National Examinations – December 2010

07-Mec-A4, Design and Manufacture of Machine Elements

3 Hours Duration

Notes:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. This is an open book examination. Candidates may use any non-communicating calculator.

3. There are 8 questions on the following 6 pages, divided into Part A and Part B. Answer three (3) questions from Part A and two (2) questions from Part B. 5 (five) questions constitute a complete paper. Only the first five questions, as they appear in your answer book, will be marked. Clearly cross off any question you do not want marked.

4. All questions are of equal mark value (20%).
PART A: Choose any three (3) problems from part A.

Q1
A square box is made by thermoforming. In straight vacuum forming the edges thin out excessively. To explain your analysis and recommendation, (a) make a sketch of pure vacuum forming, showing die and polymer temperatures; (b) show why the corners and edges should thin out and (c) suggest a production method for reduced thinning.

Q2
The Quality Control Department rejected a bent part because its surface shows orange peel; production wants to use it. To mediate the situation, (a) explain, with the aid of a sketch, the source of the effect and (b) pose a question, the answer to which will settle the issue.
Q3
Small spur gears are to be made. The gear tooth surfaces must be parallel to the axis of the gear and
must have a smooth finish. Blanking from a sheet is considered. (a) Is this a feasible proposition? (b) If
the answer is yes, make a sketch of a process (identifying the die elements) that assures the required
quality. (c) Explain why the process works (if relevant, with the aid of another sketch).

Q4
A large, flat machine-tool base is to be cast with intersecting stiffening ribs on both sides of the flat.
Show in a sketch the problem that may arise and suggest (in a sketch) at least one design modification
to minimize the problem.
A countershaft with a helical gear and a helical pinion is supported by two bearings so that the pinion is simply supported while the gear is overhung. Gear and pinion tooth loads are already determined as shown in the figure.

(a) Sketch load, shear force and bending moment diagrams for the shaft in the horizontal and vertical planes. Also, sketch shaft torsional and axial force diagrams.  
(b) Determine radial and axial loads applied to the bearings.  
(c) Make a preliminary scale drawing of the shaft with "reasonable" diameters, appropriate shoulders and provisions for axial retention.  
(d) Determine primary factors to be considered to fix the diameters.  
(e) Determine the linear deflection at the gear and angular deflection at the bearings.
The long-shoe drum brake is actuated by a mechanism that exerts a force of \( F_a = 4 \) kN. Determine:

(a) The maximum pressure.
(b) The torque and power capacities.
An L-shaped 1020 steel support bracket must support a static load of $P = 3000 \text{ lb}$, as shown in the figure. A bolt pattern using three bolts, with locations as shown has been suggested. If the bolts are to be SAE Grade 1 (see Table) with unified standard coarse threads, and if a design factor of safety of 2 is desired, recommend an appropriate bolt size and tightening torque for this application. As a practical matter, all three bolts are the same size. Make enough simplifying assumptions to expedite the calculations, since this is a preliminary design estimate.

### SAE & ASTM Bolt Grade Identification Marks and Mechanical Properties

<table>
<thead>
<tr>
<th>Bolt Grade Identification Marking</th>
<th>Specs</th>
<th>Nominal Size (in.)</th>
<th>Proof Load Stress (ksi)</th>
<th>Tensile Strength (min ksi)</th>
<th>Material Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAE Grade 1</td>
<td>1/4 to 1 1/2</td>
<td>33</td>
<td>60</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>SAE Grade 2</td>
<td>1/4 thru 3/4</td>
<td>55</td>
<td>74</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>over 3/4 thru 1 1/2</td>
<td>33</td>
<td>60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASTM A307</td>
<td>1/4 to 1 1/2</td>
<td>33</td>
<td>60</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>SAE Grade 4</td>
<td>1/4 to 1 1/2</td>
<td>65</td>
<td>115</td>
<td></td>
<td>2,a</td>
</tr>
</tbody>
</table>
A bracket supports a total load of 60 kN. E60 series welding rods are used with a safety factor of 3. Determine the weld size that should be specified.

Vertical 100 mm weld on inside of both plates along the y-axes

E60 series welding rod
SF = 3.0
Note: Each plate has two 75 mm welds and one 100 mm weld.