NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY

DEPARTMENT OF INDUSTRIAL AND MANUFACTURING ENGINEERING

Bachelor of Engineering (Hons) Degree Industrial and Manufacturing Engineering

MANUFACTURING PROCESSES I

TIE 3113

FIRST SEMESTER MAIN EXAMINATION

DECEMBER 2014

This examination paper consists of 5 pages

Time Allowed: **3 hours**

Total Marks: **100**

Special Requirements: **Nil**

Examiner's Name: **Eng. M. Makhurane**

INSTRUCTIONS AND INFORMATION TO CANDIDATES

1. Answer any five (5) questions
2. Each question carries 20 marks

MARK ALLOCATION

QUESTION	MARKS
1.	**20**
2.	**20**
3.	**20**
4.	**20**
5.	**20**
6	**20**
7	**20**
TOTAL	**100**

QUESTION 1

a) A disk 40 cm in diameter and 5 cm thick is to be cast out of pure aluminum in an open-mold casting operation. The melting temperature of aluminum is 660 ^{o}C, and the pouring temperature will be 800 ^{o}C. Assume that the amount of aluminum heated will be 5% more than what is needed to fill the mold cavity. Calculate the amount of heat that must be added to the metal to heat it to the pouring temperature, starting from a room temperature of 25 ^{o}C. The heat of fusion of aluminum is 389.3 J/g. Other properties can be obtained from Tables 4.1 and 4.2 on the last page. Assume the specific heat has the same value for solid and molten aluminum. [8]

b) Three metal pieces being cast have the same volume, but different shapes: one is a sphere, one a cube and the other a cylinder with its height equal to its diameter. Which piece will solidify the slowest? Assume n=2 [12]

QUESTION 2

A cylindrical riser with diameter to length ratio of 1.0 is to be designed for a sand casting mold. The casting geometry is illustrated in Figure Q2, in which the units are mm. If the mold constant in Chvorinov's rule is 19.5 min/mm^2, determine the dimensions of the riser so that the riser will take 0.5 min longer to freeze than the casting itself. [20]

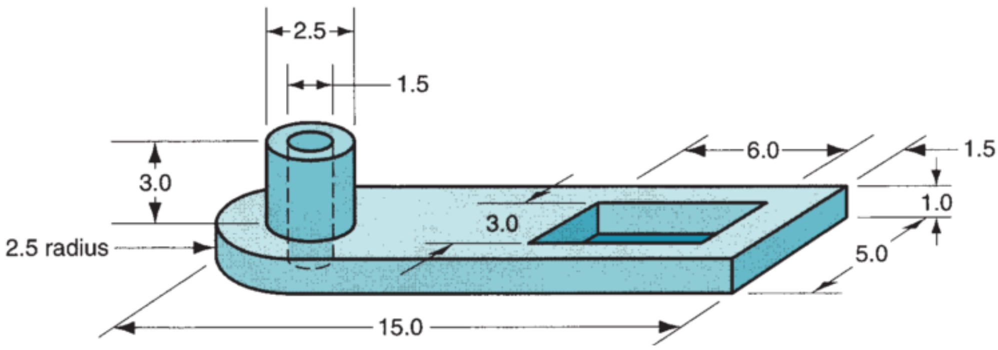

Figure Q2: Geometry of casting

QUESTION 3

a) Use the Bernouli Theorem to show that

$$v = \sqrt{(2gh)}$$ [5]

b) What are crucible furnaces? Where are they preferred and why? [7]

c) Use diagrams to illustrate the five (5) steps in Vacuum Molding [12]

QUESTION 4

Make a neat sketch of a cupola furnace, indicating its various zones and describe the following: [12]

i) Preparation before operations , [2]
ii) Operation, [2]
iii) Advantages, [2]
iv) Application. [2]

QUESTION 5

The down sprue leading into the runner of a certain mold has a lengthy of 175mm. the cross-sectional area at the base of the sprue is $400mm^2$. The mould cavity has a volume of $0.001m^3$. Determine

i. The velocity of the molten metal flowing through the base of the sprue. [6]
ii. The volume rate of flow. [6]
iii. The time required to fill the mould. [8]

QUESTION 6

a) Among its capabilities and advantages is the fact that; casting can create complex part geometries, including both external and internal shapes.
   - Briefly discuss the other four advantages. [8]

b) What manufacturing process is illustrated in Fig Q6 below. Give a brief description of the different stages as illustrated explaining why all stages are important. [12]

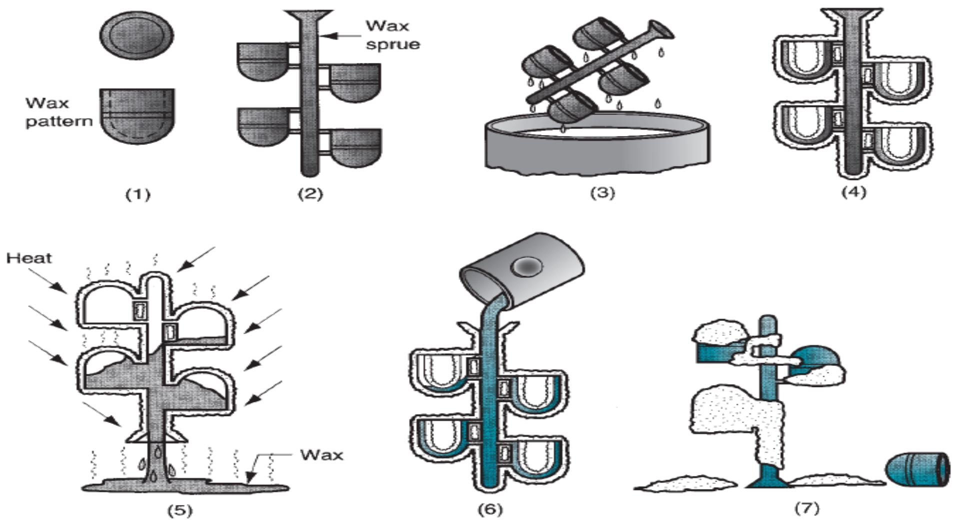

Fig Q6 : Manufacturing Process

QUESTION 7

a) Make a detailed and labeled diagram of the two different types of moulds used for casting. [8]

b) Describe the following casting defects stating how they can be avoided [12]

i. Misrun,

ii. Cold shut,

iii. Cold shot,

iv. Shrinkage cavity,

v. Microporosity,

vi. Hot tear.

TABLE 4.1 Volumetric properties in U.S. customary units for selected engineering materials.

Material	Density, ρ		Coefficient of Thermal Expansion, α		Melting Point, T_m	
	g/cm^3	lb/in^3	$°C^{-1} \times 10^{-6}$	$°F^{-1} \times 10^{-6}$	°C	°F
Metals						
Aluminum	2.70	0.098	24	13.3	660	1220
Copper	8.97	0.324	17	9.4	1083	1981
Iron	7.87	0.284	12.1	6.7	1539	2802
Lead	11.35	0.410	29	16.1	327	621
Magnesium	1.74	0.063	26	14.4	650	1202
Nickel	8.92	0.322	13.3	7.4	1455	2651
Steel	7.87	0.284	12	6.7	[a]	[a]
Tin	7.31	0.264	23	12.7	232	449
Tungsten	19.30	0.697	4.0	2.2	3410	6170
Zinc	7.15	0.258	40	22.2	420	787
Ceramics						
Glass	2.5	0.090	1.8–9.0	1.0–5.0	[b]	[b]
Alumina	3.8	0.137	9.0	5.0	NA	NA
Silica	2.66	0.096	NA	NA	[b]	[b]
Polymers						
Phenol resins	1.3	0.047	60	33	[c]	[c]
Nylon	1.16	0.042	100	55	[b]	[b]
Teflon	2.2	0.079	100	55	[b]	[b]
Natural rubber	1.2	0.043	80	45	[b]	[b]
Polyethylene (low density)	0.92	0.033	180	100	[b]	[b]
Polystyrene	1.05	0.038	60	33	[b]	[b]

Compiled from, [2], [3], [4], and other sources.
[a]Melting characteristics of steel depend on composition.
[b]Softens at elevated temperatures and does not have a well-defined melting point.
[c]Chemically degrades at high temperatures. NA = not available; value of property for this material could not be obtained.

TABLE 4.2 Values of common thermal properties for selected materials. Values are at room temperature, and these values change for different temperatures.

Material	Specific Heat	Thermal Conductivity		Material	Specific Heat	Thermal Conductivity	
	Cal/g °C[a] or Btu/lbm °F	J/s mm °C	Btu/hr in °F		Cal/g °C[a] or Btu/lbm °F	J/s mm °C	Btu/hr in °F
Metals				***Ceramics***			
Aluminum	0.21	0.22	9.75	Alumina	0.18	0.029	1.4
Cast iron	0.11	0.06	2.7	Concrete	0.2	0.012	0.6
Copper	0.092	0.40	18.7	***Polymers***			
Iron	0.11	0.072	2.98	Phenolics	0.4	0.00016	0.0077
Lead	0.031	0.033	1.68	Polyethylene	0.5	0.00034	0.016
Magnesium	0.25	0.16	7.58	Teflon	0.25	0.00020	0.0096
Nickel	0.105	0.070	2.88	Natural rubber	0.48	0.00012	0.006
Steel	0.11	0.046	2.20	***Other***			
Stainless steel[b]	0.11	0.014	0.67	Water (liquid)	1.00	0.0006	0.029
Tin	0.054	0.062	3.0	Ice	0.46	0.0023	0.11
Zinc	0.091	0.112	5.41				

Compiled from [2], [3], [6], and other sources.
[a]Specific heat has the same numerical value in Btu/lbm-F or Cal/g-C. 1.0 Calory = 4.186 Joule.
[b]Austenitic (18-8) stainless steel.