BAE701 Engineering Fundamentals

Mechanical

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Then study **Section 3-Mechanical Engineering (PDF File Page 307)**

For every topic, you need to write the short note on what you understand, formula, summary, outlines and at least 2 problems solution (Please note, each problem is solved in short form, you need to clearly reproduce them by step by step)

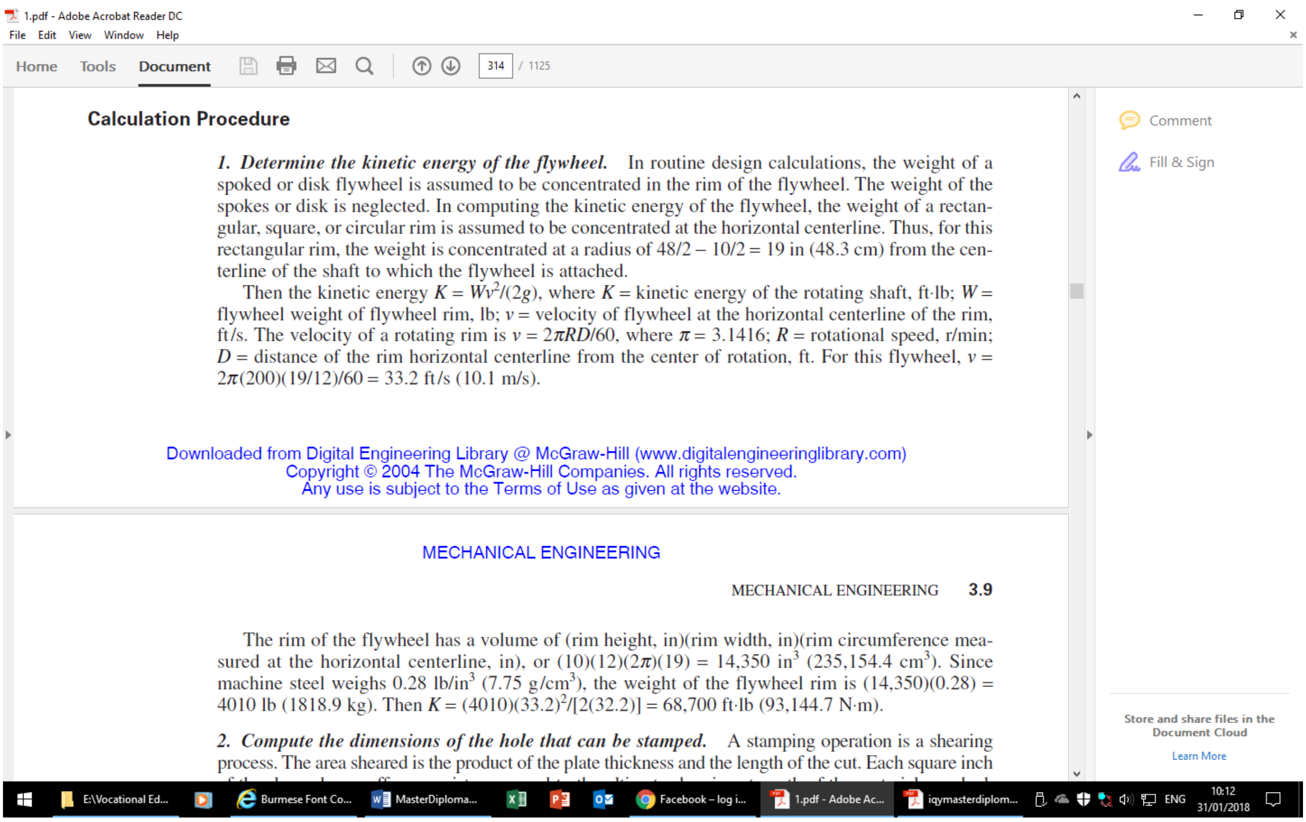
MECHANICAL DESIGN AND ANALYSIS 3.8

Page 314 Energy Stored in Rotating Flywheel

The Questions and suggested solution in the book

A 48-in (121.9-cm) diameter spoked steel flywheel having a 12-in wide × 10-in (30.5-cm × 25.4-cm) deep rim rotates at 200 r/min. How long a cut can be stamped in a 1-in (2.5-cm) thick aluminium plate if the stamping energy is obtained from this flywheel? The ultimate shearing strength of the aluminum is 40,000 lb/in2 (275,789.9 kPa).

Procedure written in the book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Calculation Procedure

1. Determine the kinetic energy of the flywheel. In routine design calculations, the weight of a spoked or disk flywheel is assumed to be concentrated in the rim of the flywheel. The weight of the spokes or disk is neglected. In computing the kinetic energy of the flywheel, the weight of a rectangular, square, or circular rim is assumed to be concentrated at the horizontal centerline. Thus, for this rectangular rim, the weight is concentrated at a radius of 48/2 – 10/2 = 19 in (48.3 cm) from the centerline of the shaft to which the flywheel is attached.

Then the kinetic energy $K = Wv^2/(2g)$, where K = kinetic energy of the rotating shaft, ft·lb; W = flywheel weight of flywheel rim, lb; v = velocity of flywheel at the horizontal centerline of the rim, ft/s. The velocity of a rotating rim is $v = 2\pi RD/60$, where $\pi = 3.1416$; R = rotational speed, r/min; D = distance of the rim horizontal centerline from the center of rotation, ft. For this flywheel, $v = 2\pi(200)(19/12)/60 = 33.2$ ft/s (10.1 m/s).

The rim of the flywheel has a volume of (rim height, in)(rim width, in)(rim circumference measured at the horizontal centerline, in), or $(10)(12)(2\pi)(19)$ = 14,350 in^3 (235,154.4 cm^3). Since machine steel weighs 0.28 lb/in^3 (7.75 g/cm^3), the weight of the flywheel rim is (14,350)(0.28) = 4010 lb (1818.9 kg). Then $K = (4010)(33.2)^2/[2(32.2)]$ = 68,700 ft·lb (93,144.7 N·m).

2. Compute the dimensions of the hole that can be stamped. A stamping operation is a shearing process. The area sheared is the product of the plate thickness and the length of the cut. Each square inch

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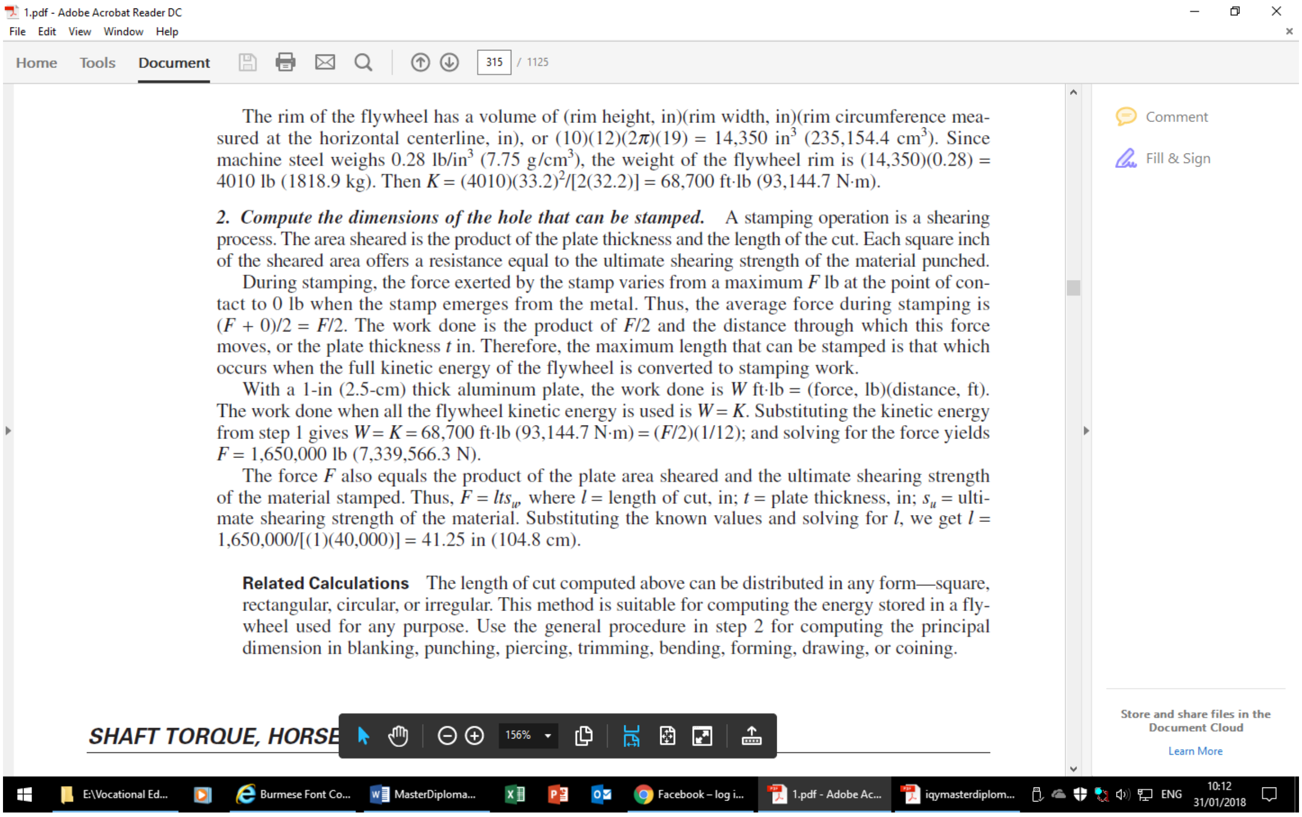


The rim of the flywheel has a volume of (rim height, in)(rim width, in)(rim circumference measured at the horizontal centerline, in), or $(10)(12)(2\pi)(19) = 14{,}350$ in^3 (235,154.4 cm^3). Since machine steel weighs 0.28 lb/in^3 (7.75 g/cm^3), the weight of the flywheel rim is $(14{,}350)(0.28) = 4010$ lb (1818.9 kg). Then $K = (4010)(33.2)^2/[2(32.2)] = 68{,}700$ ft·lb (93,144.7 N·m).

2. Compute the dimensions of the hole that can be stamped. A stamping operation is a shearing process. The area sheared is the product of the plate thickness and the length of the cut. Each square inch of the sheared area offers a resistance equal to the ultimate shearing strength of the material punched.

During stamping, the force exerted by the stamp varies from a maximum F lb at the point of contact to 0 lb when the stamp emerges from the metal. Thus, the average force during stamping is $(F + 0)/2 = F/2$. The work done is the product of $F/2$ and the distance through which this force moves, or the plate thickness t in. Therefore, the maximum length that can be stamped is that which occurs when the full kinetic energy of the flywheel is converted to stamping work.

With a 1-in (2.5-cm) thick aluminum plate, the work done is W ft·lb = (force, lb)(distance, ft). The work done when all the flywheel kinetic energy is used is $W = K$. Substituting the kinetic energy from step 1 gives $W = K = 68{,}700$ ft·lb (93,144.7 N·m) $= (F/2)(1/12)$; and solving for the force yields $F = 1{,}650{,}000$ lb (7,339,566.3 N).

The force F also equals the product of the plate area sheared and the ultimate shearing strength of the material stamped. Thus, $F = lts_u$, where l = length of cut, in; t = plate thickness, in; s_u = ultimate shearing strength of the material. Substituting the known values and solving for l, we get $l = 1{,}650{,}000/[(1)(40{,}000)] = 41.25$ in (104.8 cm).

Related Calculations The length of cut computed above can be distributed in any form—square, rectangular, circular, or irregular. This method is suitable for computing the energy stored in a flywheel used for any purpose. Use the general procedure in step 2 for computing the principal dimension in blanking, punching, piercing, trimming, bending, forming, drawing, or coining.

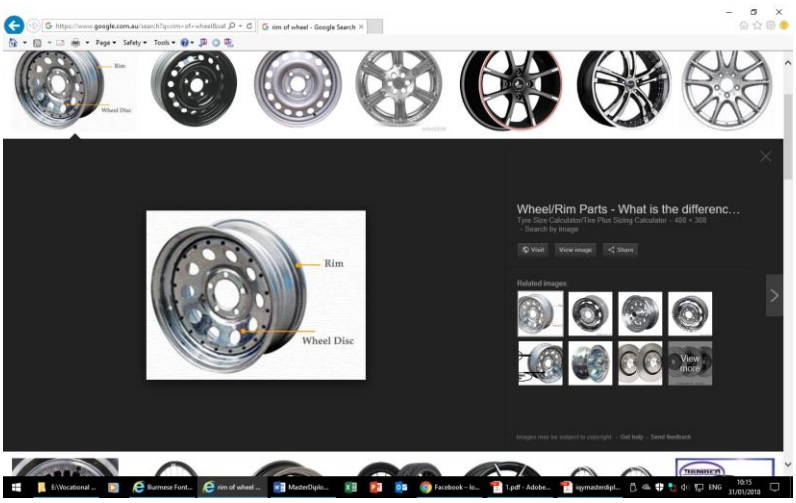
SHAFT TORQUE, HORSE

That process is simplified as below

Step 1

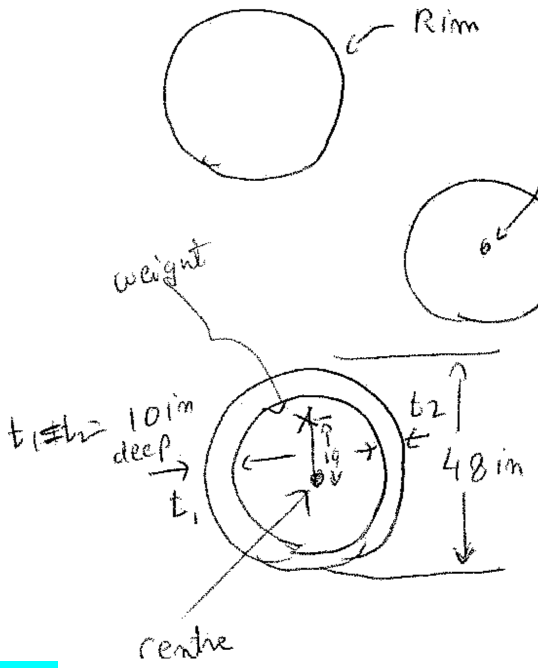
1. Determine the kinetic energy of the flywheel. In routine design calculations, the weight of a spoked or disk flywheel is assumed to be concentrated in the rim of the flywheel. The weight of the spokes or disk is neglected. In computing the kinetic energy of the flywheel, the weight of a rectangular, square, or circular rim is assumed to be concentrated at the horizontal centerline. Thus, for this rectangular rim, the weight is concentrated at a radius of 48/2 □ 10/2 = 19 in (48.3 cm) from the centreline of the shaft to which the flywheel is attached.

The weight of flywheel is at the rim of wheel (rim of wheel? Internet search –



Step (1) (1)

The weight of flywheel is at the rim of wheel



weight of Spoke is neglected

Kinetic energy is at centre Line

Kinetic energy point

weight is at $= \frac{48}{2} - \frac{10}{2}$

$= 19$ in

Weight is at 19 in

($19 \times 2.54 = 48.3$ cm)

from centre Line

Step 2

Then the kinetic energy $K = Wv2/(2g)$, where K = kinetic energy of the rotating shaft, ft⊕lb; W = flywheel weight of flywheel rim, lb; v = velocity of flywheel at the horizontal centerline of the rim, ft /s.

The velocity of a rotating rim is $v = 2pRD/60$, where $p = 3.1416$; R = rotational speed, r/min;
D = distance of the rim horizontal centerline from the center of rotation, ft. For this flywheel,

$v = 2p(200)(19/12)/60 = 33.2$ ft /s (10.1 m/s).

Step(2)
Kinetic Energy $K = \frac{Wv^2}{2g}$

K = kinetic Energy of rotating shaft (ft-lb)

W = weight of fly wheel (lb)

v = velocity of fly wheel at the horizontal centre line of the rim (ft/s)

v = velocity of rotating rim

$$v = \frac{2\pi RD}{60}$$

$\pi = 3.1416$, R = Rotational speed r/min

D = Distance of the rim horizontal centre line from centre of rotation (ft)

D = 19 in = 19/12 ft

$$v = \frac{2\pi RD}{60} = \frac{2 \times 3.1416 \times 200 \times \left(\frac{19 \text{ in}}{12}\right) ft}{60}$$

(2)

$$= 33.2 \text{ ft/sec}$$

3.3 ft = 1 m $\therefore$ $33.2 \text{ ft/sec} = \frac{33.2}{3.3}$

$$= 10.1 \text{ m/s}$$

Step 3

The rim of the flywheel has a volume of (rim height, in)(rim width, in)(rim circumference measuredat the horizontal centerline, in), or (10)(12)(2*p*)(19) = 14,350 in3 (235,154.4 cm3).

Since machine steel weighs 0.28 lb/in3 (7.75 g/cm3), the weight of the flywheel rim is (14,350)(0.28) = 4010 lb (1818.9 kg). Then *K* = (4010)(33.2)2/[2(32.2)] = 68,700 ft⊕lb (93,144.7 N⊕m).

Step (3) volume of fly wheel

Rim height = 10

Rim weight = 12

Rim circumference = $2\pi(19)$

Because it was given

(rim height, in) (rim width, in) (rim circumference)

$\downarrow$ 10 $\quad\downarrow$ 12 $\quad\downarrow (2\pi)(19)$

$\therefore \quad 10 \times 12 \times 2\pi \times 19 = 14350 \text{ in}^3$

(or) $\quad 1 \text{ in} = 2.54 \text{ cm}$

$14350 \times (2.54)^3 = 235154.4 \text{ cm}^3$

Steel weight 0.28 lb/in^3 (or) 7.75 gm/cm^3

$\therefore$ weight of flywheel rim $= 14350 \times 0.28$

$= 4010 \text{ lb}$

$1 \text{ Kg} = \text{lb} \times 0.456$ $\quad \therefore (4010 \times 0.456)$

$= 1828.9 \text{ Kg}$

$$K = \frac{W v^2}{2g} = \frac{4010 \times 33.2^2}{2 \times 32.2} = 68700 \text{ ft-lb}$$ ③

(or)

$$= \frac{1828.9 \times 10.2^2}{2 \times 9.8} = 93144.7 \text{ N-m}$$

Step 4

2. Compute the dimensions of the hole that can be stamped.

A stamping operation is a shearing process.The area sheared is the product of the plate thickness and the length of the cut. Each square inch of the sheared area offers a resistance equal to the ultimate shearing strength of the material punched.
During stamping, the force exerted by the stamp varies from a maximum F lb at the point of contact to 0 lb when the stamp emerges from the metal. Thus, the average force during stamping is $(F+0)/2 = F/2$.

The work done is the product of $F/2$ and the distance through which this force moves, or the plate thickness t in. Therefore, the maximum length that can be stamped is that which occurs when the full kinetic energy of the flywheel is converted to stamping work.

With a 1-in (2.5-cm) thick aluminum plate, the work done is W ft⊕lb = (force, lb)(distance, ft).
The work done when all the flywheel kinetic energy is used is $W = K$.
Substituting the kinetic energy
from step 1 gives $W = K = 68,700$ ft⊕lb (93,144.7 N⊕m) $= (F/2)(1/12)$; and solving for the force yields

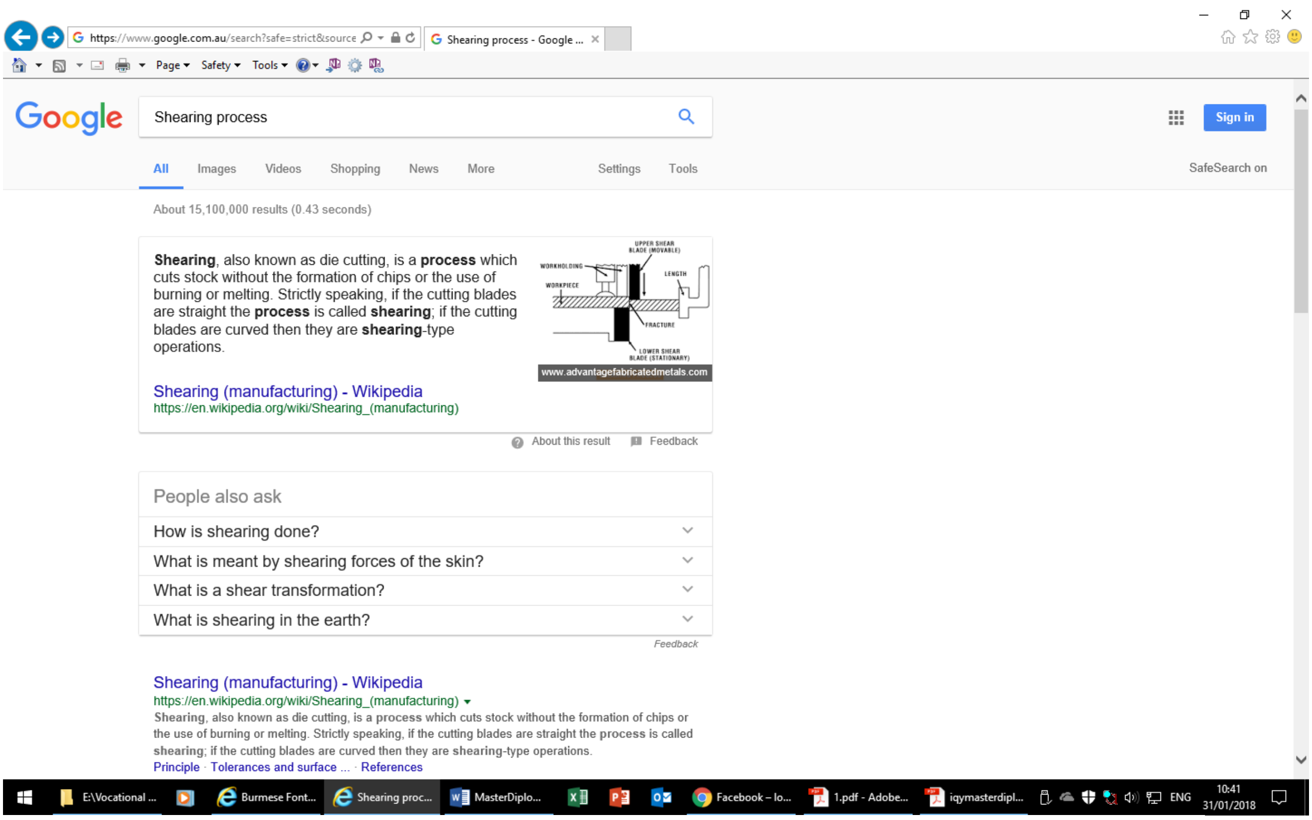
$F = 1,650,000$ lb (7,339,566.3 N).

The force F also equals the product of the plate area sheared and the ultimate shearing strength
of the material stamped. Thus, $F = ltsu$, where l = length of cut, in; t = plate thickness, in; su = ultimate shearing strength of the material.
Substituting the known values and solving for l,

we get $l = 1,650,000/[(1)(40,000)] = 41.25$ in (104.8 cm).

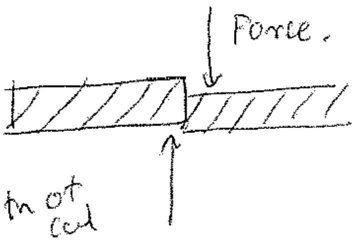
Note
A stamping operation is a shearing process.The area sheared is the product of the plate thickness and the length of the cut. Each square inch of the sheared area offers a resistance equal to the ultimate shearing strength of the material punched.

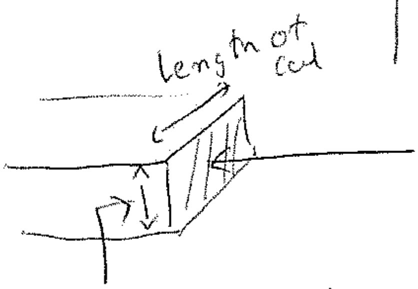
Shearing process—Internet search



Step 4

Shearing





Square in of Sheared Area = ultimate Shearing Strength.

Average force during stamping $= \frac{F+0}{2} = \frac{F}{2}$

Because 0 lb at stamp emerged from metal

work done = Product of $\frac{F}{2}$ and thickness 't'

$= \frac{F}{2} \times t$

work done when all flywheel kinetic Energy used

$W = K$ where $K = 68700$ ft-lb
(or)
93144.7 N-m

$\therefore W = 68700$ ft-lb (93144.7 N-m)

$W = \frac{F}{2} \times t$ where $t = 1$ in
(or) $\frac{1}{12}$ ft

$\therefore W = \frac{F}{2} \times \frac{1}{12}$

$68700 = \frac{F}{2} \times \frac{1}{12}$ $\therefore F = 68700 \times 2 \times 12$

$= 1650000$ lb

(or)

$93144.7 = \frac{F}{2} \times \frac{1}{12}$ $\therefore F = 93144.7 \times 2 \times 12$

$= 7339566.3$ N

F equals the product of the plate area sheared and the ultimate shearing strength

$F =$ plate area sheared $\times$ ultimate shearing strength

$F = l\, t\, s_u$

l = length of cut

t = plate thickness

S_u = ultimate shearing strength of material

$$F = l\ t\ S_u$$

$$1650000 = l \times (1\ in) \times 40{,}000$$

(given ultimate shearing strength of Alluminium)

$$l = \frac{1650000}{1 \times 40{,}000} = 41.25\ in$$

(or) 104.8 cm

In this problem

You know

- Rim of wheel
- Shearing process
- Kinetic energy
- $$K = \frac{W v^2}{2g}$$
- Average force during stamping $= \frac{F+0}{2} = \frac{F}{2}$
- work done = Product of $\frac{F}{2}$ and thickness 't'

  $= \frac{F}{2} \times t$

  F = plate area sheared × ultimate shearing strength
- $F = l\ t\ S_u$

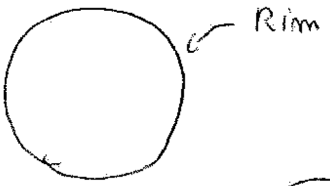
Additional notes

Related Calculations The length of cut computed above can be distributed in any form—square, rectangular, circular, or irregular. This method is suitable for computing the energy stored in a flywheel used for any purpose. Use the general procedure in step 2 for computing the principal dimension in blanking, punching, piercing, trimming, bending, forming, drawing, or coining.

All calculations on the next page

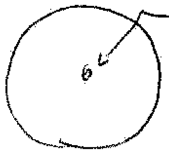
Step (1)

The weight of flywheel is at the rim of wheel

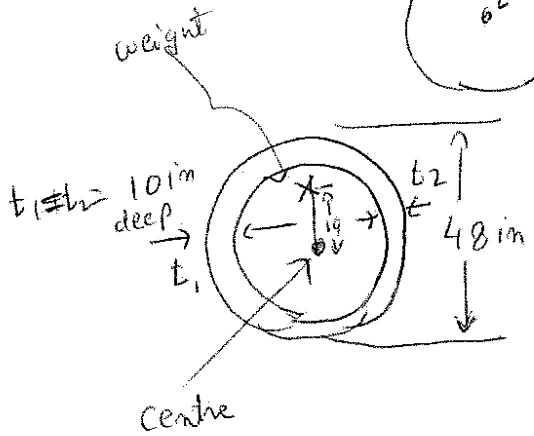


weight of Spoke is neglected

Kinetic energy is at centre Line



Kinetic energy point



weight is at $= \frac{48}{2} - \frac{10}{2}$

$= 19$ in

Weight is at 19 in

$(19 \times 2.54 = 48.3$ cm)

from centre Line

Step (2)

Kinetic Energy $\quad K = \frac{Wv^2}{2g}$

K = kinetic Energy of rotating shaft (ft-lb)

W = weight of fly wheel (lb)

v = velocity of fly wheel at the horizontal centre Line of the rim (ft/s)

v = velocity of rotating rim

$$v = \frac{2\pi RD}{60}$$

$\pi = 3.1416$, R = Rotational speed r/min

D = Distance of the rim horizontal centre Line from centre of rotation (ft)

$D = 19\ in = 19/12\ ft$

$v = \frac{2\pi R D}{60} = \frac{2 \times 3.1416 \times 200 \times \left(\frac{19\ in}{12}\right) ft}{60}$ (2)

$= 33.2\ ft/sec$

$3.3\ ft = 1\ m \quad \therefore \quad 33.2\ ft/sec = \frac{33.2}{3.3}$

$= 10.1\ m/s.$

Step(3) Volume of fly wheel

Rim height = 10

Rim weight = 12

Rim circumference = $2\pi(19)$

Because it was given

(rim height, in) (rim width, in) (rim circumference)

10   12 $(2\pi)(19)$

$\therefore 10 \times 12 \times 2\pi \times 19 = 14350\ in^3$

(or) $1\ in = 2.54\ cm$

$14350 \times (2.54)^3 = 235154.4\ cm^3$

Steel weight $0.28\ lb/in^3$ (or) $7.75\ gm/cm^3$

$\therefore$ weight of flywheel rim = 14350×0.28

$= 4010\ lb$

$1\ Kg = \underline{lb} \times 0.456 \quad \therefore (4010 \times 0.456)$

$= 1818.9\ Kg$

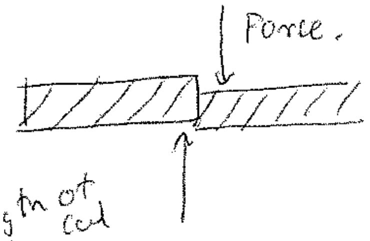
$$K = \frac{W v^2}{2g} = \frac{4010 \times 33.2^2}{2 \times 32.2} = 68700 \text{ ft-lb}$$ (3)

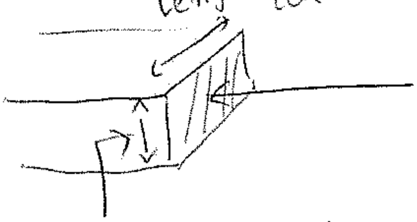
(or)

$$= \frac{1818.9 \times 10.2^2}{2 \times 9.8} = 93144.7 \text{ N-m}$$

Step 4

Shearing





Square in of Sheared Area = ultimate Shearing Strength.

Average force during stamping $= \frac{F+0}{2} = \frac{F}{2}$

Because 0 lb at stamp emerged from metal

work done = Product of $\frac{F}{2}$ and thickness 't'

$$= \frac{F}{2} \times t$$

work done when all flywheel kinetic Energy used

$W = K$ where $K = 68700$ ft-lb (or) 93144.7 N-m

$\therefore W = 68700$ ft-lb (93144.7 N-m)

(4)

$$w = \frac{F}{2} \times t$$ where $t = 1$ in (or) $\frac{1}{12}$ ft

$$\therefore w = \frac{F}{2} \times \frac{1}{12}$$

$$68700 = \frac{F}{2} \times \frac{1}{12}$$ $\therefore F = 68700 \times 2 \times 12$

$= 1650000$ lb

(or)

$$93144.7 = \frac{F}{2} \times \frac{1}{12}$$ $\therefore F = 93144.7 \times 2 \times 12$

$= 7339566.3$ N

F equals the product of the plate area sheared and the ultimate shearing strength

F = plate area sheared × ultimate shearing strength

$$F = l\, t\, s_u$$

l = length of cut
t = plate thickness
s_u = ultimate shearing strength of material

$$F = l\, t\, s_u$$

$$1650000 = l \times (1\text{ in}) \times 40{,}000$$ ← given ultimate shearing strength of Aluminium

$$l = \frac{1650000}{1 \times 40{,}000} = 41.25\text{ in}$$ (or) 104.8 cm

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This is my worked example for Section 3-Mechanical Engineering (PDF File Page 307)

Sections , you will find it in Block Letters

MACHINE DESIGN AND ANALYSIS
METALWORKING
COMBUSTION
POWER GENERATION
INTERNAL-COMBUSTION ENGINES
AIR AND GAS COMPRESSORS AND VACUUM SYSTEMS
MATERIALS HANDLING
PUMPS AND PUMPING SYSTEMS
PIPING AND FLUID FLOW etc

For every topic, you need to write the short note on what you understand, formula, summary, outlines and at least 2 problems solution (Please note, each problem is solved in short form, you need to clearly reproduce them by step by step)

It means that , from

MACHINE DESIGN AND ANALYSIS-------------- you prepare the detailed solution like as my worked example for two problems

METALWORKING -------------- you prepare the detailed solution like as my worked example for two problems

BAE708 Engineering Knowledge

http://www.highlightcomputer.com/MasterofEngineeringMechanicalCourseWorkGraduateDiplomaSyllabus.pdf

From the list of the subject, select two subjects, ask me to send the e-Book. Then you have to do the followings

The students will have to write 20 pages study report for each of the subjects outlined below.
The report needs to include

Book review- Review on each chapter of the book highlighting the key concepts, key formula, key theory & practical application concepts

Own idea on how to apply those concepts in real practical applications.
Examples of engineering designs that use the concepts & knowledge expressed in those books (If any)

Your comment on each book

BAE708 will be completed when you have done the above tasks

Text books can be downloaded from

Master Diploma resources

www.highlightcomputer.com/masterdiplomaresources.htm

Worked Example BAE689 Mechanical Design

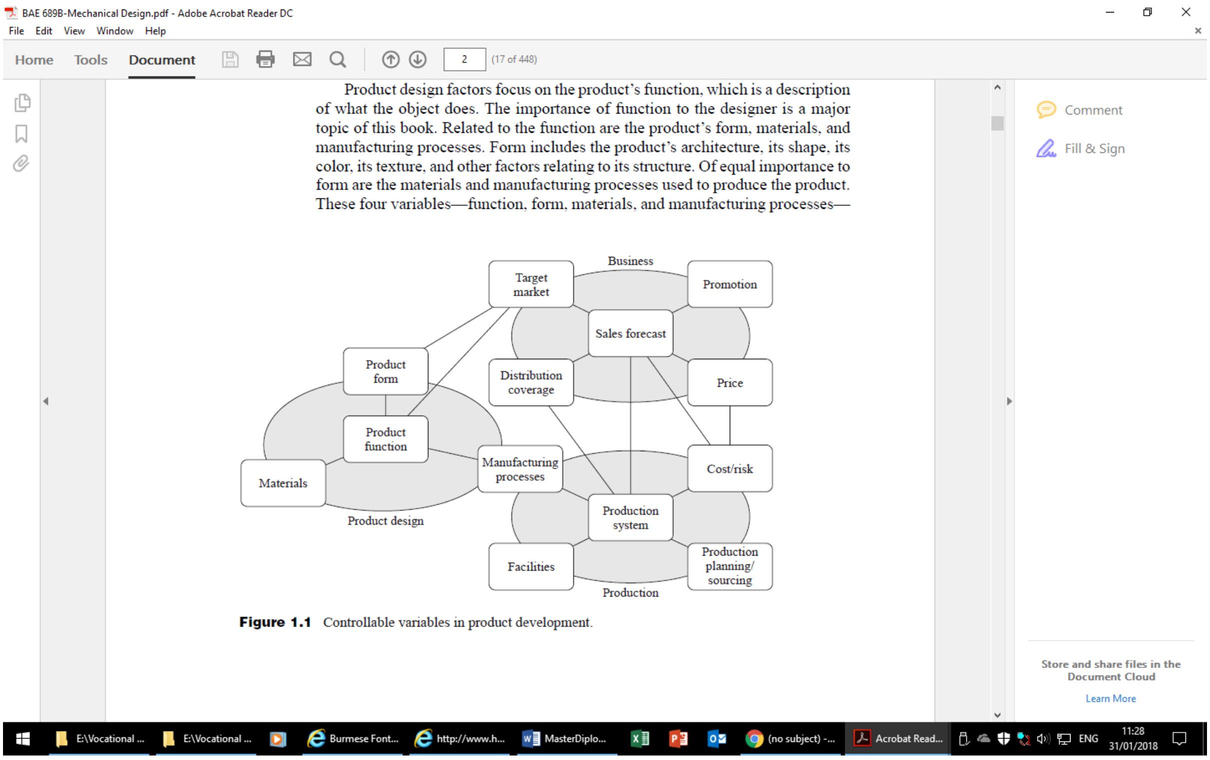
Book review- Review on each chapter of the book highlighting the key concepts, key formula, key theory & practical application concepts

Chapter 1 Why study Design Process?

Key concepts

- there are certain techniques that can be used during the design process to help ensure successful results
- it focuses not on the design of any one type of object but on techniques that apply to the design of all types of mechanical objects
- the tools to develop an efficient design process regardless of the product being developed

Key Formula / If the process is described by diagram, you can use it



Product design factors focus on the product's function, which is a description of what the object does. The importance of function to the designer is a major topic of this book. Related to the function are the product's form, materials, and manufacturing processes. Form includes the product's architecture, its shape, its color, its texture, and other factors relating to its structure. Of equal importance to form are the materials and manufacturing processes used to produce the product. These four variables—function, form, materials, and manufacturing processes—

Figure 1.1 Controllable variables in product development.

Key Theory

MEASURING THE DESIGN PROCESS WITH PRODUCT COST, QUALITY, AND TIME TO MARKET

The three measures of the effectiveness of the design process are product cost, quality, and time to market

Practical Applications

The data points for Company B are actual for a U.S. automobile manufacturer, and the dashed line for Company A is what is typical for Toyota

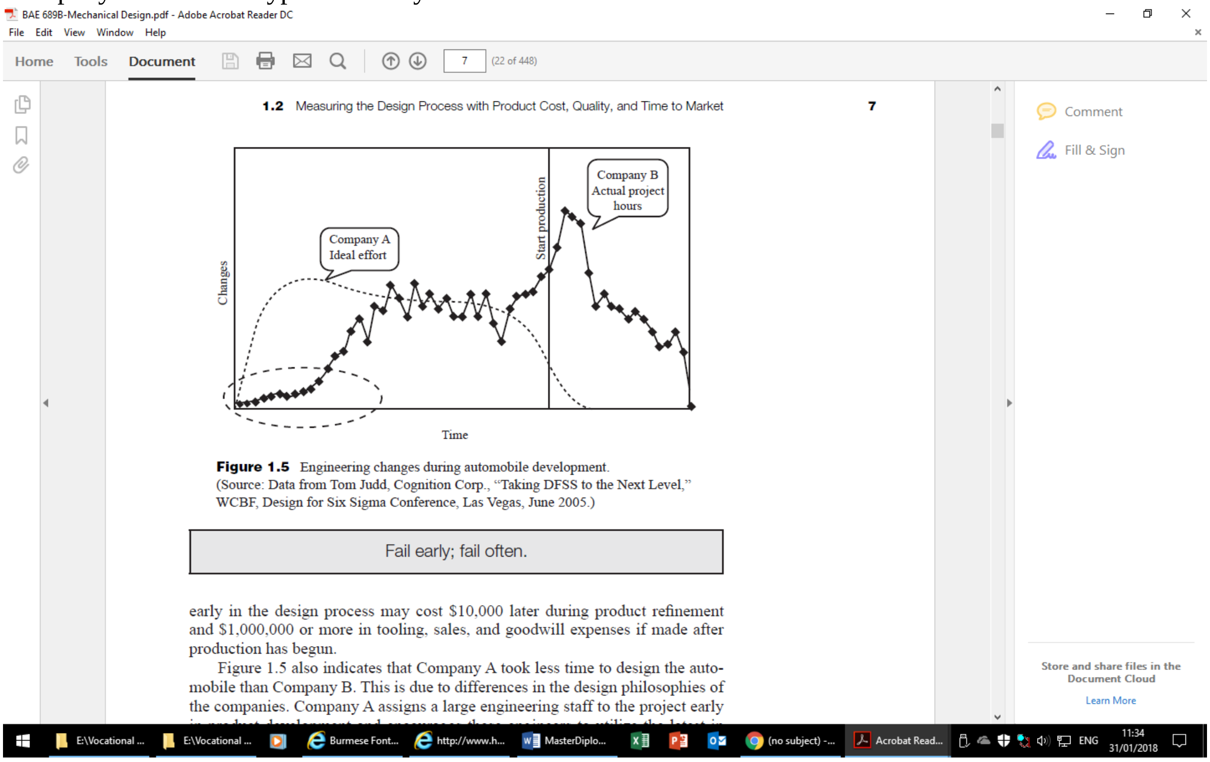


Figure 1.5 Engineering changes during automobile development.
(Source: Data from Tom Judd, Cognition Corp., "Taking DFSS to the Next Level," WCBF, Design for Six Sigma Conference, Las Vegas, June 2005.)

Fail early; fail often.

early in the design process may cost $10,000 later during product refinement and $1,000,000 or more in tooling, sales, and goodwill expenses if made after production has begun.

Figure 1.5 also indicates that Company A took less time to design the automobile than Company B. This is due to differences in the design philosophies of the companies. Company A assigns a large engineering staff to the project early

B- US Company did a little change at the beginning , but it will have to change a lot at production phase

A-Toyota company did a lot of changes and modifications at the start, so in long term, it has all necessary designs which do not need to change a lot in long term.

Own idea on how to apply those concepts in real practical applications.

In engineering design at the early stage, the designer is important to modify the design in several aspects so that the design will sustain for a long term.

Examples of engineering designs that use the concepts & knowledge expressed in those books (If any)

1. *Establish* the need or realize that there is a problem to be solved.
2. *Plan* how to solve the problem.
3. *Understand* the problem by developing requirements and uncovering existing solutions for similar problems.
4. *Generate* alternative solutions.
5. *Evaluate* the alternatives by comparing them to the design requirements and to each other.
6. *Decide* on acceptable solutions.
7. *Communicate* the results.

Your comment

This chapter also provided the knowledge on

- History of design process
- Life of product
- Solution for design problem
- Knowledge and learning during design
- Design for sustainability

It is my example for BAE689B Mechanical Design Chapter 1, you need to do the similar study notes for the rest of chapters if you choose to do the study report on BAE689B Engineering Design.

If you choose to do the study report on other books/ subjects, you need to follow the same way.

For BAE702 to 707, just follow the study instructions and submit the assignments

For Masters part 2, design, if you are working, you can submit your workplace design work. If you are not working at the site, you need to find one engineering topic, collect the reference resources, internet search and write a paper.

Reference

www.iqytechnicalcollege.com/BAE 689B-Mechanical Design.pdf

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