaren - low uncertainty with existing products
  - Exclusivity of McLaren cars is enhanced by the fact that they are "hand-made".
  - The quality control process at McLaren also reflects the high value of the vehicle.
  - McLaren operates at very high margins, allowing them a level of flexibility with labour costs and hence cost control is not considered to be a critical issue.

[2/3 of the marks are assigned to describing very clearly 2 reasons for the differences. The remaining marks are assigned based on the detail of the response and especially the facts and figures provided to support the answers]