LEARNING MATERIALS

SEMESTER : 5TH SEMESTER

BRANCH : MECHANICAL ENGINEERING

SUBJECT :DESIGN OF MACHINE ELEMENTS (TH-2)

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CHAPTER – 1

Q.1 Define Factor of Safety. 2008 (1-a)

Ans: It is destined as the ratio of the maximum stress to the working stress mathematically

$$\text{Factor of safety} = \frac{\text{Maximum stress}}{\text{working or design stress}}$$

Q2. Define working stress 2008 (1-b) 2018 (w) 1a

Ans: When designing machine parts, it is desirable to keep the stress linear than the maximum or ultimate stress at which failure of the material takes place. This stress is known as the working stress yield stress.

Q.3 Define strain energy and resilience - 2008, 2007 (1-c) (1-a)

Ans: Resilience $\rightarrow$ It is the property of a material used to store energy and to resist shock and impact loads.

Strain energy $\rightarrow$ It is the property of a material to resist fracture due to high impact loads like harmmer blows.

Q4. Name factors governing design of machine element 2006-1(b), 2019-s-1-c,

Ans: The factors which govern the design of machine element are cost, strength, stiffness, wear resistance light weight minimum dimensions realibility durability economy of performanance operation safty, ease of assembly, ease of similarity of service, easy in of materials appearance etc.

Q5. Define ultimate stress 2006 1(b)

Ans: It is defined as the largest stress obtained by dividing the largest value of the load reach in a test to the original cross-section area of the last piece, What do you mean by adaptive design: This type of design needs no skill. A designer of ordinary technical training can do this design. The designer makes slight modification in design of existing product.

Q6. What is yield point stress. ***2006 1(a)***

Ans: In case of ductile material thesttress corresponding to the yield point is called yield point stress. What is fatigue.

When a material is subjected to repeated stress it fails at stresses below yield point stress. Such type of failure of material is known as fatigue.

Q.8. Define hardness, briffeness toughness and creep 2006 2(g) 2018 (w)1b

Ans: Hardness: It is that property of a material by virtue of which it can resist to wear scratch etc. It also means the ability of metal to cut another metal.

Brittleness:- It is the property of a material opposite to ductility. It is the property of breaking of a material with little

III) **Creep:-** when a parft is subjected to a constant stress at high temperature for a long time, it will undergo a slow and permanent of deformation called creep

iv) **Machinability:-** It is the property of a material which resters to a relative case with which it can be cut.

v) **Malleabilituy:-** It is the property of a material which permits to be rolled or hammered into thin sheets or plates.

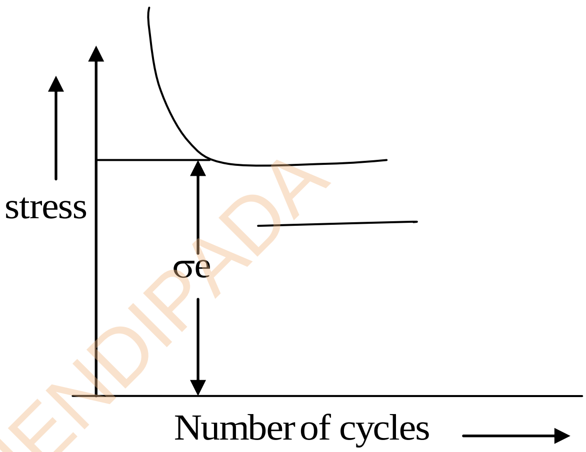
vi) **Stiffness:-** It is the ability of a material resist deformation under stress. The modulus at elasticity (E) is the measure of stiffness.

Q7. What is stress concentration.

Ans: Whenever a machine component changes the shape of its cross section, the simple stress distribution longer holds good and the neighbourhood of the discontinuity is different. This irregularity in the stress distribution caused by abrupt changes of form is called stress concentration.

08. Define endurance limit 2003 (1-c)

Ans: It is defined as the maximum value of completely reversed bending stress which a polished standard specimen can with stand without failure for infinite number of cycles (10^7 cycles)



Q9. Describe design procedure 2012 (1-b), 2019-s-1-b

Ans:
i. Recognition of need or aim for which the machine is to be designed.
ii. Select the possible mechanism or group of mechanisms which will give the desired motion.
iii. Analysise the forces acting on each member of the machine and the energy transmitted by each member
iv. Select the material best suited for each member of the machine.
v. Design the machine elements i.e. size by considering the force or stress acting on them in such a way that each member should not deslect or destrom than the permissible limit.
vi. Modify the size of the member to facilitate ease of manufacturing cost optimization etc.

vii. Drow the detailed drowing of each element and the assembly of the machine with complete specification.

viii. As per drawing manufacture the product with the best suitable method.

Q10. State mechanical properties of material 2012 (2-b)

Ans: **i. Strength** : It is the ability of a material to resist the externally applied forces without breaking or yielding.

ii. Elasticity: It is the ability of a material to regain its original shape after deformation when the external forces are removed. This property is desirable for materials used in tools and machines performance distortion cast iron is a brittle material.

Toughness: It is the property as a material to resist fracture due to high shock or impact loads like hammer blow. The toughness of the material decreases.

Creep: When a part is subjected to a constant stress at high temperature for a long time it will undergo a slow and permanent deformation called creep.

Q.11 What is Fatigue 2014(w)

Ans: When a material is subjected to repeated stresses, it fails at stresses below yield point stress, such type of failure of material is known as fatigue.

What do you mean by adaptive design.

This type of design needs no special knowledge or skill. A designer of ordinary technical training can do this design. In this type of design the designer makes slight modification in the design of existing product.

1. What is fatigue

Ans: When a material is subjected to repeal stresses, it fails at stresses below yield point stress. Such type of failure of material ks known as fatigue.

2. What do you mean by adaptive dsign.

Ans: This type of design needs no skill. A dsigner of ordinary technical training can do this design. The designer makes slight modification in the design of existing product.

CHAPTER:2

Problem

A double riveted lap joint with chain riveting is to be made for allowable stresses are f_t = 60 MPa, f_s = 50Mpa and f_c = 80 Mpa. Find the rivet diameter pitch of rivet and distance between rows of rivet. 2015 (s), 4(c)

Given data :

t = 10 mm

f_t = 60 MPa =60 N/mm^2

f_s = 50 MPa = 50 N/mm^2

f_c = 80 MPa = 80 N/mm^2

Diameter of rivet: Since the thickness of plate is greater than 8 mm so diameter of rivet hole d = $6\sqrt{t} - 6\sqrt{10}$ = 18.96 mm

The diameter of rivet hole , d = 19 mm corresponding to diameter of rivet of d = 18 mm

Problem:

A steam boiler is to be designed for a working pressure of 4N/mm^2 with a inside diameter of 160 cm. Give the design calculations for the circumferential joint for the following working stress for steel plates and rivets 2015(w),3(b)

In tension = 75 MPa

In shear = 60 MPa

In crushing = 125 MPa

Given data

P = 4N/mm^2

D = 160 cm = 1600 mm

Б_t = 75 MPa = 75 N/mm^2

τ = 60 MPa = 60 N/mm^2

Б$_c$ = 125 MPa = 125 N/mm^2

Design of circumferential joint thickness of boiler shell (t)

Thickness of boiler shell t = $t = \frac{PD}{2\sigma_t} + 1mm$

$$= \frac{4 \times 1600}{2 \times 75} + 1mm = 53.6mm$$

Diameter of rivets

Since the curess of shell is greater than 8 mm so diameter of rivet d = 6√t=6√53.6=43.9 mm

The diameter of rivet hole d = 44 mm

Corresponding to rivet dia of 43.9 mm

Number of rivets

Let n = Number of rivets

Shearing resistance of rivet = n × π/4 ××d^2

Total shearing load acting on the circumferential joint = π/4 × D^2 × P

Equating equation (i) and (ii) we get

$$n \times \frac{\pi}{4} \times d^2 \times \tau = \frac{\pi}{4} \times D^2 \times P$$

$$\Rightarrow n = \frac{D^2 P}{d^2 \times \tau} = \frac{(1600)^2 \times 4}{(44)^2 \times 60} = 88.15mm \text{ say } 89mm$$

Pitch of rivets

Assuming the joints to be double riveted lap joint with Zig-Zag riveting number of rivets per row 89/2 = 44.5 say 45

Pitch of rivets,

$$P_1 = \frac{\pi \times (D + t)}{\text{Number of rivets per row}}$$

$$= \frac{\pi(1600 + 53.6)}{45} = 115.4\,\text{mm say } 116\,\text{mm}$$

$$\frac{\text{Efficiency of Joint}}{\text{Efficiency of circumferential Joint}}$$

$$\eta_c = \frac{p_1 - d}{p_1} = \frac{116 - 44}{116} = 0.62 \text{ or } 62\%$$

$$\frac{\text{Distance between rows of rivets}}{\text{Distance between rows for zig-zag rivetting}}$$

$$= 0.33p_1 + 0.67 \times d = 0.33 \times 116 + 0.67 \times 44 = 67.76\,\text{mm say } 68\,\text{mm}$$

Margin

Margin, m = 1.5 d = 1.5 × 44 = 66 mm

Pitch of rivet (P)

Pitch of rivet is obtained by equating tearing resistance of plate to shearing resistance of rivet.

Tearing resistance of plate Pt = (p − d) × t × f_t

= (p − 19) × 10 × 60 N = (p − 19) × 600 N.

Shearing resistance of rivet, P_s = n × π/4 × d^2 × f_s

= 2 × π/4 $(19)^2$ × 50 N = 28338.5 N

$$\text{or } p = \frac{28338.5}{600} 47.23 \text{mm}$$

Or p = 47.23 + 19 = 66.23 mm

According to I.B.R

Maximum pitch, P_{max} = c × t6 + 41.28 mm

=2.62 × 10 + 41.28 = 67.48 mm

Taking c = 2.62

Taking minimum value

Pitch, p = 66.23 mm

Distance between rows of rivet (p_b)

For chain riveting

P_d = 2d = 2 × 19 = 38 mm

Margin

M = 1.5 d = 1.5 × 19 = 28.5 mm

Failure of joint

Tearing resistance of plate, p_t = (p – d) × t × ft

= (66.23 – 19) × 10 × 60 N = 28338 N

Shearing resistance of rivet , $P_s = n \times \pi/4 \times d^2 \times f_s$

= 2 × π/4 × $(19)^2$ × 50 N = 28338.5 N.

Crushing resistance of rivet $P_c = n \times d \times t \times f_c$

= 2 × 19 × 10 × 80 N = 30400 N

Strength of joint = least of p_t, p_s and p_c = 28338 N.

Strength of solid plate = $p \times t \times f_t$

$= 66.23 \times 10 \times 60$ N = 39738 N

Efficiency of joint, $\eta = \dfrac{\text{strength of joint}}{\text{strength of solid plate}} = \dfrac{28338}{29738} = 0.71 \text{ or } 71\%$

Q. Define pitch and diagonal pitch.

Ans: Pitch: It is the distance from centre of one rivet to the centre of next rivet measured parallel to seam. It is denote by ‘p’

Diagonal pitch:- It is the distance between the centre of rivets in adjacent rows of zig-zag riveted joint, it is denoted by ‘p_b’

Q. Write assumptions in design of pressure vessels.

i) The load on the joint is equally shared

ii) The tensile stress is equally distributed over the section of metal between rivets.

iii) The shearing stress of all rivets is uniform.

iv) the crushing stress is uniform.

v) There is no bending stress is rivets

vi) The friction between surface of plate is neglected.

Problem: A triple riveted lap joint with zig-zag riveting is to be designed to connect two plates of 6 mm thickness. Determine the diameter of rivet, pitch of rivet and distance between rows of rivet. Indicate how the joint will fail. Assume

$\sigma_t = 120$ MPa, $\tau = 100$ MPa and $\sigma_c = 150$ MPa 2014(w), 2(c)

Given data:

Thickness of plate, $t = 6$ mm

Permissible tensile stress, $\sigma_t = 120$ Mpa

Permissible shear stress, $\tau = 100$ Mpa

Permissible crushing stress $\sigma_c = 150$ Mpa

Since thickness of plate is less than 8 mm so diameter of rivet hole is calculated by equating shearing resistance of rivet to crushing resistance of rivet. Since the joint is triple riveted lap joint and there are three rivets per pitch length so n = 3 is taken.

Shearing resistance of rivet

$$P_s = n \times \frac{\pi}{4} \times d^2 \times \tau = 3 \times \frac{\pi}{4} \times d^2 \times 100 N = 235.5 d^2 N.$$

Crushing resistance of rivet, $P_c = n \times d \times t \times \sigma_c$

$3 \times d \times 6 \times 150$ N = 2700 d N.

Taking $P_s = P_c$ we get

$235.5\ d^2 = 2700d$ or $d = 2700/235.5 = 11.5$ mm

The diameter of rivet hole d = 13 mm

Corresponding to diameter of rivet of Pitch of rivet.

Let P = Pitch of rivet

Tearing resistance of plate

$P_t = (p - d) \times t \times \sigma_t = (p - 13) \times 6 \times 120$ N $= (p - 13) \times 720$ N.

Shearing resistance of rivet

$P_s = n \times \pi/4 \times d^2 \times \tau = 3 \times \pi/4 \times (13)^2 \times 100$ N = 39799.5 N

Pitch of rivet is obtained by equating $p_t = p_s$

$\therefore\ (p - 13) \times 720 = 39799.5$

Or $p - 13 = \frac{39799.5}{720} = 55.28$

Or p = 55.28 + 13 = 68.28 mm

According to IBR, maximum pitch $P_{max} = c \times t + 41.28$ mm

For lap joint and 3 rivets per pitch length C = 3.47 is taken

$\therefore P_{max} = C \times t + 41.28 \text{ mm} = 3.47 \times 6 + 41.28 \text{ mm} = 20.82 + 41.28 = 62.1$ mm say 63 mm

Since P_{max} is less than p so pitch, $P = P_{max} = 63$ mm.

Distance between rows of rivet

Distance between rows of rivets for zig-zag riveting

$P_b = 0.33p + 0.67\ d$

$= 0.33 \times 63 + 0.67 \times 13 = 20.79 + 8.71 = 29.5$ mm

Q.7 How does a riveted Joint fail ? 2003 (3-a)

Ans: A riveted joint will fail due to following reasons.

i) Due to tearing of plate at an edge.

ii) Due to shearing of rivet.

iii) Due to crushing of rivet.

Q.8 State Types of welded joint 2010 (1-g), 2019-s-6-a,

Ans: Following two types of welded joint are important from the subject point of view

a) Lap joint or filled joint

b) bult joint

The bult joint may be

i) square bult joint

ii) single v – bult joint

iii) single U – bult joint

iv) Double V – bult joint

v) Double U bult joint

Problem:

A plate of 75mm width and 12.5 mm thick is joined with another plate by means of a single transverse and double parallel fillet weld. The maximum tensile and shear stress 70and 56 MPa respectively. Find the length of each parallel fillet weld joint as the joint is subjected to both static and fatigue load.

2018-W-2-c

Ans:

(c)

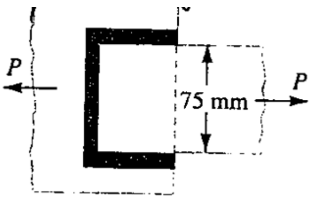


Fig. 10.15

Solution. Given : Width = 75 mm ; Thickness = 12.5 mm ; σ_t = 70 MPa = 70 N/mm^2 ; τ = 56 MPa = 56 N/mm^2.

The effective length of weld (l_1) for the transverse weld may be obtained by subtracting 12.5 mm from the width of the plate.

$$\therefore \quad l_1 = 75 - 12.5 = 62.5 \text{ mm}$$

Length of each parallel fillet for static loading

Let $\quad l_2$ = Length of each parallel fillet.

We know that the maximum load which the plate can carry is

$$P = \text{Area} \times \text{Stress} = 75 \times 12.5 \times 70 = 65\,625 \text{ N}$$

Load carried by single transverse weld,

$$P_1 = 0.707\, s \times l_1 \times \sigma_t = 0.707 \times 12.5 \times 62.5 \times 70 = 38\,664 \text{ N}$$

and the load carried by double parallel fillet weld,

$$P_2 = 1.414\, s \times l_2 \times \tau = 1.414 \times 12.5 \times l_2 \times 56 = 990\, l_2 \text{ N}$$

$\therefore$ Load carried by the joint (P),

$$65\,625 = P_1 + P_2 = 38\,664 + 990\, l_2 \quad \text{or} \quad l_2 = 27.2 \text{ mm}$$

Adding 12.5 mm for starting and stopping of weld run, we have

$$l_2 = 27.2 + 12.5 = 39.7 \text{ say } 40 \text{ mm } \textbf{Ans.}$$

Length of each parallel fillet for fatigue loading

From Data book, we find that the stress concentration factor for transverse welds is 1.5 and for parallel fillet welds is 2.7.

$\therefore$ Permissible tensile stress,

$$\sigma_t = 70 / 1.5 = 46.7 \text{ N/mm}^2$$

and permissible shear stress,

$$\tau = 56 / 2.7 = 20.74 \text{ N/mm}^2$$

Load carried by single transverse weld,

$$P_1 = 0.707\, s \times l_1 \times \sigma_t = 0.707 \times 12.5 \times 62.5 \times 46.7 = 25\,795 \text{ N}$$

and load carried by double parallel fillet weld,

$$P_2 = 1.414\, s \times l_2 \times \tau = 1.414 \times 12.5\, l_2 \times 20.74 = 366\, l_2 \text{ N}$$

$\therefore$ Load carried by the joint (P),

$$65\,625 = P_1 + P_2 = 25\,795 + 366\, l_2 \quad \text{or} \quad l_2 = 108.8 \text{ mm}$$

Adding 12.5 mm for starting and stopping of weld run, we have

$$l_2 = 108.8 + 12.5 = 121.3 \text{ mm } \textbf{Ans.}$$

Problem:

Two plates of 10 mm thickness each are to be joined by means of single riveted double strap bult joint. Determine the rivet diameter, rivet pitch, strap thickness and efficiency of Joint. Take the working stresses in tension and shearing as 80 MPa and 60 Mpa respectively. 2012(W). 3(c)

Given data:

Thickness of plate, t = 10 mm

Tensile, stress σ_t = 80 MPa = 80 N/mm^2

Shear stress, τ = 60 MPa = 60 N/mm^2

Diameter of rivet (d)

Since thickness of plate, is greater than 8 mm Diameter of rivet hole,

$d = 6\sqrt{t} = 6\sqrt{10} = 18.97$ mm

From design data Book

The standard diameter of rivet hole (d) is 19 mm corresponding to diameter of rivet 18 mm

Pitch of rivet (p)

Tearing resistance of plate, $P_t = (p - d) \times t \times \sigma_\tau$

$= (P - 19) \times 10 \times 80 = 800\ (P - 19)$ N------------- (1)

Shearing resistance of rivet

$P_S = n \times 1.875 \times \pi/4 \times d^2 \times t$

$= 1 \times 1.875 \times \pi/4 \times (19)^2 \times 60 = 31{,}90$ N------------- (2)

Equating equation (1) and (2)

$800\ (P - 19) = 31,\ 900 \Rightarrow P - 19 = 39.87 \Rightarrow P = 39.87 + 19 = 58.87$ say 60 mm

According to 1.3.2

The maximum pitch of rivet for double strap Joint the value C = 1.7.5

$P_{max} = 1.75 \times 10 + 41.28$ mm = 58.75 mm say 60 mm

$\therefore\ P = P_{max} = 60$ mm

THICKNESS OF COVER PLATE.

$T_1 = 0.625\ t = 0.625 \times 10 = 6.25$ mm

EFFICIENCY OF JOINT. TEARING RESISTANCE OF PLATE

$P_t = (p - d) \times t \times \sigma_t = (60 - 19) \times 10 \times 80 = 32,\ 800$ N

SHEARING RESISTANCE OF RIVET.

$P_S = n \times 1.875 \times \pi/4 \times d^2 \times \tau$

$= 1 \times 1.875 \times \pi/4 \times (19)^2 \times 60 = 31{,}900$ N

Strength of Joint = least of p_t and p_S = 31,900 N.

Strength of un riveted plate per pitch length , $P = P \times t \times \sigma_t = 60 \times 10 \times 800 = 48{,}000$ N

Efficiency of Joint, η = least of p_t of P_s/Strength of un riveted palte

= 31,900/48,000 = 0.665 or 66.5 %.

DETERMINE STRENGTH AND EFFICIENCY OF RIVETTED JOINT (2019-s-6-b)

TEARING OF PLATE

p = pitch of rivet

d = diameter of rivet hole

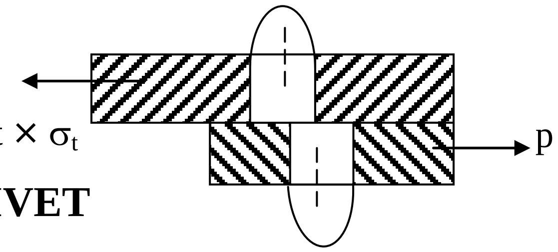
t = the cuver of plate

σ_t = permissible tensile strem for plate material

Tearing area per pitch length

$At = (p - d) \times t$

Tearing resistance, $p_t = At, \sigma_t = (p - d) \times t \times \sigma_t$



Shearing of rivet in lag joint

SHEARING RESISTANCE OF RIVET

Shearing area $A_s = \pi/4 \times d^2$

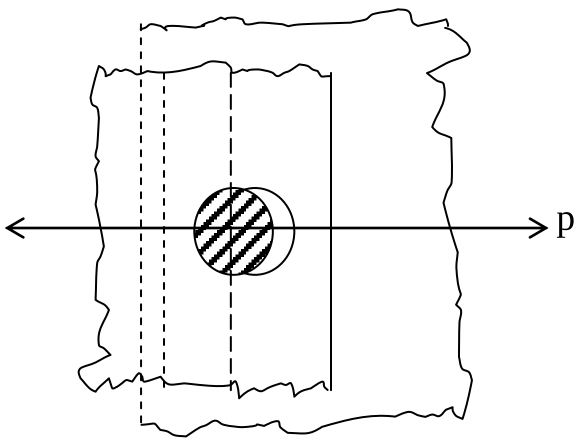
Shearing resistance $P_s = n \times \pi/4 \times d^2 \times \tau$

CRUSHING RESISTANCE OF RIVET

Crushing area per rivet

$A_C = d \,.\, t$

Total crushing area = n.d.t.



Crushing resistance P_C = n.d.t. σ_C

Strength of joint is the maximum force which the joint can transmit with out failure

Strength o+f Joint = least of p_t, p_s or p_C

Efficiency of Joint it is the ratio of strength of joint to the strength of solid plate

$$\text{Efficiency of joint, } \eta = \frac{\text{Strength of joint}}{\text{Strength of solid plate}}$$

Q. ***Define pitch and diagonal pitch***

Ans: Pitch: It is the distance from centre of one rivet to the centre of next rivet measured parallel to seam. It is denoted by 'P'

Diagonal pitch: It is the distance between the centres of rivets in adjacent rows of zig-zag riveted joint. It is denoted by 'Pb'

Q. ***Write assumption in design of pressure vessel***

i. The load on the joint is equally shared by all rivets

ii. The tensile stress is equally distributed over the section of metal between rivets.

iii. The shearing stress of all rivets is uniform

iv. The crushing stress is uniform.

v. there is no bending stress in rivets.

vi. The friction between surface of plate is neglected.

DESIGN OF FASTENING ELEMENT

Q1. Mention the efficiency of riveted joint 2009, 2007 (1-iv) (7-v)

Ans: The efficiency of a riveted joint is defined as the ratio of the strength of riveted joint to the strength of the un-riveted or solide plate. We have already discussed that strength of the riveted joint = least of $p_t.p_s$ and p_c. Strength of the un-riveted of solid plate per pitch length = p × t × σ_t. Efficiency of the rivetted joint $\eta = \frac{\text{list of } p_t, p_s \text{ and } p_c}{p \times t \times \sigma_t}$

Q2. Name different riveted joints 2007 (1-d)

Ans:
- → Single rivetted lap joint
- → Double rivetted (chain or zig-zag) lap joint
- → Tripple rivetted (chain or zig-zag) lap joint
- → single riveted single cover butt
- → single rivetted double cover butt
- → Double rivetted single cover butt (chain or zig-zag)
- → Double rivetted double cover butt (chain or zig-zag)

Q3. Name different types of welded joints with their advantages over other joints 2007, 2006 (1-x), (1-d), 2018-w-2-b

Ans: Types of welded joint – square butt joint, single V-butt, single U-butt, Double V-butt joint, Double U-butt joint.

Advantages of welded joint –

i. It is lighter

ii. It has smooth appearance. So it look pleasing

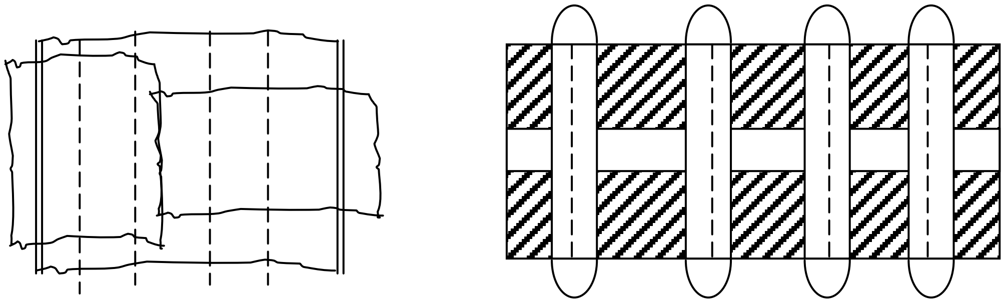
iii. It takes less time.

iv. It provides maximum efficiency.

v. Alteration and addition can be easily made

vi. The process of welding provides very rigid joint.

Q4. Sketch a double rivetted cover butt joint 2009 (1-a)



Q5. Define strength and efficiency of rivetted joint 2012 (6-b),2019-s-6-b

Ans: The efficiency of a rivetted joint is destined as the ratio of the strength of riveted joint to the strength of the un riveted or solid plate. We have already discussed that strength of the rivetted joint = least of p_t, p_s and p_c.

Strength of the un rivetted or solid plate per pitch length = $p \times t \times \sigma_t$

$\therefore$ Efficiency of the riveted joint $\eta = \dfrac{\text{list of } p_t, p_s \text{ and } p_c}{p \times t \times \sigma_t}$

p = pitch of the rivets.

t = Thickness of the plate

σ_t = permissible tensile stress.

Q. Name different types of welded joints with their advantages over other joints (2007 (1-x) 2006 (1(d))

Ans: i. A welded joint has a great strength, often a welded joint has strength of the parent metal itself.

ii. Welded joints can be made more than 100 % strong i.e. the joint will never foil.

iii. The welded joints provide maximum efficiency (may be 100 %) which is not possible in case of riveted joints.

iv. With adoption of welding, there is no need of patterns moulds etc.

v. As the welded structure is smooth in appearance therefore it loods pleasing.

vi. Fabrication by welding results in lighter constructions and there is saving in material.

vii. Alternations and additions can be easily made in the existing structure.

viii. With welding techniques it is possible to added the specific material with desired characteristics to any portion of the machine part.

Ix. The welding provides very rigid joints. This is in line with the modern trend of providing rigid brames.

x. In welded connections, the tensions members are not weakened as in case of riveted joints.

xi. The process of welding takes less time than the riverting

xii. Sometimes the members are of such shape (i.e. circular steel pipes) that they afford difficulty for riveting , But they can be easily welded.

xiii. It is possible to weld any part of a structure at any point but riveting requires enough clearance.

DEFINE PITCH AND DIAGONAL PITCH

PITCH: It is the distance from centre of one rivet to the centre of next rivet measured parallel to seam. It is denoted by ‘p’

Diagonal pitch: It is the distance between the centres of rivets in adjacent rows of zig-zag riveted joint. It is denoted by ‘Pb’

Write assumption in design of pressure vessel

i. The load on the joint is equally shared by all rivets

ii. The tensile stress is equally distributed over the section of metal between rivets.

iii. The shearing stress of all rivets is uniform

iv. The crushing stress is uniform.

v. there is no bending stress in rivets.

vi. The friction between surface of plate is neglected.

From data book according to SWG3 the standard diameter of wire

$d = 6.401$ mm

Mean diameter of spring coil, $D = 5d$

$= 5 \times 6.401 = 32.005$ mm.

Outer diameter of spring coil, $d_0 = d + d = 32.005 + 6.401 = 38.406$ mm

Number of turns of coil.

Let n = Number of active turns of coil compression of spring $\delta = \dfrac{8WC^3n}{Gd}$

$$\text{or } 25 = \frac{8 \times 1000 \times 5^3 \times n}{84 \times 10^3 \times 6.401} = 1.86n$$

$$\text{or } n = \frac{25}{1.86} = 13.44 \text{ say } 14$$

For squared and ground ends the total number of turns

$n' = n + 2 = 14 + 2 = 16$

Free length of spring

Free length of spring = n'd + δ + 0.15 δ

=16 × 6.401 + 25 + 0.15 × 25 = 131.2 mm

Pitch of coil

Pitch of coil, $P = \frac{\text{Free length}}{n'-1} = \frac{131.2}{16-1} = 8.25\,\text{mm}$

Problem :

Design a compression helical spring to carry a load of 500 N with a deflection of 25 mm. the spring index may be taken is 8. The permissible shear stress of spring material is 350 MPa, modulus of rigidity is 84 KN/mm^2 2014(w),7(c)

Wahl's stress factor, $K = \frac{4C-1}{4C-4} + \frac{0.615}{C}$

Where C = spring index

Given data:

W = 500 N

δ = 25 mm

C = D/d = 8

τ = 350 N/mm^2

G = 84 KN/mm^2 = 84 × 10^3 N/mm^2

Mean diameter of spring coil

Let D = Mean diameter of spring coil

d = Diameter of spring wire

Wahls stress factor, $K = \frac{4C-1}{4C-4} + \frac{0.615}{C}$

$$= \frac{4\times8-1}{4\times8-4} + \frac{0.615}{8} = 1.183$$

$$\text{Max.shear factor, } K = \frac{4C-1}{4C-4} + \frac{0.615}{C}$$

$$== \frac{4\times8-1}{4\times8-4} + \frac{0.615}{8} = 1.183$$

$$\text{Max. shear stress, } \tau = K\times\frac{8WC}{\pi d^2} = 1.183\times\frac{8\times500\times8}{\pi\times d^2}$$

$$\Rightarrow 420 = \frac{12058.8}{d^2} \Rightarrow d^2 = \frac{12058.8}{420} = 28.71$$

Form design data Book according to SWG5 the standard diameter of wire, d = 5.385 mm

Mean diameter of spring coil D = 8d = 8 × 5.385 = 43.08 mm

Outer diameter of spring coil, D_0 = D + d = 43.08 + 5.385 = 44.465 mm

Number of turns of coil

Let n = Number of active turns of coil

Compression of spring $(\delta) = \frac{8WC^3n}{5d}$

$$\Rightarrow \quad 25 = \frac{8\times500\times(8)^3\times n}{84\times10^3\times5.385} \Rightarrow n = 5.52 \text{ say } 6$$

For squared and ground ends the total number of turns

n' = n + 2 = 6 + 2 = 8

Free length of spring

$L_f = n'd + \delta + 0.15 \times \delta$

$=(8 \times 5.85) + 25 + (0.15 \times 25) = 71.83$ mm

Pitch of coil, $P = \dfrac{\text{Free length}}{n'-1} = \dfrac{71.83}{8-1} 10.26\,\text{mm}$

Define spring index,

It is defined as the ratio of mean diameter of spring coil to mean diameter of spring wire.

Spring index, C = D/d

Problem:

A compression spring coil made of an alloy steel is having the following specification

Mean diameter of coil = 60 mm

Wire diameter = 6 mm

Number of coils = 20

If the spring is subjected to an axial load of 600 N calculate maximum shear stress, to which the spring material is subjected

Mean diameter of coil, D = 60 mm

Diameter of wire, d = 6 mm

Number of coils, n = 20

Axial bad , w = 600 N

Maximum shear stress, τ = ?

Spring index, C = D/d = 60/6 = 10

Wahl's stress factor, $K = \frac{4C-1}{4C-4} + \frac{0.615}{C}$

$= \frac{4 \times 10 - 1}{4 \times 10 - 4} + \frac{0.615}{10} = 1.14$

Maximum shear stress, $\tau = K \times \frac{8WC}{\pi d^2}$

$= 1.14 \times \frac{8 \times 600 \times 10}{\pi \times (6)^2} = 484\, N/mm^2$

Problem:

Design a helical compression spring for a maximum load of 1200 N for a deflection of 30 mm using the value of spring index as 5. The maximum shear stress for spring wire is 420 MPa and modulus of rigidity is 84 KN/mm^2

Wahl's stress factor, $K = \frac{4C-1}{4C-4} + \frac{0.615}{C}$

Where C = spring Index 2014(w), 6(b)

Given data

W = 1200 N

δ = 30 mm

C = D/d = 5

τ = 420 MPa = 420 N/mm^2

G = 84 KN/mm^2 = 84 × 10^3 N/mm^2

Mean diameter of spring

Let D = Mean diameter of spring coil

d = Diameter of spring wire

$$K = \frac{4C-1}{4C-4} + \frac{0.615}{C}$$

Wahl's stress factor,

$$= \frac{4\times5-1}{4\times5-4} + \frac{0.615}{5} = 1.31$$

Maximum shear stress, induced in wire

$$\tau = K\times\frac{8WC}{\pi d^2} \Rightarrow 420 = 1.31\times\frac{8\times1200\times5}{\pi d^2}$$

$$\Rightarrow d = \sqrt{\frac{8\times1200\times5\times1.31}{\pi\times420}} = 6.9\,mm$$

From design data Book according to SWG2 the standard diameter of wire d = 7.01 mm

Mean diameter of spring coil, D = 5mm = 5 × 7.01 = 35.05 mm

Outer diameter of spring coil, d = D + d = 35.05 + 7.01 = 42.06 mm

Number of turns of coil

Let n = Number of active turns of coils

Compression of spring, $\delta = \frac{8WC^3n}{Gd}$

$$\Rightarrow \quad 30 = \frac{8\times1200\times5^3n}{84\times10^3\times7.01}$$

$$\Rightarrow \quad n = \frac{30\times84\times10^3\times7.01}{8\times1200\times5^3} = 14.7 \text{ say } 15$$

For squared and ground ends total number of turns, n' = n + 2 = 15 + 2 = 17

Free length of spring = n' d + δ + 0.15 × δ

= (17 × 7.01) + 30 + (0.15 × δ) = 153.67 mm

Pitch of coil $= \frac{\text{Free length}}{n'-1} = \frac{153.67}{17-1} 9.6mm$

Q.Derive an expression for spring rate of helical spring. 2018-w-4-b

We know that,

F=-kx

Therefore, k=Fx

The **Spring Constant Formula** is given as, k=FxWhere,

- **F** = Force applied,
- **x** = displacement by the spring

It is expressed in **Newton per meter (N/m)**.

DESIGN OF SPRING

Q. What do you mean by surge in spring

2009,(1-ix),2012(7-a),2005(6-b)

Ans: When one end of a helical spring is resting on a rigid support and the other end is loaded suddenly then all the coils of the spring coil not suddenly deflect equally, because some time is required for the propagation of the stress along the spring wire. A little consideration will show that in the beginning the end coils of the spring in contact with the applied load takes up whole of the deflection and then it transmits a large part of its deflection to the adjacent coils. In this way a wave of compression propagates through the coils to the supported end from where it is reflected back to the deflected end. This wave of compression travels along the spring indefinitely . If the applied load is of fluctuating types as in the case of valve spring in internal combustion engines and if the time interval between the load applications is equal to the time required for the wave.

Q.3. Define solid length and free length of a closely coiled spring. 2005, 2008 1(g), 5(I,II) 2019-s-7-a

Ans: Solid length when the compression spring is compresed until the coils come in contact with each other then the spring is said to the solid, the solid length of a spring is the product of total numbers of coils and the distance diameter of the wire.

Free Lengths: The free length of a compression spring as shown in fig. is the length of the spring in the plus the maximum deflection or compressed of the spring and clearance between the adjacent coils.

Pitch : The pitch of the coil is designed as the axial distance between adjacent coils in un compressed state.

Q4. State the materials used for helical spring 2008 (1-i)

Ans: the metarial of the spring should have high fatigue strengths, high ductility , high resilience creep resistant. The spring are mostly made from oil tempered carbon steel wires containing 0.60 to 0.70 percent carbon and 0.60 to 1.0 percentage managanese.

Q.5. Define the following terms used in spring

i) Solid length

ii) Free length

iii) Pitch

iv) Wahl's stress factor

iv) ***Wahl's stress factor (k)***

In order to take into accured the effect of direct shear and change in coil curvature a stress factor is destined, which is known as Wahl's stress factor (k) $K = \frac{4C-1}{4C-4} + \frac{0.615}{C}$

Where C = spring index = D/d

Q: state the formula for stress in helical spring of a circular wire. (2018-w-5-a)

$\tau = K \times \frac{8\,WC}{\pi\, d\, 2}$