Høgskolen i Østfold
Avdeling for ingeniørfag

EKSAMENSOPPGAVE

Fag: IRM13112, part 2 (5 stp) **Teacher: Olav Aaker**

Groups: **12MAS, 12MASY, 11DES**	**Date: June 3, 2013**	**Time: 0900-1200**
Number of assignment pages: 4 (this one included)	**Number of attachment pages: 2**	
Sensurfrist: 28 June		
Allowable aids: Electronic calculator, technical tables, writing tools, supplied folder of accomplished assignments/ Tillatte hjelpemidler: Elektronisk kalkulator, tekniske tabeller, skriveredskap, utdelt mappe med utførte øvinger		
THE CANDIDATE MUST CHECK THAT THE SET OF PROBLEMS IS COMPLETE/ KANDIDATEN MÅ SELV KONTROLLERE AT OPPGAVESETTET ER FULLSTENDIG		

If you miss any information necessary to solving the problems, use reasonable assumptions, and explain the reason for your assumptions

Dersom du savner opplysninger som er nødvendige for at du skal kunne løse oppgavene, gjør rimelige antagelser og begrunn disse.

Numeric values shall be in SI units, unless otherwise specified./ Oppgi alle svar i SI enheter hvis annet ikke er spesifisert.

The results from this exam is part of the final evaluation as described in the subject description./ Resultatet fra denne eksamenen er en del av sluttevalueringen i faget, slik det er angitt i fagbeskrivelsen.

The questions are in English language, and are repeated in Norwegian in *italic* letters / Spørsmålene er på engelsk, og gjentas på norsk i *kursiv*.

Problem 1 General questions (20%)

Some questions from the subject

1. What is a casting process? / *Hva er en støpeprosess?*
2. Choose a casting process, and explain how metal parts can be made using this process/ *Velg en støpeprosess, og forklar hvordan man kan lage metalldeler med denne prosessen.*
3. What is a chip breaker?/ *Hva er en sponbryter?*
4. What is a drawing process? / *Hva er en trekkeprosess*
5. How can objects be produced by powder metal processing? / *Hvordan kan gjenstander produseres med pulvermetall?*
6. What is the Taylor tool life equation, and for what purpose is it used?/ *Hva er Taylorligningen for verktøyslitasje, og hva brukes den til?*
7. What is Reynolds number, when and why do we need to know it?/ *Hva er Reynolds tall, når og hvorfor trenger vi det?*
8. Considering costs, is it better to use a manual or CNC based lathe for production purposes? Explain how you would proceed to answer this question in a real-life situation./ *Med tanke på kostnader, bør man bruke manuell eller CNC dreibenk til produksjon? Forklar hvordan du ville gå frem for å besvare dette spørsmålet for noen som har dette problemet.*
9. Describe how MIG/MAG welding (GMAW) works./ *Forklar hvordan MIG/ MAG sveising (GMAW) virker.*
10. If a manufactured part has dimensions outside the specified tolerances, what can be the reason for this? Name three different sources of error./ *Hvis en del som er produsert ikke tilfredstiller toleransene, hva kan grunnen være? Angi tre mulige årsaker.*

Problem 2: Material removal and power consumption (40%)

In a lathe, you are going to reduce the diameter of a cylindrical bolt from 50 mm to 49 mm. The bolt is made of steel, and the turning will take place in one pass. Data for this turning process:

1. Feed rate: 0.2 mm/rev
2. Spindle speed: 3000 rpm
3. Total length of turned area: 100mm
4. Specific energy requirement for cutting: $5 \frac{Ws}{mm^3}$

Based on the above data, and other data supplied in the attachments to this assignment, answer the following questions:

1. How long will the turning process take to complete?
2. At least how much power (kW) is required?
3. What will be the required spindle torque during the turning process?

In a lathe, you are going to reduce the diameter of a cylindrical bolt from 50 mm to 49 mm. The bolt is made of steel, and the turning will take place in one pass.

/Du skal dreie ned en sylindrisk bolt fra 50mm til 49mm. Dreiingen utføres med ett kutt. Data for dreiingen:

1. *Mating:*
2. *Spindelhastighet: 3000 rpm*
3. *Total lengde på dreid flate: 100mm*
4. *Spesifikk energi for å fjerne materialet:* $5 \frac{Ws}{mm^3}$

Basert på disse dataene, og andre opplysninger vedlagt denne oppgaven, svar på følgende spørsmål:

1. *Hvor lang tid tar det før dreiingen er utført?*
2. *Minst hvor mye effekt (kW) trengs?*
3. *Hvilket dreiemoment trengs på spindelen for å utføre dreiingen?*

Problem 3 Questions about metal casting/ spørsmål om metallstøping (30%)

1. Explain the principle of sand casting./ *Forklar prinsippet for sandstøping*
2. Attached to this assignment, you find two different versions of the Bernoulli equation. Answer these two questions:/ *I vedlegget finner du to ulike versjoner av Bernoullis ligning. Svar på følgende to spørsmål:*
   a. What is the basic idea for developing the Bernoulli equation? (Hint: Which quantity is conserved?)/ *Hva er utgangspunktet for å utlede Bernoullis ligning? (Hint: Hvilken størrelse er bevart?)*
   b. What is the difference between the two versions of the Bernoulli equation in the attachment?/ *Hva er forskjellen mellom de to versjonen av Bernoullis ligning i vedlegget?*
3. What is the continuity equation, and how can it be used with the Bernoulli equation to find the dimensions of a sprue in a sand-mold?/ *Hva er kontinuitetsligningen, og hvordan kan denne brukes sammen med Bernoullis ligning for å finne dimensjonen på nedløpet i en sandform?*

Problem 4 Questions based on the Jøtul factory visit (10%)

1. What method is used for casting metal parts at Jøtul?/ *Hva slags støpemetode bruker man på Jøtul?*
2. In the casting process at Jøtul, a very smooth surface is obtained in the casting process itself, without further manchining. How is this done?/ *Jøtul oppnår en svært fin overflate på delene de støper uten videre overflatebehandling, hvordan får de til dette?*

Attachments/ *Vedlegg*

Bernoulli equation:

$$h + \frac{p}{\rho g} + \frac{v^2}{2g} = Const$$

$$mgh + pV + \frac{mv^2}{2} = Const$$

Continuity equation:

$$Q = A_1 v_1 = A_2 v_2$$

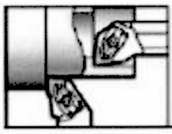
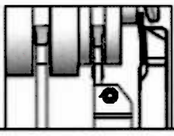
Reynolds number:

$$Re = \frac{\rho v D}{\eta}$$

Power and torque:

$$P = \omega * T$$

Formulas and definitions

Turning

Cutting speed (v_c)
(m/min)

$$v_c = \frac{D_m \times \pi \times n}{1000}$$

Spindle speed (n)
(rpm)

$$n = \frac{v_c \times 1000}{\pi \times D_m}$$

Metal removal rate (Q)
(cm³/min)

$$Q = v_c \times a_p \times f_n$$

Net power (P_c)
(kW)

$$P_c = \frac{v_c \times a_p \times f_n \times k_c}{60 \times 10^3}$$

Machining time (T_c)
(min)

$$T_c = \frac{l_m}{f_n \times n}$$

Specific cutting force (k_c)
(N/mm²)

$$k_c = k_{c1} \times h_m^{-m_c} \times \left(1 - \frac{\gamma_0}{100}\right)$$

Average chip thickness (h_m)

Round inserts
(mm)

$$h_m = \frac{360 \times f_n \times a_p}{iC \times \pi \times \arccos\left(1 - \frac{2 \times a_p}{iC}\right)}$$

Note: arccos in degrees

Insert shapes: C, D, S, T, V, W
(mm)

$$h_m = f_n \times \sin \kappa_r$$

Max. chip thickness (h_{ex})

Round inserts
(mm)

$$h_{ex} = f_n \times \sqrt{\frac{4\,a_p}{iC} - \left(\frac{2\,a_p}{iC}\right)^2}$$

Insert shapes: C, D, S, T, V, W
(mm)

$$h_{ex} = f_n \times \sin \kappa_r$$

Profile depth (R_{max})
(µm)

$$R_{max} = \frac{f_n^2 \times 125}{r_\varepsilon}$$

Parameter	Meaning	Metric unit
D_m	Machined diameter	mm
a_p	Depth of cut (D.O.C.)	mm
f_n *)	Feed per revolution	mm/r
v_c	Cutting speed	m/min
n	Spindle speed	rpm
P_c	Net power	kW
Q	Metal removal rate	cm³/min
T_c	Machining time	min
l_m	Machined length	mm
h_m	Average chip thickness	mm
h_{ex}	Maximum chip thickness	mm
k_c	Specific cutting force	N/mm²
k_{c1}	Specific cutting force valid for $h_m = 1$ mm	N/mm²
m_c	Correction factor for actual h_m	
κ_r	Entering angle	degree
γ_0	Chip rake angle	
r_ε	Nose radius	mm
R_{max}	Profile depth	µm
SCL	Spiral Cutting Length	m

*) In parting and grooving, f_{nx} (radial feed) and f_{nz} (axial feed) are also used.

Spiral Cutting Length (SCL)

External or internal (straight) turning
(m)

$$SCL = \frac{D_m \times \pi}{1000} \times \frac{l_m}{f_n}$$

Facing
(m)

$$SCL = \left(\frac{D_{m1} + D_{m2}}{2} \times \frac{\pi}{1000}\right) \times \frac{l_{m1}}{f_n}$$

Taper cutting
(m)

$$SCL = \left(\frac{D_{m1} + D_{m2}}{2} \times \frac{\pi}{1000}\right) \times \frac{l_{m2}}{f_n}$$

$$l_{m2} = \sqrt{(l_{m1})^2 + \left(\frac{D_{m1} - D_{m2}}{2}\right)^2}$$