MANUFACTURING PROCESSES SME 2713

ENGINE VALVE AND VALVE SEAT (AUTOMOBILE)

GROUP 5

MUHAMAD AFHAM BIN AHMAD

MUHAMAD AL BARAQ ISHARUDIN

NG AIK KIM

NG PING YIK

NG SIEW FOH

CONTENT

TITLE	*PAGE NUMBER*
Project Summary	**2**
Introduction	**3**
Methodology	**4**
Technical Drawing	**5-8**
✧ *Exhaust valve*	
✧ *Exhaust valve seat insert*	
✧ *3D Drawing*	
✧ *Sketches*	
Material Selection	**9-14**
✧ *Exhaust valve*	
✧ *Exhaust valve seat insert*	
Process Selection	**15-22**
✧ *Exhaust valve*	
✧ *Exhaust valve seat insert*	
References	**23**
Appendix A	**24**
Appendix B	**25**

Project Summary

The very first task that given to us by our manufacturing lecturer, En Zulkepli bin Haji Muhammad was design and analyzing the material and manufacturing processes that was involve in manufacturing our project products that are engine valve and valve seat which are function at automobile engine.

After we have done some research relevant to engine valve and valve seat at internet, borrow books at Perpustakaan Sultanah Zanariah (PSZ) and also went to P21 borrow the engine valve and valve seat. We have found that there are too many types of engine valve and valve seat in the market today. So we have decided to specify our project product to monometallic exhaust valve and another product is exhaust valve seat insert.

Next we do the material selection based on the details that we had found. We had list down few criteria that act as a guideline based on operation, function, surrounding environment, location in engine block and other components that function together with exhaust valve and exhaust valve seat insert. By this method, we will choose the most suitable material for both products.

The next step is process selection for exhaust valve and exhaust valve seat insert. Characteristics of chosen material will be the priority and then followed by final properties required, size, shape and thickness of product, tolerances required and last but not least manufacturing cost.

Aim of this project :

- ✓ To analyzing the material and manufacturing processes that was involve in manufacturing exhaust valve and exhaust valve seat insert.
- ✓ To recommended suitable material and method of manufacturing exhaust valve and exhaust valve seat insert.

- ✓ To learn the flow of processes that involve for producing a product.

Introduction

In this project, the exhaust valve is the component that located in the cylinder head whereas exhaust valve seat insert is component that fitted into the cylinder head. Both are working at the similar environment and have a closed relationship as ultimate goal of both of them are to control the exchange of gases in internal combustion engine. They are intended to seal the working space inside the cylinder against the manifolds.

Exhaust valve is precision engine components used to open to permit the burned gases to exhaust from cylinders. Therefore exhaust valve are exposed to serve thermal loads and chemical corrosion. Exhaust valve are opens and closes as many as 2000 times per mile (1.6km)

(Source by : Automotive Engineering 7th edition, published McGraw-Hill Book Company)

.

Exhaust valve seat insert is the surface against which an intake or an exhaust valve rests during the portion of the engine operating cycle when that valve is closed. It is critical component to ensure complete sealing of the combustion chamber so that the required compression and ignition pressures can be generated inside cylinder. (Source by : Internal Combustion Engine Handbook by Richard van Basshuysen and Fred Schafer, published by SAE)

Generally the material for manufacturing exhaust valve and exhaust valve seat insert basically have properties of working at high temperature continuously and resistance to corrosion due to their surrounding environment that expose to them.

Process involved for both products also basically need high dimensional accuracy and heat treatment since both have direct contact

during functioning in cylinder to ensure complete sealing of the combustion chamber.

Methodology

Group Meeting : We had record our minutes during meeting [refer appendix A]

Task Division : We had assign each member of our group a specified task to done the project more efficiently [refer below at this page]

Dimension of the actual product of our project :

- ✓ Borrow the product at P21 [refer appendix A]
- ✓ Measure at methodology lab [refer appendix A]

Gathering relevant information and details about our project product

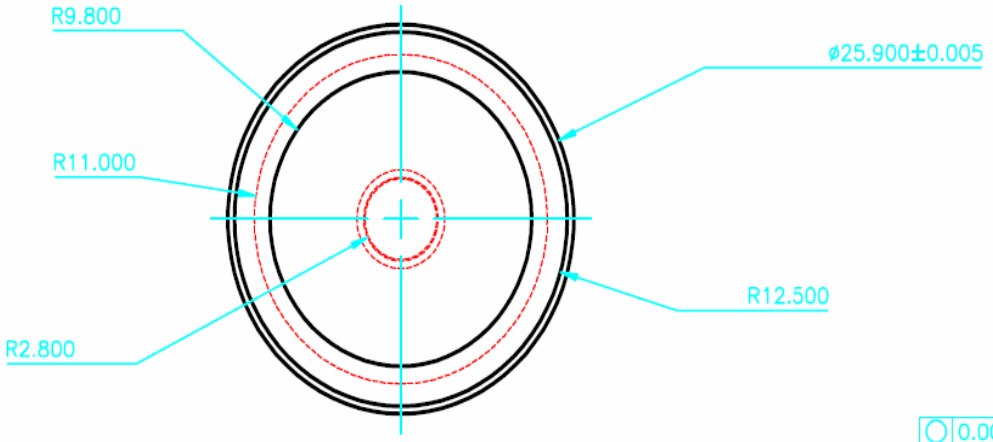
- ✓ Borrow book from PSZ [refer reference]
- ✓ Surf the internet [refer appendix B]
- ✓ Consultation with En Zulkepli bin Haji Muhammad [refer appendix A]

Material and process selection

- ✓ Refer to book that borrow from PSZ [refer reference]
- ✓ Surf the internet [refer appendix B]
- ✓ Consultation with En Zulkepli bin Haji Muhammad [refer appendix A]

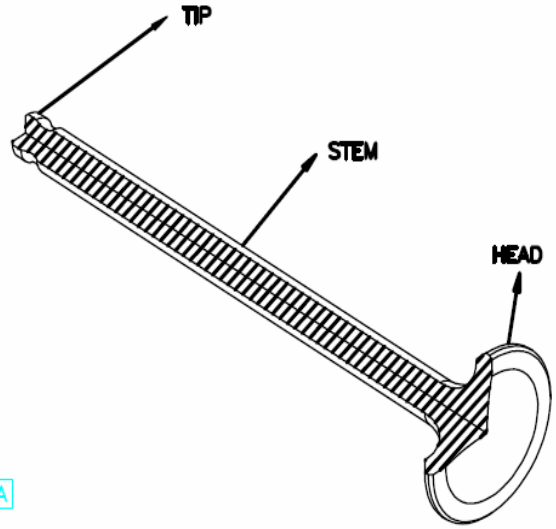
Group Member	Task
MUHAMAD AFHAM BIN AHMAD MUHAMAD AL BARAQ ISHARUDIN	Process Selection for both product
NG PING YIK	Technical Drawing for both product

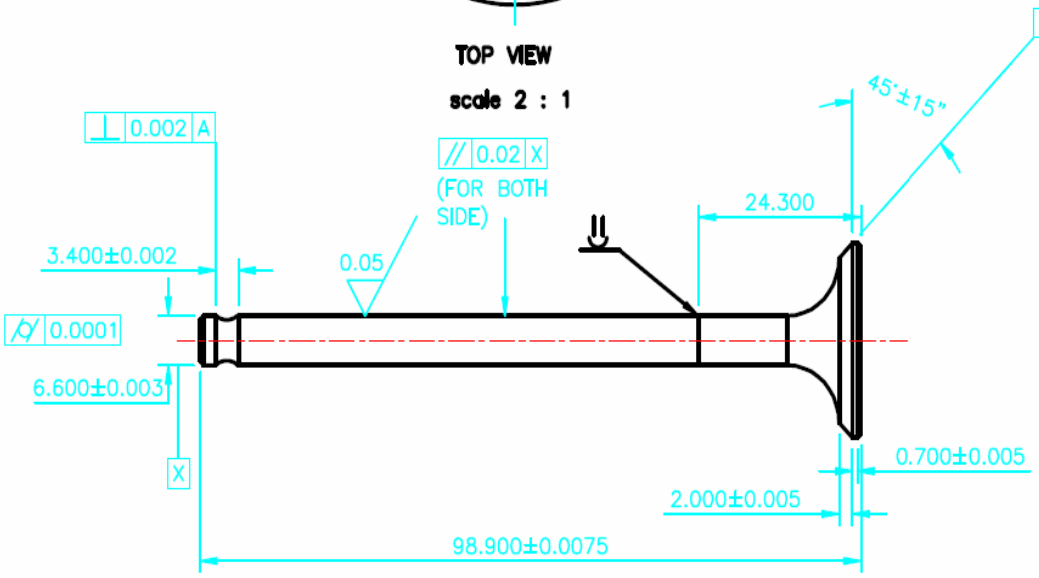
NG AIK KIM NG SIEW FOH	Material Selection for both product



TOP VIEW

scale 2 : 1



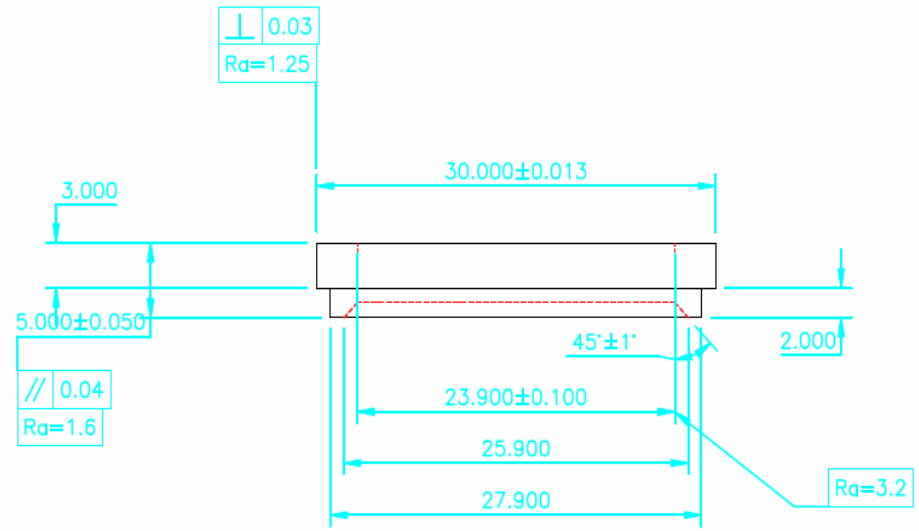


SIDE VIEW

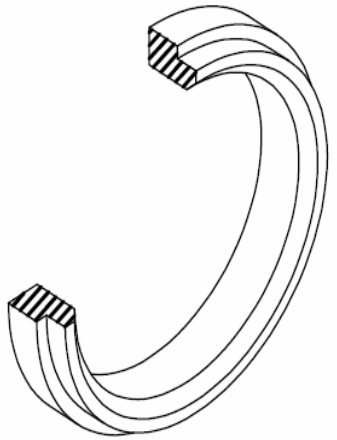
SCALE 1 : 1

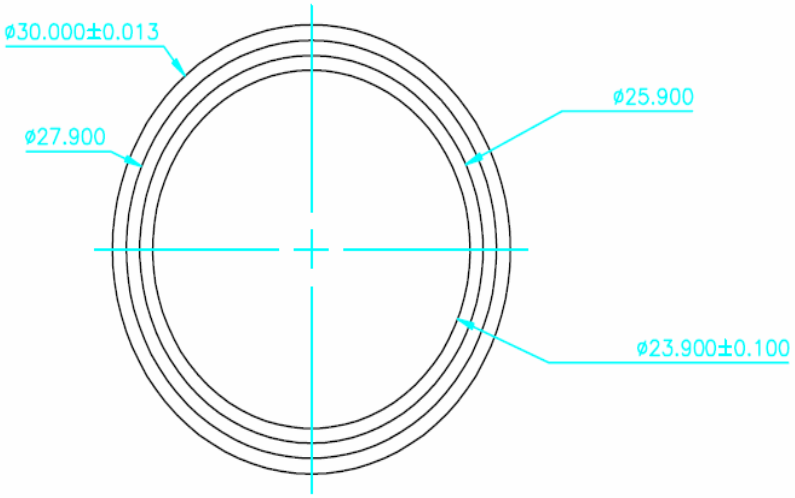
ALL DIMENSIONS ARE IN MILIMETER
8.PART IS SUBJETED TO HEAT TREATMENT FOR HARDNING
7.AT VALVE STEM MAX Ra=0.2
6.PERFORM ABRASIVE POLISHING TO REMOVE CHROME NODULES
5.VALVE STEM IS HARD CHROME PLATING AT THICKNESS .003MM
4.ONLY DIMENSION AND TOLERANCE AS STATED ARE ACCEPTABLE
3.ALL TOLERANCE ARE ±0.0025 UNLESS OTHERWISE STATED
2.REMOVE ALL BURRS AND SHARP EDGE.
1.PROCESS ON COMPONENT: VARIOUS

UNIVERSITI TEKNOLOGI MALAYSIA FAKULTI KEJURUTERAAN MEKANIKAL	TAJUK: ENGINE VALVE (EXHAUST VALVE)	DILUKIS OLEH: GP5	REF ID: TD-EV-20022008	MATERIAL SPEC: DUPLEX SAF2507 (UNS S32760)	SURFACE FINISHING: SUPER FINISHING



SIDE VIEW

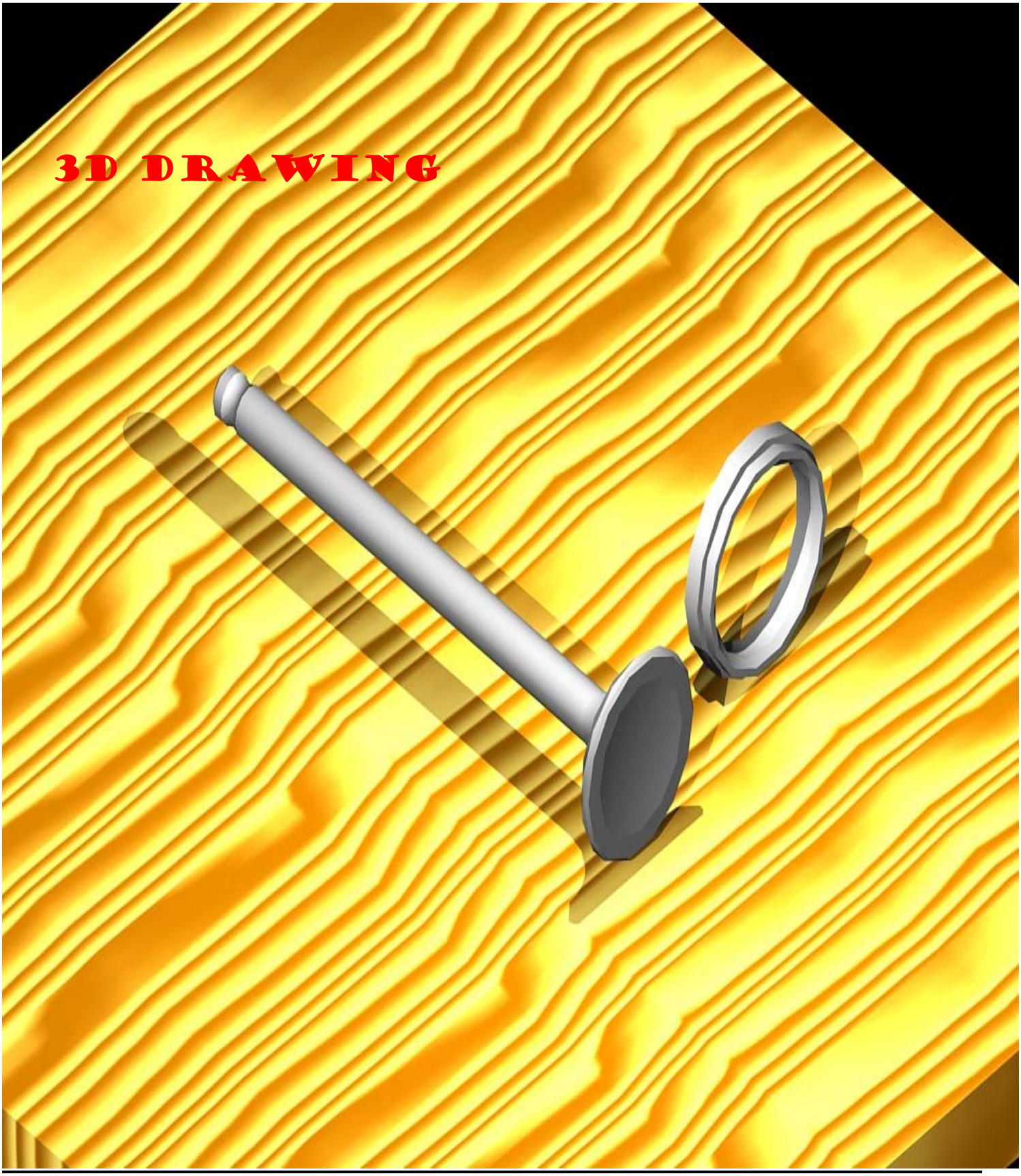




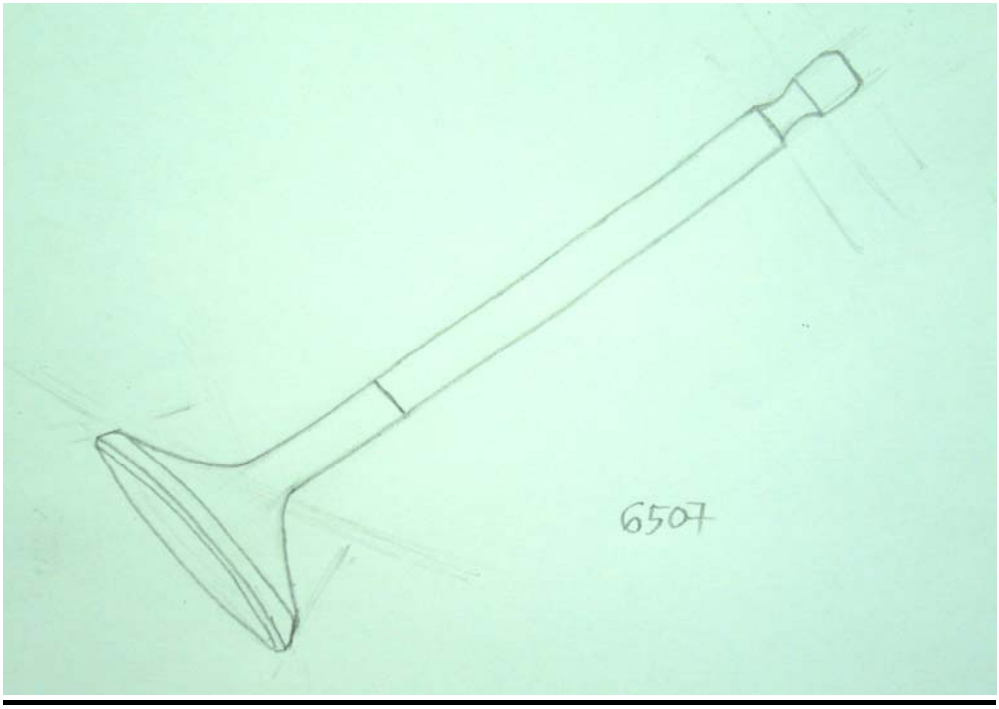
TOP VIEW

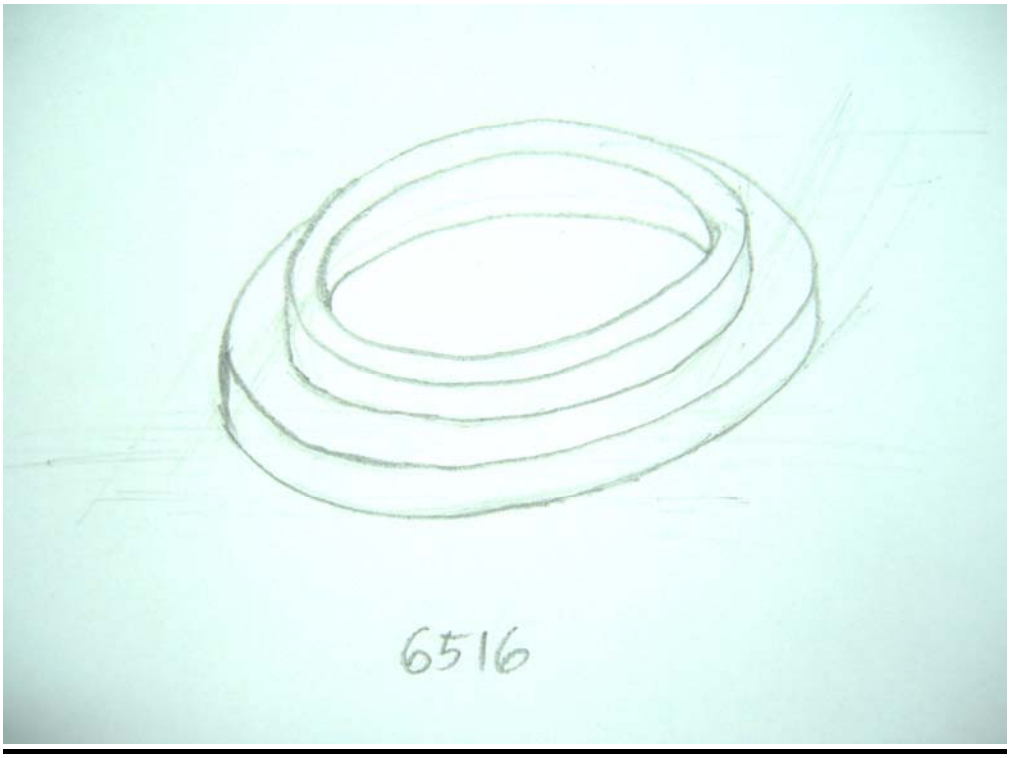
ALL DIMENSIONS ARE IN MILIMETER
5.PART IS SUBJETED TO HEAT TREATMENT FOR HARDNING.
4.ONLY DIMENSION AND TOLERANCE AS STATED ARE ACCEPTABLE.
3.ALL TOLERANCE ARE ±0.03MM UNLESS OTHERWISE STATED.
2.REMOVE ALL BURRS AND SHARP EDGE.
1.PROCESS ON COMPONENT: VARIOUS.

UNIVERSITI TEKNOLOGI MALAYSIA FAKULTI KEJURUTERAAN MEKANIKAL	TAJUK: EXHAUST VALVE SEAT INSERT	DILUKIS OLEH: GP5	TARIKH: 20.2.2008	REF ID: TD–EVSI–20022008	MATERIAL SPEC: STAINLESS STEEL 410	SURFACE FINISHING: GRINDING,BORING


3D DRAWING

Sketches





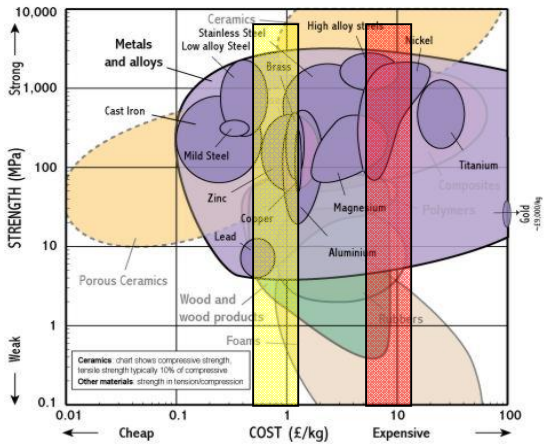
MATERIAL SELECTION

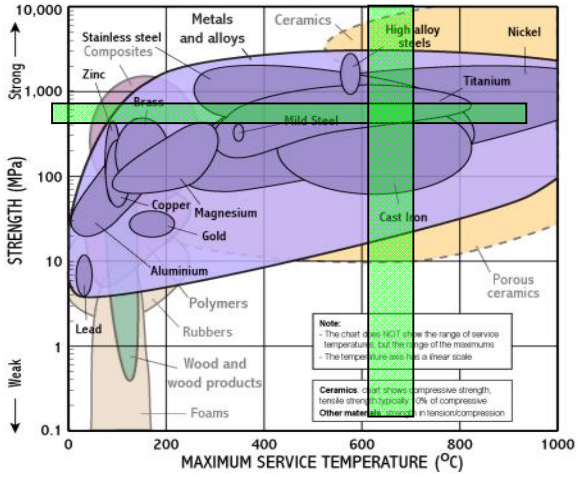
EXHAUST VAVLE

Before start the material selection for exhaust valve, it is important that we know exactly the operation of exhaust valve, function of exhaust valve, surrounding environment that expose to exhaust valve, location of exhaust valve in engine block and other components that function together with the exhaust valve. The reason is we can list down the criteria for manufacturing the exhaust valve. By this way, we will have a correct guidelines to choose the most suitable material for exhaust valve.

CRITERIA OF EXHAUST VALVE

- Resistance to high-temperature corrosion [~700°C]
- Hot strength (endurance strength at high temperature)
  [~500MPa]
- Hot hardness [strength at ~700°C]
- Resistance to oxidation
- Resistance to seizing and galling
- Availability of material supplied
- Overall cost (material and manufacturing costs) [moderate]





Nickel

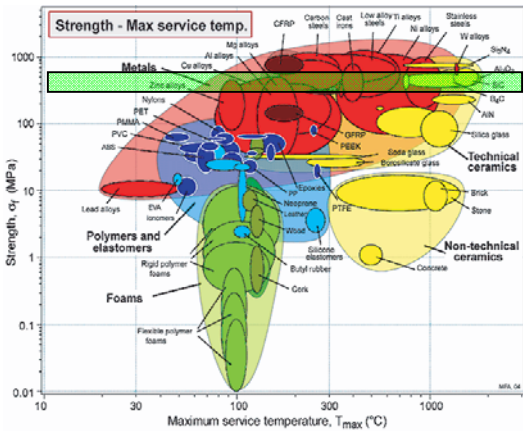
Steel

Chart: Copyright Granta Design Ltd, Cambridge, England. Reproduced with Permission.

www.grantadesign.com

	Steel	Nickel
Melting Point(> 400°C)	√	√
Tensile Strength (~500MPa)	√	**x**
Cost of material (Moderate)	**moderate relative to nickel**	**High relative to steel**

From the table shown above, the material that fulfill our criteria is only **STEEL**. Therefore we eliminate nickel and so only left the steel group.



From the strength-temperature ashby chart, the suitable steel had been chosen is **STAINLESS STEEL**

Chart: Copyright Granta Design Ltd, Cambridge, England. Reproduced with Permission.
www.grantadesign.com

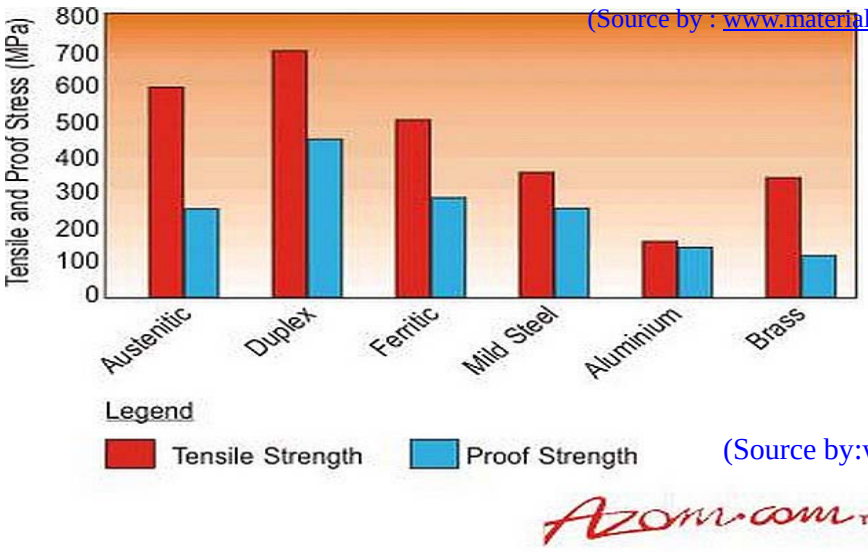
Stainless Steels are iron-base alloys containing Chromium. Stainless steels usually contain less than 30% Cr and more than 50% Fe. They attain their stainless characteristics because of the formation of an invisible and adherent chromium-rich oxide surface film. This oxide establishes on the surface and heals itself in the presence of oxygen.

Stainless steels are commonly divided into five groups:

- Martensitic stainless steels
- Ferritic stainless steels
- Austenitic stainless steels
- Duplex (ferritic-austenitic) stainless steels

- Precipitation-hardening stainless steels.

(Source by : www.materialsengineer.com)



(Source by:www.azom.com)

Material	Austenintic	Ferritic	Martenitic	Duplex
Standard	304	430	410	SAF2507
Yield strength 0.2% offset, ksi	42	50	45	80
Ultimate tensile strength, MPa	580	520	510	800
Elongation in 2 inches, %	55	25	25	15
Hardness(Rockwell)	B80	B85	B80	C32
Density, lb/in³	0.29	0.28	0.28	0.28
Modulus of elasticity, Mpsi	28	29	29	29
Coefficient of thermal expansion, µ/°F(68-212°F)	9.6	5.8	5.5	7.2

(Source by : www.matweb.com)

	Austenitic	Ferritic	Martensitic	Duplex
Resistance to Corrosion	√	√	√	√
Resistance to seizing and galling	√	√	√	√
Hot Strength (~500MPa)	√	√	√	√

Resistance to Oxidation	√	√	√	√

From table and chart above that had been shown, we have enough evidence to choose **DUPLEX** as our material for valve because :

- It is the combination of both ferrite and austenite
- improved strength over austenitic stainless steels
- improved resistance to corrosion than austenitic stainless steel
- greater tensile and yield strengths than austenitic stainless

(Source by : Practical Guideline for Fabrication Duplex Stainless Steel by International Molybdenum Association)

Finally, the specific type of material that we choose is

SAF 2507® (UNS S32750)

Reason:

- high resistance to general corrosion
- very high mechanical strength
- physical properties that offer design advantages
- high resistance to erosion corrosion and corrosion fatigue
- low coefficient of thermal expansion (Source by : www.matweb.com)

Table below are the properties of SAF 2507® (UNS S32750)

Chemical Analysis
Typical values (Weight %)

C	Cr	Ni	Mo	N	Others
0.020	25	7	4.0	.27	S=0.001
PREN = [Cr%] + 3.3 [Mo%] + 16 [N%] ⩾ 40					

Mechanical Properties

Ultimate Tensile Strength, ksi	116 min.
0.2% Offset Yield Strength 0.2%, ksi	80 min.
0.1% Offset Yield Strength 0.2%, ksi	91 min.
Elongation in 2 inches, %	15 min.
Hardness Rockwell C	32 max.
Impact Energy, ft.-lbs.	74 min.

Physical Properties

Density	lb/in^3	0.28
Modulus of Elasticity	psi x 10^6	29
Coefficient of Thermal Expansion 68-212°F/°F	$x10^{-6}$/°F	7.2
Thermal Conductivity	Btu/h ft °F	8.7
Heat Capacity	Btu/lb/°F	0.12
Electrical Resistivity	Ω-in x 10^{-6}	31.5

(Source by : www.oceanint.com)

Exhaust valve seat insert

CRITERIA FOR MATERIAL SELECTION OF ENGINE VALVE SEAT INSERT

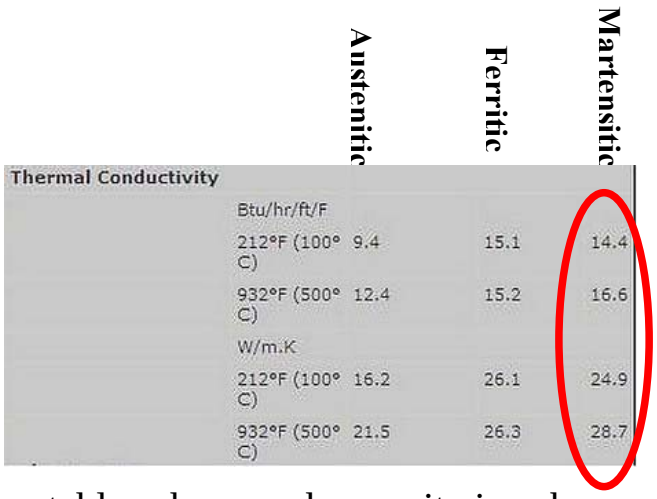
- Sufficiently wear resistant to avoid wear by the continuous pounding of the valve on it
- Strong enough to resist the hammering by the valve
- Sufficiently oxidation and corrosion resistance to prevent damage from impurities in the fuel
- Hot Hardness and strength [~500MPa] (wear resistance at high temperature) [700°C (exhaust)]
- High thermal conductivity (to keep valve temperature within reasonable limits)

Since the engine valve and valve seat insert are operating at the same location in the automobile engine block and experience the same condition (high temperature cause by combustion of air-fuel mixture). So the group of the material that can be choose is similar with material

of engine valve that is Stainless Steel.

	Austenitic	Ferritic	Martensitic	Duplex
Resistance to Corrosion	√	√	√	√
Hot Strength (~500MPa)	√	√	√	√
Resistance to corrosion	√	√	√	√

Since the different types of stainless steel also fulfill the criteria needed, strength, resistance to oxidation and corrosion, wear resistant to avoid wear by the continuous pounding of the valve on it, therefore the only left criteria is thermal conductivity.



Thermal Conductivity		Austenitic	Ferritic	Martensitic
	Btu/hr/ft/F			
	212°F (100° C)	9.4	15.1	14.4
	932°F (500° C)	12.4	15.2	16.6
	W/m.K			
	212°F (100° C)	16.2	26.1	24.9
	932°F (500° C)	21.5	26.3	28.7

(Source by : www.ssina.com)

From the table shown above, it is observed that the thermal conductivity of stainless steel is getting higher as the temperature increases, therefore it is most effectively material to transfer the heat from the engine valve via the valve seat insert to cylinder head. So the most suitable material for manufacturing engine valve seat insert is Martensitic Stainless Steel.

Finally, the specific material that we choose for manufacture exhaust

valve seat insert is Stainless Steel 410

Properties of Stainless Steel 410

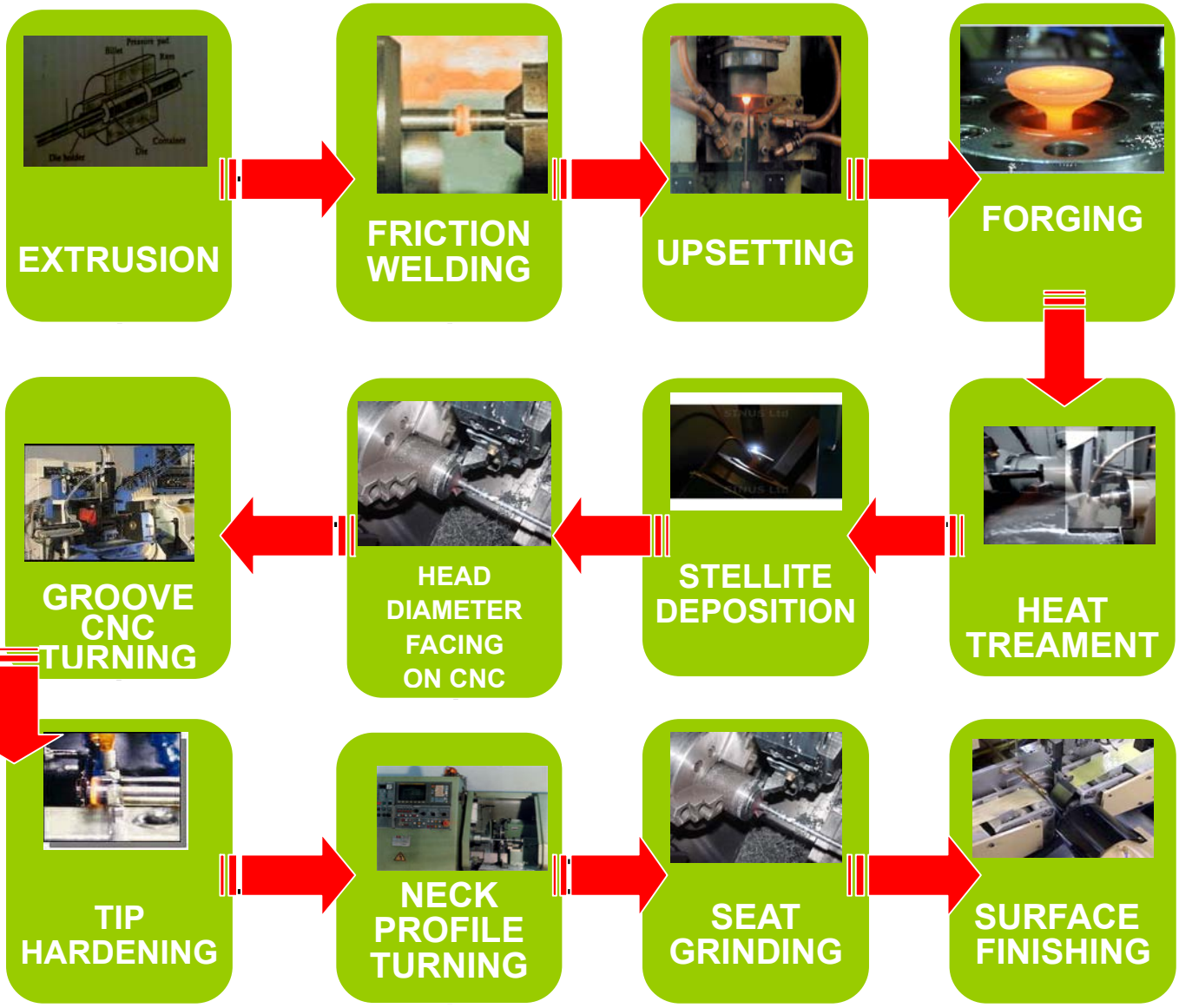
Chemical Composition		
Carbon,C	<= 0.150 %	
Chromium,Cr	11.5 - 13.5 %	
Manganese, Mn	<= 1.00 %	
Nickel, Ni	<= 0.500 %	
Phosphorous, P	<= 0.0400 %	
Silicon, Si	<= 1.00 %	
Sulfur, S	<= 0.0300 %	
Density	7.64 g/cc	
Tensile Strength, Ultimate	510 MPa	Annealed
Tensile Strength, Yield	290 MPa	0.2% offset, Annealed
Thermal Conductivity	24.9 W/m-K @Temperature 100 Â°C	

(Source by : www.ssina.com)

Process Selection

- **Exhaust Valve**

Flow Processes



(Source by : www.enginevalves.net/main.htm)

EXTRUSION

First, the raw material (Stainless Steel rod) is undergoing hot direct extrusion to get the required diameter.

Advantages :

1. High production volume
2. Low cost per pound
3. Many types of raw materials

Disadvantages :

1. Limited complexity of parts
2. Uniform cross-section shape only

FRICTION WELDING

Friction welding is a process of joining head diameter of the engine valve with the straight rod use fully automatic machine. It is needed only for the bimetallic valve. Friction welding technology is a completely mechanical solid-phase process in which heat generated by friction is used to create high-integrity joint between similar or dissimilar metals, and even thermoplastics.

Advantages :

1. Quality control cost is minimal with a guarantee of high quality welds
2. Weld cycle is extremely short so that the productivity is attractive

Disadvantages :

1. Costs in tooling and setup
2. Tight concentricity requirements

UPSETTING

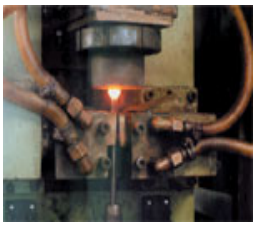
After the raw material is undergoing extrusion, the next step is upsetting process. This process purpose is to give initial shape that will be forwarded to next step that is forging process.

Steps :

1. *The steel is heated by electrical resistance between two contacts.*

2. *As the steel reaches its plastic temperature more material if forced through the contacts by a hydraulic ram until enough volume is "upset" to make the pre-form.*

3. *Then, the pre-form is then passed immediately to the forge.*



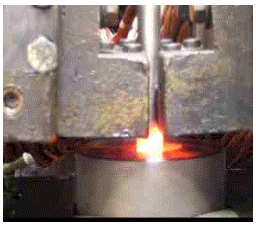


Image of upsetted part

FORGING

After upsetting process the upsetted part will go through forging process immediately. Forging is the term for shaping metal by using localized compressive forces. The forging process of producing exhaust valve is Hot Forging on Friction Screw and High Speed Precision Forging Presses, where the press capacity is 5kgs.

Advantages :

1. Flexibility of design process
2. Versatility of the forging itself.
   The design is not limited to the basic dimensions of the bar

Disadvantages :

1. The skill involved is not easily acquired
2. Tooling needed represents a considerable amount of time and money invested.

HEAT TREAMENT

The next step after the exhaust valve had been forged is heat treatment. Heat treatment of these grades consists of solution treatment so as to get a single phase structure.

Advantages :

1. Rearrange microstructure of the material.

Steps :

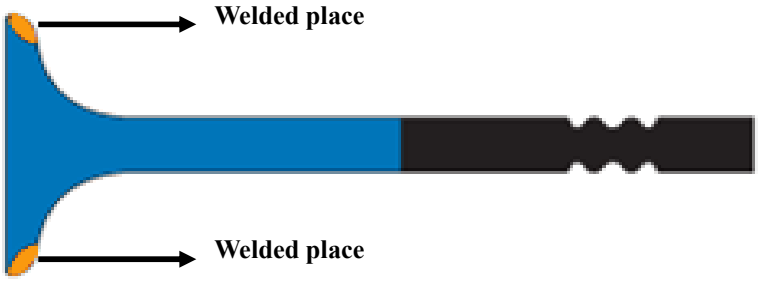
1. *Solution treatment is carried out by heating the steel to about 1200°C.*
2. *It is then followed by quenching which results in the retention of high temperature phase at room temperature.*
3. *Quenched steel is then aged at about 750°C. In the aged condition, the structure consists of austenite and intermetallic compounds. Due to high ageing temperature, these steel can be used successfully up to about 650°C.*

STELLITE DEPOSITION

The follow up process after the heat treatment is satellite welding process. Stellite is a special alloys that welded onto the seat. Purpose is to improve the corrosion and high temperature wear resistance, mainly in exhaust valves; a cord of special material is placed onto the valve seat.

Advantages :

1. High residual stresses are relieved
2. Hardness improved.
3. Overlaid with corrosion and wear resistant material (stellite) for long service life.



HEAD DIAMETER FACING

The next process is head diameter facing by turning process (CNC). The machine used is PLC Controlled Special Purpose Auto Lathes, capability of turning parts up to diameter 150 mm. Purpose of this process is to precisely produce the required diameter for the head part of exhaust valve.

Advantages :

1. Economical precision in desired dimension.
2. Capability for nonrotationally-symmetric control.

Disadvantages :

1. Need to combine developing precision engineering technique with a high performance but flexibility computer software.

GROOVE CNC TURNING

After the head diameter of exhaust valve is precisely produce, the exhaust valve will go through turning process (CNC) again but this time is used to make a groove at the end of stem valve.

Advantages :

1 Economical precision in desired dimension.
2 Capability for nonrotationally-symmetric control.

Disadvantages :

1. Need to combine developing precision engineering technique with a high performance but flexibility computer software.

TIP HARDENING

The next process is tip hardening process. The machine used is fully automatic machine, which is Valve Stem-End Induction Hardening machine that can provide perfect quality of hardening. The purpose of this process is to increase the wear resistant of the tip since this part is continuously pounded by camshaft during the operation of exhaust valve.

Advantages :

1. Increasing the cyclic crack resistance of structural parts.

NECK PROFILE TURNING

The following process is neck profile turning. Once again the exhaust valve will go through CNC turning process but this time is to make a curve at the neck of the exhaust valve.

Advantages :

1 Economical precision in desired dimension.
2 Capability for nonrotationally-symmetric control.

Disadvantages :

1. Need to combine developing precision engineering technique with a high performance but flexibility computer software.

SEAT GRINDING

After the neck profile turning the coming up process is seat grinding. The typical seat angle is 45˚but 30˚and 20˚also may be used. The grinding process need to meet the accuracy required since seat angle is critical surface to ensure complete sealing of the combustion chamber with exhaust valve seat insert.

SURFACE FINISHING

The final step is surface finishing. The surface finishing chosen for exhaust valve is by chard chrome plating at the contact area at the valve stem. The chrome thickness is from 3µm to 7µm. This step is to enhance the lifetime of the exhaust valve.

Advantages :

1. Characterize surface roughness and quality**.**

Alternative Process

Abrasive polishing : can be used whenever the exhaust valve is chrome plate in order to remove any chrome nodules still present and to level out any unevenness. Roughness after the polishing is a maximum Ra 0.2.

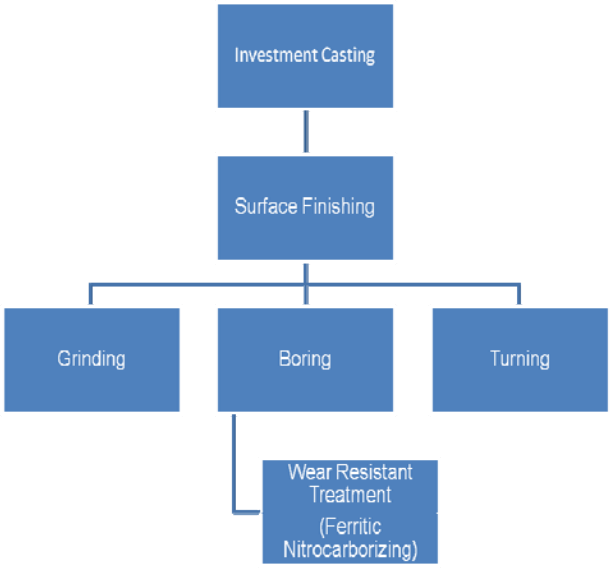
Alternative Process

Nitriding the valve : Bath immersion and plasma nitriding are used. The nitriding layers, approximately 10 to 30µm in thickness are extremely hard at the surface and are particularly insensitive to wear.

(source by : Internal Combustion Engine Handbook by Richard van Basshuysen and Fred Schafer, published by SAE)

- **Exhaust Valve Seat Insert**

Flow Processes



(Source by : www.wipo.int/portal/index.html.en)

INVESTMENT CASTING

This process is chosen for the production of exhaust valve seat insert since its shape is small and need to be mass produced with high accuracy dimension and surface finishing. Using the Lost Wax process to produce intricate and metallurgical accurate castings with tight tolerances, this method is used to mass produce parts with near net dimensions and a high quality "as cast finish" thereby producing a visually attractive finish and reducing machining cost.

Steps :

1. *A mechanical drawing of exhaust valve seat insert is used to generate design for the wax.*
2. *Wax is injected into die to make pattern.*
3. *The pattern then is gated to a central sprue and the pattern clusters are dipped in ceramic slurry several times until gain desired shell thickness.*
4. *After the pattern clusters is fired and pre-heated, the metal molten is pour into the ceramic mould*
5. *Finally, mold material is broken from casting and the exhaust valve seat inserts is ready for surface finishing.*

Advantages:	**Disadvantages:**
1. Complex shapes possible	1. Castings Generally Limited to 10 Lbs or Less
2. Thin wall section possible	2. Expensive Dies for Wax Pattern
3. High production rates	3. Expensive Unit Cost, Labor Intensive
4. High dimensional accuracy	
5. Minimum Surface Treatment Prior to Plating	

SURFACE FINISHING

After produce exhaust valve seat insert from investment casting. The next process is surface finishing to obtain the required dimension accurately. The surface finishing included grinding, boring and turning.

Steps :

1. *Exhaust valve seat insert is grinding by using double disk grinder closed to finish size.*
2. *A lathe is next utilized to bore the inside diameter by using lathe machine.*
3. *A finish double disk grinder operation now grinds the exhaust valve seat insert into finish size.*
4. *The final machining operation is precision machining of the seating surface. Turning is a common method of doing this and it is necessary to control seat angle seat surface finish to the required tolerances. Another potential manufacturing method would be to grind the precision seat.*

((Source by : www.wipo.int/portal/index.html.en)

WEAR RESISTANCE TREATMENT Ferritic Nitrocarborizing

After the exhaust valve seat insert is precision formed, it is treated to increase the wear resistance of the insert. However, the wear resistance treatment should preferably produce a minimum amount of dimensional distortion to the precision formed exhaust valve seat insert. The wear resistance treatment typically produces less than 0.05 mm dimensional change on the surface of the insert. Ferritic nitrocarburizing is a thermochemical diffusion process whereby nitrogen and carbon are simultaneously introduced into the surface of ferrous metals to develop or enhance particular engineering properties and thus increase performance.

Advantage :

1. Increases wear resistance of exhaust valve seat insert at a depth of 0.05mm

Steps :

1. *The inserts were ferritic nitrocarburized in a molten salt bath (composed of a mixture of cyanates and carbonates of sodium and potassium)*
2. *The process is carried out at a subcritical treatment temperature, typically 1075°F (580°C)*

3. *A hardened surface layer with a 750 HK minimum Knoop hardness at a depth of 0. 05 mm will produced.*

(Source by : www.wipo.int/portal/index.html.en)

REFERENCES

BOOK

1. Automotive Engineering 7th edition, published McGraw-Hill Book Company.
2. Internal Combustion Engine Handbook by Richard Van Basshuysen and Fred Schafer, published by SAE International.
3. Practical Guideline for the Fabrication of Duplex Stainless Steel by International Molybdenum Association.

INTERNET

4. www.enginevalves.net/main.htm
5. www.grantadesign.com
6. www.materialsengineer.com
7. www.matweb.com
8. www.oceanint.com
9. www.ssina.com
10. www.wipo.int/portal/index.html.en

APPENDIX A

Date	Remark
Date : 9/1/2008 Venue : FKM Time : 2.00pm	Discussion about product that wanted to design. All five members attended the meeting.
Date : 12/1/2008 Venue : PSZ Time : 2.00pm	Searched books and information about the project via internet and at PSZ. Choose some components that to make it as proposal. The member attended the meeting is Ng Aik Kim, Ng Ping Yik, Ng Siew Foh.
Date : 15/1/2008 Venue : Mr. Zulkepli room Time : 2.00pm	Submitted proposal to Mr. Zulkepli. The proposal had been approved and research about the engine valve and a retainer was required. All five members attended the meeting.
Date : 17/1/2008 Venue : FKM Time : 2.00pm	Discussed about the problems of the project in FKM. Information about the retainer is difficult to search. Hence retainer was replaced by the valve seat with Mr.Zulkepli`s permission.
Date : 18/1/2008 Venue : P21 and Methodology Lab Time : 3.00pm	We go to P21 to borrow the product and measure the dimension at methodology lab. All five members attended the meeting.
Date : 20/1/2008 Venue : KRP Time : 2.00pm	Distributed task into section for all member to search information. All five members attended the meeting.
Date : 18/2/2008 Venue : N28 Time : 9.00pm	Search information about the part/component of the project via internet. All five members attended the meeting.
Date : 28/2/2008 Venue : Mr. Zulkepli room Time : 4.00pm	Meet with Mr. Zulkepli to obtain some opinions for the project. All five members attended the meeting.
Date : 1/3/2008 Venue : KRP Time : 12.00pm	Combined all the information and do some correction about the project. All five members attended the meeting.
Date : 2/3/2008 Venue : KRP Time : 12.00pm	Some extra information was added into the project. All five members attended the meeting.
Date : 3/3/2008 Venue : FKM Time : 10.00pm	Practice for presentation in FKM. Borrowed surface texture plate to obtain information about surface finishing from Methodology Lab. All five members attended the meeting.

APPENDIX B


Search Capabilities for Materials Property Data - Mozilla Firefox
MatWeb
MATERIAL PROPERTY DATA
Search MatWeb for Property Information
Search Results
AK Steel 410 Martensitic Stainless steel