PRINCE OF SONGKLA UNIVERSITY
FACULTY OF ENGINEERING

Midterm Examination: Semester II — Academic Year: 2008
Date: December 22, 2008 — Time: 9:00-12:00
Subject: 226-301 Advanced Manufacturing Technology — Room: หัวหุ่น

ทุจริตในการสอบ โทษขั้นต่ำคือ ปรับตกในรายวิชาที่ทุจริต และ พักการเรียน 1 ภาคการศึกษา

INSTRUCTION:

1) There are 12 questions in 5 pages.
2) Attempt all 12 questions in the answer-book provided.
3) All calculators, notes and materials are allowed.
4) Total score is 130.

Question	Full Score	Assigned Score
Q1	5	
Q2	10	
Q3	15	
Q4	15	
Q5	5	
Q6	20	
Q7	5	
Q8	10	
Q9	10	
Q10	5	
Q11	15	
Q12	15	
Total	130	

Assoc. Prof. Somchai Chuchom

Q1 What are the fundamentals of rapid prototyping? (5 points)

Q2 Describe the advantages of rapid prototyping in terms of its beneficiaries such as the product designers, tool designers, manufacturing engineers, marketers, and consumers. (10 points)

Q3 Choose one of the rapid prototyping systems from each initial form of its material (liquid-based, solid-based, and powder-based). For each chosen system, describe its process method and highlight the key strengths or weaknesses involved (15 points)

Q4 Examine a coffee cup as shown in Figure 1 (assume the same material for the whole piece), determine in which orientation you would choose to produce the part if using a) FDM process and b) LOM process. Sketch and explain your idea. (15 points)

Figure 1

Q5 Ceramic and cermet cutting tools have certain advantages over carbide tools. Why, then, are they not completely replacing carbide tools? (5 points)

Q6 Read the CASE STUDY 'Manufacture of Stents' and answer the following questions. (20 points)

6.1) Explain all the processes involved in manufacturing of a 'Stent'

6.2) Why is the 316L stainless steel selected for MULTI-LINK TETRA™ ?

6.3) What are the purposes of applying chemical etching and electropolishing proesses for MULTI-LINK TETRA™ ?

6.4) Summarize the design processes applied for high precision and proper performance stent.

CASE STUDY	**Manufacture of Stents**

Heart attacks, strokes, and other cardiovascular diseases claim one life every 33 seconds in the United States alone.[1] These illnesses are attributed mostly to coronary artery disease, which is the gradual buildup of fat (cholesterol) within the artery wall causing the coronary arteries to become narrowed or blocked. This condition reduces the blood flow to the heart muscle and eventually leads to a heart attack, stroke, or other cardiovascular diseases. One of the most popular methods today for keeping blocked arteries open is to implant a stent into the artery. The MULTI-LINK TETRA™ (shown in Fig. 27.18) consists of a tiny mesh tube that is expanded using a balloon dilatation catheter and implanted into a blocked or partially blocked coronary artery. A stent serves as a scaffolding or mechanical brace to keep the artery open. A stent offers the patient a minimally invasive method for treating coronary heart disease for which the alternative is usually open-heart bypass surgery—a procedure with greater risk, pain, rehabilitation time, and cost to the patient.

Stent manufacturing is extremely demanding, and the accuracy and precision of its design are paramount for proper performance. The manufacture of the stent must allow satisfaction of all of the design constraints and provide an extremely reliable device; thus, strict quality control procedures must be in place throughout the manufacturing process. When designing a stent, there are many material-selection factors to consider, such as radial strength, corrosion resistance, endurance limit, flexibility, and biocompatibility. Radial strength is important, because the stent must withstand the pressure the artery exerts on the stent upon expansion.

Because the stent is implantable in the body, it must be corrosion resistant; also, it must be able to withstand the stress undulations caused by heart-beats. Consequently, the material also must have high resistance to fatigue. In addition, the stent must have the appropriate wall thickness in order to be flexible enough to negotiate through the tortuous anatomy of the heart. Above all, the material must be biocompatible to the body, because it remains there for the rest of the patient's life. A standard material for stents—one that satisfies all of these requirements—is 316L stainless steel.

The pattern of a stent also affects its performance. A finite-element analysis of the stent's design first is performed to determine how the stent will perform under the stresses induced by the beating heart. The strut pattern, tube thickness, and strut-leg width all affect the performance of the stent. Many different patterns are possible, such as the MULTI-LINK TETRA™ stent, which is shown in Fig. 27.19 and includes some of the critical dimensions.

A stent starts out as a drawn stainless-steel tube with an outer diameter that matches the final stent dimension and a wall thickness selected to provide proper strength when expanded. The drawn tube then is laser machined to achieve the desired pattern (Fig. 27.20a). This method has proven to be very effective because of the small, intricate pattern of the stent and the tight dimensional tolerances that it must have. As the laser cuts the pattern of the stent, it leaves small metal slugs that need to be removed; therefore, it is very important that the laser cut all the way through the tube wall. A thick oxide layer or slag inevitably develops on the stainless steel due to the thermal and chemical attack from the air. In addition, weld splatter, burrs, and other surface defects result from laser machining. Therefore, finishing operations are required to remove the splatter and oxide layer.

The first finishing operation after laser machining involves chemical etching to remove as much of the slag on the stent as possible; this operation typically is done in an acid solution, and the resulting surface is shown in Fig. 27.20b. Once the slag has been sufficiently removed, any residual burrs from the laser-machining process need to be removed, and the stent surface must be finished. It is very important that the surface finish of the stent be smooth to prevent possible formation of clots (thrombi) on the stent. To remove the sharp points, the stent is electropolished by passing an electrical current through an electrochemical solution to ensure a proper surface finish (Fig. 27.20c) that is both shiny and smooth. The stent then is placed onto a balloon catheter assembly, sterilized, and packaged for delivery to the surgeon.

Source: Courtesy of K. L. Graham, Guidant Corporation.

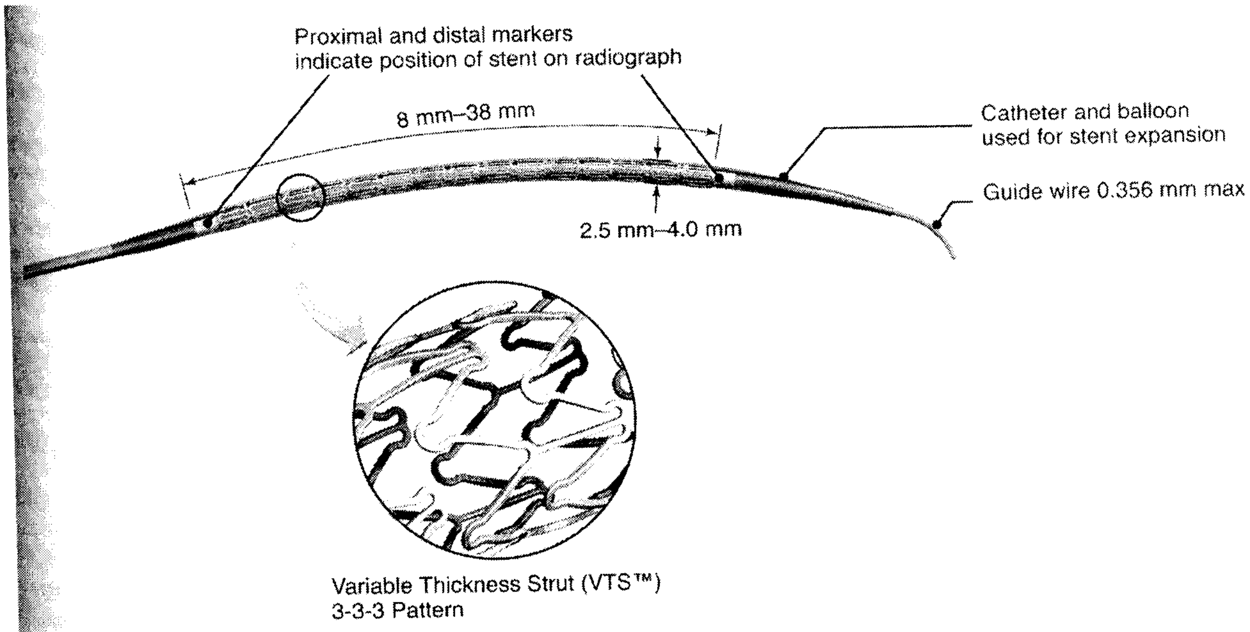

FIGURE 27.18 The Guidant MULTI-LINK TETRA™ coronary stent system.

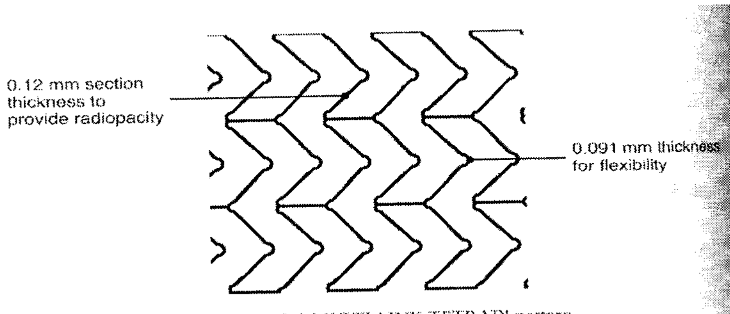

FIGURE 27.19 Detail of the 3-3-3 MULTI-LINK TETRA™ pattern.

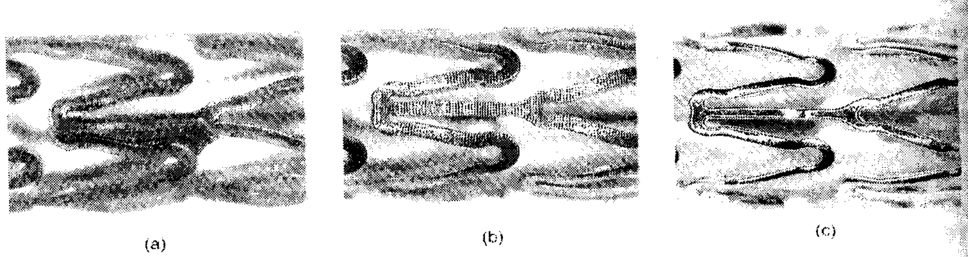

FIGURE 27.20 Evolution of the stent surface. (a) MULTI-LINK TETRA™ after lasing. Note that a metal slug still is attached. (b) After removal of slag. (c) After electropolishing.

Q7 Explain how the EDM process is capable of producing complex shapes. (5 points)

Q8 Describe your thoughts regarding the laser-beam machining of nonmetallic materials. Give several possible applications, including their advantages as compared to other processes. (10 points)

Q9 Ultrasonic machining is best suited for hard and brittle materials, explain why. (10 points)

Q10 What are the consequences of allowing the temperature to rise during grinding? (5 points)

Q11 Why is high-speed cutting important? What should be considered when applying high-speed machining regarding to a) the machine tools and b) the cutting tools. (15 points)

Q12 Choose one of the advanced manufacturing processes covered in the class, show what you know about it and specify a part or product that is most appropriate produced by this chosen process. (15 points)
