**NATIONAL SENIOR CERTIFICATE**

**GRADE 12**

**MECHANICAL TECHNOLOGY NOVEMBER 2015**

**MEMORANDUM**

**MARKS: 200**

**This memorandum consists of 19 pages.**

**QUESTION 1: MULTIPLE-CHOICE QUESTIONS**

|  |  |  |
| --- | --- | --- |
| 1.1 | B  | (1) |
| 1.2 | B  | (1) |
| 1.3 | B  | (1) |
| 1.4 | A  | (1) |
| 1.5 | C / D | (1) |
| 1.6 | B  | (1) |
| 1.7 | A  | (1) |
| 1.8 | D  | (1) |
| 1.9 | A  | (1) |
| 1.10 | D  | (1) |
| 1.11 | D  | (1) |
| 1.12 | C  | (1) |
| 1.13 | B  | (1) |
| 1.14 | B  | (1) |
| 1.15 | A  | (1) |
| 1.16 | B  | (1) |
| 1.17 | A  | (1) |
| 1.18 | D  | (1) |
| 1.19 | A  B for Afrikaans only | (1) |

|  |  |  |
| --- | --- | --- |
| 1.20 | C  | (1) |
|  |  | **[20]** |

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**QUESTION 2: SAFETY**

2.1 **Personal Safety Angle grinder**

• Wear eye safety protection

• Wear ear plugs or muffs

• Wear safety boots with steel toe caps

• Wear overalls Leather apron

• Wear gloves

(Any 3 x 1) (3)

2.2 **Safety – Hydraulic Press**

• The predetermined pressure of the hydraulic press must not be exceeded

• Ensure the pressure gauges is in a working order 

• Platform on which the work piece rests must be rigid and square with the cylinder of the press 

• The prescribed equipment must be used

• Check that securing pins for the platform are fitted properly

• Check on hydraulic pipes for leaks/ oil on floor

• Bearing need to be placed in a suitable jig

(Any 3 x 1) (3)

2.3 **Safety – Spring tester**

• Be very careful that the jaws/clamp of the spring tester does not slip out

• Use correct attachments of the valve spring tester to compress the spring. 

• Do not stretch or compress the spring more than indicated in the specification 

(Any 2 x 1) (2)

|  |  |  |
| --- | --- | --- |
| 2.4 | **Safety – Bearing and Gear puller**• Make sure that the puller is the right one to use • Do not use a hammer on the puller • Use the correct spanner to tighten the clamps and to pull off the object • Make certain that the puller is at a 90° to the work piece • Legs of the puller must not be worn• Use the slip cover to prevent injury• When working with the puller do not work directly behind the puller in case it slips(Any 2 x 1) | (2) |
|  |  | **[10]** |

**QUESTION 3: TOOLS AND EQUIPMENT**

3.1 **Tests**

3.1.1 A **cylinder leakage tester** is used to check whether gases leak

from the cylinder in the engine during compression stroke.  (2)

3.1.2 The purpose of the **fuel pressure tester** is to test the fuel operating pressure in the system  and fuel pressure in the fuel

line that runs to the direct injection.  (2)

3.1.3 The purpose of the **torsion tester** is to investigate the relationship between momentum or torque applied to material and influence of

material length and torsional deflection.  (2)

3.2 **Reasons to perform cylinder leakage test**

• Power loss

• Low compression

• To determine whether cylinder head gasket has blown

• Oil consumption due to excessive leakage past the piston rings

• To identify leaking valves as a cause of excessive smoking

(Any 2 x 1) (2)

3.3 **Reasons for high CO reading**

• Rich mixture setting

• Incorrect idle speed

• Clogged air filter

• Faulty choke

• Faulty injectors

(Any 2 x 1) (2)

|  |  |  |
| --- | --- | --- |
| 3.4 | **Tests that can be performed using a multi-meter**• Current flow• Voltage test Battery• Resistance test• Transistor test• Continuity test• Temperature• Diode and capacitor testing(Any 2 x 1) | (2) |
|  |  | **[12]** |

4.1 **Iron-carbon equilibrium diagram**

4.2 **Iron-carbon Structures**

(9)

4.2.1 **Pearlite** is the combination of ferrite and cementite  and it

contains 0,83% of carbon content before heat treatment  (2)

|  |  |  |
| --- | --- | --- |
| 4.2.2 | **Cementite** is formed when carbon content rises above 0,83%, the carbon combines with pearlite crystals to form a very hard structure.  | (2) |
|  |  | **[13]** |

**QUESTION 5: TERMINOLOGY**

5.1 **Calculation – spur gear**

5.1.1

Module =

PCD T

= 108 

36

= 3 

(2)

5.1.2 OD = PCD + 2m

= 108 + 2(3) 

= 108 + 6 

= 114 mm  (3)

5.1.3 Cutting depth = 2,157 m or 2,25 m

= 2,157 x 3  2,25 x 3 

= 6,47 mm  6,75 mm 

(2)

5.1.4 Addendum = m

= 3 mm 

(1)

5.1.5 Dedendum = 1,157 m or 1,25 m

= 1,157 x 3  1,25 x 3 

= 3,47 mm  3,75 mm  (2)

5.1.6 Circular pitch = m x 𝜋

= 3 x 𝜋 

= 9,43 mm  or 9,42 mm 

(2)

5.1.7 Clearance = 0,157 m or 0,25m

= 0,157 x 3  0,25 x 3 

= 0,47 mm  0,75 mm 

5.2 **Advantages for compound slide:**

• The chips have a better chance of curling away, which prevents tearing of the thread. This results in a better finish. 

• The left edge of the cutting tool performs most of the work whilst the right edge helps to polish the thread. 

• The load on the tip of the cutting tool is less than the cross-slide method. 

• If the cutting tool has broken down, it is easy to pick up the thread 

• Faster than the cross slide method 

(2)

• Can cut a larger screw pitch (Any 2 x 1) (2)

5.3 **Disadvantages screw cutting – cross-slide method:**

• The point of the tool, which is the weakest part of the tool, does most of the cutting. 

• Because both edges of the tool do the cutting, two chips curl onto each other. This can result in a torn thread. 

• A large load can damage the cutting tool/cutting edge. 

• Slower method 

(Any 2 x 1) (2)

5.4 **Indexing:**

Indexing = 40 n

= 40

72

= 10 × 3



OR 5 × 6 

18 3 9 6

= 30

54 

No full turns and 30 holes in a 54 - hole plate 

(4)

5.5 **Advantages of Up-cut milling**

• A quick feed may be used 

• Vibration experienced is less 

• Less strain on the cutter and arbor 

• There is a positive pressure on the feed screw spindle and nuts because the direction of the cutter is against the direction of the feed 

• Metals with hard scale, start the cut under the scale where the metal is softer, this extends the life of the cutter 

• More accurate (precise) 

• Better finish 

(Any 2 x 1) (2)

5.6 **Disadvantages of Down-cut milling**

• A fine feed must be used 

• Vibration of the arbor is unavoidable 

• The cutter will come into contact with the hard scale of a scale material, which is harmful to the cutter teeth

• Cutter get blunt more easily 

• Poor finish 

• Slack on the table-feed must be eliminated 

(Any 2 x 1) (2)

5.7 **Calculate: parallel key**

5.7.1

Width = D

4



= 42

4 

= 10,5 mm

(2)

5.7.2

Thickness = D

6

= 42 

6

= 7 mm 

(2)

**[30]**

**QUESTION 6: JOINING METHODS**

6.1 **Shielding gas**

It forms the arc plasma, stabilises the arc on the metal being welded, and shields the arc and molten weld pool.

• Reduces atmospheric contamination

• It reduces excessive spatter and sparks any 1 x 2 (2)

|  |  |  |
| --- | --- | --- |
| 6.2 | **Relationship between voltage and wire feed** |  |
|  | Higher voltage results in a higher melt rate therefore you need a higher |
| 6.3 | feed rate.**Weld defects (causes)** | (3) |

6.3.1 **Slag inclusion**

• Included angle too narrow

• Rapid chilling

• Welding temperature to low / current to low

• High viscosity of molten metal

• Slag not removed from previous weld run

• Current setting to low

• Correct welding technique

• Surface contamination (Any 2 x 1) (2)

|  |  |  |
| --- | --- | --- |
| 6.3.2 | **Incomplete penetration** |  |
|  | • Speed too fast  |
|  | • Joint design faulty |
|  | • Electrode too large |
|  | • Current too low |
|  | • Wrong welding technique | (Any 2 x 1) | (2) |

6.4 **Weld defects (preventative)**

|  |  |  |
| --- | --- | --- |
| 6.4.1 | **Porosity**• Use correct current• Hold a longer arc• Use correct electrodes• Check for impurities• Must shield the weld• Correct welding technique (Any 2 x 1) | (2) |
| 6.4.2 | **Lack of fusion**• Use correct welding technique• Use the correct size of electrode• Use the correct current setting• Prepare the plate bevel/V-groove accordingly• Correct welding technique (Any 2 x 1) | (2) |

|  |  |  |
| --- | --- | --- |
| 6.7 | **Transceiver**A unit that is used to send a sound wave (transmit)  and then act as a receiver to listen to the ultrasonic wave as it reflected through the metal. • To determine defects  | (2) |
|  |  | **[25]** |

6.5 **Destructive tests**

6.5.1 **Free bend test**

• Measures the ductility of the weld deposit and the heat- affected area adjacent to the weld. 

• To determine the percentage of elongation of the weld.  (2)

6.5.2 **Nick break test**

• It determines the internal quality of the weld and can

reveal an internal defect if present.  (2)

6.5.3 **Machinability test**

• It is used to determine the weld's hardness and its strength. 

• To determine the machinability of the weld (2)

6.6 **Atmospheric contamination (MIGS/MAGS welding)**

• Inadequate shielding gas-flow

• Excessive shielding gas flow (this can cause aspiration of air into the gas stream)

• A severely blocked gas nozzle or a damaged gas supply system

(leaking hoses, fittings etc.) 

• Excessive wind in the welding area (this can blow away the gas

shield)  (4)

**QUESTION 7: FORCES**

7.1 **Equilibrant**

**280cos50°**

**280sin50°**

**280 N**

**300 N**

**200sin35°**

**300sin30°**

**300cos30°**

**30°**

**35°**

**50°**

**350 N**

**200 N**

**200cos35°**

7.1.1

7.1.2

∑ HC = 280cos50° - 200cos35 - 300cos30° − 350

= 179,98 - 163,83 - 259,81 − 350

= - 593,66N

∑ VC = 280sin50° + 300sin30° − 200sin35°

= 214,49 + 150,0 − 114,72

= 249,77 N

 



 



(5)

(4)

**OR**

|  |  |  |  |
| --- | --- | --- | --- |
| **7.1.1****Horizontal components** | **Magnitudes** | **7.1.2****Vertical components** | **Magnitudes** |
| 300NCos30 0 | -259,81 N  | 280NSin50 0 | 214,49N  |
| 200NCos35 0 | -163,83 N  | 300NSin30 0 | 150,0 N  |
| 350 N | -350 N  | 0 N | 0 N |
| 280NCos50 0 | 179,98 N  | 200Sin35 0 | -114,72N  |
| **TOTAL** | **-593,66 N**  | **TOTAL** | **249,77 N** |

7.1.3

E2 = HC2 + VC2 

E = − 593,66 2 + 249,77 2 

E = 644,06 N

 22,82°

249,77N

E

7.1.4

Tanθ = VC HC

= 249,77

593,66

593,66N



(3)

θ = 22,820 

E = 644,06 N at 22,820 south of east 

OR

= 22

0 49

minutes

south of east

(3)

7.2 **Stress and Strain**

**Stress = Pa Diameter = m Force = N**

**Force**

Stress = force area

Force = Stress × Area 

2

Force

= 3500 000 × π × 0,025 

4

Force

= 3,5×106

× 4,90873852 *x* 10−4 

=1718,06 N

Force

= 1,72 kN 

(4)

7.3 **Stress and Strain**

A = Limit of proportionality 

B = Elastic limit 

C = Yield point 

D = Maximum stress 

E = Break stress / Break point (5)

|  |  |  |
| --- | --- | --- |
| 7.4 | **Reactions**Taking moments around A=(255 x 1,125) + (800 x 3,25) = (B x 7,75) + (350 x 1)286,88 + 2600 = 7,75B + 350B = 2536,88/7,75B = 327,34 NTaking moments around B=A x 7,75 = (800 x 4,5) + (255 x 6,625) + (350 x 8,75)A x 7,75 = 3600 + 1689,38 + 3062,5A = 8351,88/7,75A = 1077,66 N | (6) |
|  |  | **[30]** |

|  |  |  |
| --- | --- | --- |
| 8.7 | **Grease**• Grease has a very high viscosity to ensure that it coats and sticks to the bearing surface it is lubricating.• To reduce rust • To reduce noise • Helps cool the bearings • Increases the lifespan of the bearings • Reduces friction  | (2) |
|  |  | **[15]** |

**QUESTION 8: MAINTENANCE**

|  |  |  |
| --- | --- | --- |
| 8.1 | **Viscosity**To ensure that the gears are well coated with oil and do not lose the barrier of lubrication between them.  | (2) |
| 8.2 | **Reason using SAE20W50**This to ensure that the oil is able to satisfy the operational requirements over a range of temperature from start-up to running hot.   | (2) |
| 8.3 | **Pour point**Pour point is the lowest temperature at which a liquid remains pourable.  | (1) |
| 8.4 | **Maintain cutting fluid** |  |

• Avoid contamination of the cutting fluid by draining and regularly

replacing it. 

• Always clean the machine's splash tray of metal cutting after use. 

• Regularly wipe cutting fluid splashes of machine parts. 

• Ensure that the sump is topped up from time to time and check that there is sufficient flow of cutting fluid to the cutting tool. 

• Filter oil on a regular basis

• Ensure that the correct soluble oil to water ratio is correct 

|  |  |  |
| --- | --- | --- |
| 8.5 | (Any 3 x 1)**Belt drive maintenance** | (3) |
|  | Belt tends to stretch with prolonged use therefore they will need to be |  |
|  | tightened periodically and checked for correct alignment. |  |
|  | To transmit maximum torque without slippage | (2) |
| 8.6 | **Reason skimming flywheel** |  |
|  | The clutch plate presses against the flywheel. Due to friction between theclutch and flywheel it creates grooves/cracks in the flywheel. The grooves will need to be removed by a precision machining process known as |  |
|  | skimming before the new clutch plate is fitted. |  |
|  | To ensure that the co-efficient of friction the surfaces are at its maximum.  |  |
|  | To reduce wear and protect the new clutch plate.  | (3) |

**QUESTION 9: SYSTEMS AND CONTROL**

9.1 **Gear drives**

9.1.1 **Number of teeth idler**

NA × TA = NB × TB

N × T

T = A A 

B

NB

= 500 × 46 

1000

= 23 teeth 

(3)

9.1.2 **Rotation frequency of the output shaft**

NB × TB = NC × TC

NA × TA = NC × TC

N = NB × TB 

C

TC **OR**

= 1000 × 23 

60

= 383,33 r/min 

N = NA × TA 

TC

C

= 500 × 46 

60

= 383,33 r / min 

(3)

9.2 **Pulley Drives**

9.2.1 **Diameter of the driven pulley**

N1 × D1 = N2 × D2

D = N1 × D1 

2

N2

= 7,2 × 600 

12

= 360 mm 

(3)

9.2.2 **Power transmitted:**

P = (T1 − T2 )πDn

T1 = 2,5

T2

P = (300 −120) π × 0,6 × 7,2 

= 2 442,9 Watts



= 2,44 kW

T = 300 

2 2,5

= 120 N

**OR**

P = (T1 − T2 )πdn

P = (300 −120) π × 0,36 ×12 

= 2 442,9 Watts 

T1 = 2,5 

T2

= 2,44 kW

T = 300

2 2,5

= 120 N

(3)

9.3 **Hydraulics**

9.3.1 **Fluid pressure**

2

π

A B = ~~D~~

4 

π

2

= x 0,076

4 

= 4,536459792 ×10-3 m2

P = F A B

B



= 4000 Pa

4,536459792 ×10-3

= 881744,837 Pa 

= 881,74 kPa

(4)

9.3.2 **Diameter of piston A**

PA = PB

P = FA

B

A A

A = FA

A

PB

A = 140 N

A 881744,837N/m2 

A = 1,5877609 × 10 − 4

A

A = 1,59 × 10 − 4 

A

πD2

= 

4

D = A A × 4

π



1,59 × 10 − 4 × 4

=

π

= 0,0142182 m

= 14,22 mm 

(5)

9.4 **Traction Control**

• Prevent wheel from spinningif the torque transmitted to any other wheel which exceeds the minimum traction

• Safety feature 

(2)

|  |  |  |
| --- | --- | --- |
| 9.5 | **Air Bags**It is seen as a passive safety feature because the driver and passengers in the vehicle do not need to activate the air bags or do anything to be protected by air bags.  | (2) |
|  |  | **[25]** |

**QUESTION 10: TURBINES**

10.1 **Reaction Turbine**

• Francis

• Kaplan 

• Tyson

• Gorlov 

(Any 2 x 1) (2)

10.2 **Impulse Turbine**

• Impulse turbine changes the velocity of a water jet. 

• The jet pushes on the turbine's curved blades which changes the direction of the flow

• The resulting change in momentum (impulse) causes a force on the turbine blades. 

• Since the turbine is spinning the force acts through a distance and the diverted water flow is left with diminished energy. 

• Prior to hitting the turbine blades the water's pressure is converted to kinetic energy by a nozzle and focused on the turbine. 

• No pressure change occurs at the turbine blades.  (6)

10.3 **Control of speed of steam turbine**

To prevent the turbine rotor leading to an over-speed trip. This causes the

nozzle valves that control the flow of steam to the turbine to close.  (2)

10.4 **Advantages of gas turbine**

• Smooth running due to absence of reciprocating parts. 

• No rubbing parts such as piston so that internal friction and wear are almost eliminated. 

• Easy starting. 

• Can use wide range of fuels. 

• No water cooling system required. 

• Non-poisonous exhaust giving very little trouble with pollution

• Require little routine maintenance. 

• Very high power-to-weight ratio, compared to reciprocating engines.

• Moves in one direction only, with far less vibration than a reciprocating engine. 

• Low operating pressures. 

• High operation speeds.

• Low lubricating oil cost and consumption. 

(Any 3 x 1) (3)

10.5 **Auxiliary power units**

• To supply auxiliary power for larger machines. 

• To supply compressed air for aircraft ventilation. 

• Start power for larger jet engines, electrical and hydraulic power units.

(Any 2 x 1) (2)

10.6 **Purpose of supercharger**

• To fill the cylinder with an increased pressure that is higher than atmospheric pressure. 

• To increase the compression pressure in the cylinder. 

• To increase the volumetric efficiency of the engine.

• To produce more engine power

• Eliminates power loss above sea level

(Any 2 x 1) (2)

10.7 **High altitude**

At high altitude less oxygen is available for combustion.

Loss of power  (2)

|  |  |  |
| --- | --- | --- |
| 10.8 | **Advantage turbocharger**Uses the exhaust gases to operate the turbo charger. No loss of power - needed to drive supercharger | (1) |
|  |  | **[20]** |

**TOTAL: 200**