FAILURE ANALYSIS STUDY ON THE CUTTER BLADE OF POLYPROPYLENE PELLETER DRIVE

By

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FINAL REPORT PROJECT

Submitted to the Mechanical Engineering Programme

In Partial Fulfillment of the Requirements for the

Degree Bachelor of Engineering (Hons)

(Mechanical Engineering)

JANUARY 2009

Universiti Teknologi PETRONAS

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CERTIFICATION OF APPROVAL

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Approved by,

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CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

Mohamad Fitri Bin Rusli

ABSTRACT

This report basically discusses the Failure Analysis Study on Cutter Blade of Polypropylene Pelleter Drive. The objective of the project is to conduct failure analysis method on the cutter blade and to determine the causes of its failure. This report also discuss on the types wear and its wear mechanism. In this study, the author had obtained the cutter blades and background data of the sample. The author had conducted visual inspection of the sample, Vickers hardness test and microscopic inspection under optical microscope and scanning electron microscope or SEM. The result obtain from this study confirms that the blade materials is Titanium Carbide, high wear resistance material but brittle. This material data are obtained from the manufacturer datasheet. During preliminary stage, the samples show excessive and uneven wear on its cutting surface, some of the blades had chipped at titanium carbide tip. The chipped samples are selected and cut using electric discharge machining to obtain its cross section. These samples then are mounted to berkelite press then grinded and polished for microscopic evaluation. Microscopic inspection reveals the materials have voids in its microstructure. These voids tend to reduce its strength and the tip can break easily upon impact. Fractography result shows the tip fractures when being hit by foreign particles, the fractures are consistence with the cutting path of the blades. Mechanical testing using Vickers Hardness Test, the result obtained is Hv=797. The excessive wear on the cutter blades is suspected from poor operating procedure. During high melt index, polymer tends to produce tailings. To counter this problem the operator need to advance the pelleter rotor forward to the die plate. This resulting higher contact force and high wear rate. Lack of proper monitoring of cooling water entering the chamber may have lead to the chipping of TiC tip, debris may have come in between the blades during operation and collide with the tip. During cleaning of the chamber, the author had found sand inside the chamber. The outcome of these studies will provide recommendations in term of modifying operating procedure and installing device to prevent from entering the pelleter assembly.

ACKNOWLEDGEMENT

In the Name of ALLAH,

The Most Gracious, The Most Merciful

First and foremost the author's utmost gratitude goes to the author's supervisor, AP. Dr. Othman Bin Mamat. Without his guidance and motivation, the author would not have succeeded to complete the project.

To the Final Year Project Coordinator, Dr Puteri Sri Melor Megat Yussof.

Also goes to the respective peoples at MTBE/PP (M) Sdn. Bhd. Especially people at the Maintenance Department for helping the author in gathering information and data.

To the entire technician in Mechanical Engineering Department, thank you for assisting the author in completing his project.

The author also takes the opportunity to express his gratitude to the individuals that have taken the time and effort to assist the author in completing the project. Without the cooperation of these individuals, no doubt the author would have faced some minor complications throughout the course.

Finally, thanks and love goes to the author's family and the loved one.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

During the author's 8-month of industrial internship period at Rotating Section, Plant Maintenance Department of MTBE/PP (M) SDN. BHD. The author involves in the replacement of set of cutter blades attached to the pelleter drive unit.

The blades is a bimetallic type with the tip holder is made from stainless steel and bonded with titanium carbide tip (refer to APPENDIX 1, material section). These sets of blades are mounted to the pelletizer drive rotor as shown in Figure 1.

Figure 1: Cutter blades attached to the pelletizer drive rotor.

The pelletizer drive is used to cut polypropylene melt into small pellets inside a chamber circulated with pellet cooling water. Pellets produced are carried along with cooling water and then dewatered and dried.

For the cutting action become possible, the blades must rotate against the die plates where the melt polymer is pushed through the nozzles. The blades must make contact with the die plate (refer to APPENDIX 2). The die plate also is made made from titanium carbide. This is an operating requirement by the manufacturer and shall not be altered or the pellet will become out of specification.

Figure 2 to 5 shows the schematic drawings of the overall pelleter drive assembly and its subcomponents.

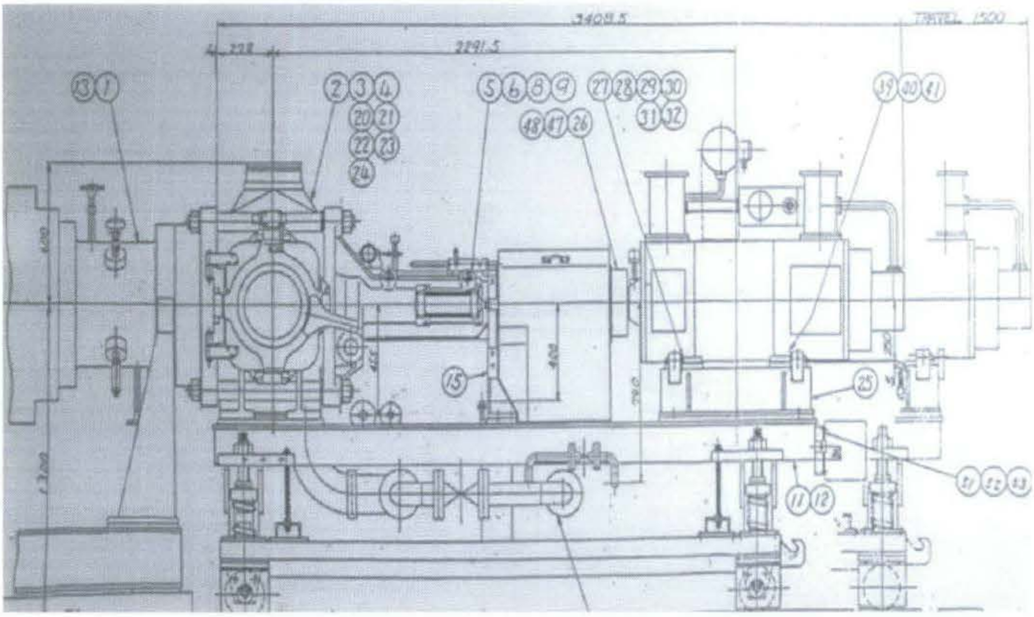


Figure 2: Overall assembly of pelletizer unit; pellet cooling water chamber window and DC motor drive end assembly[1].

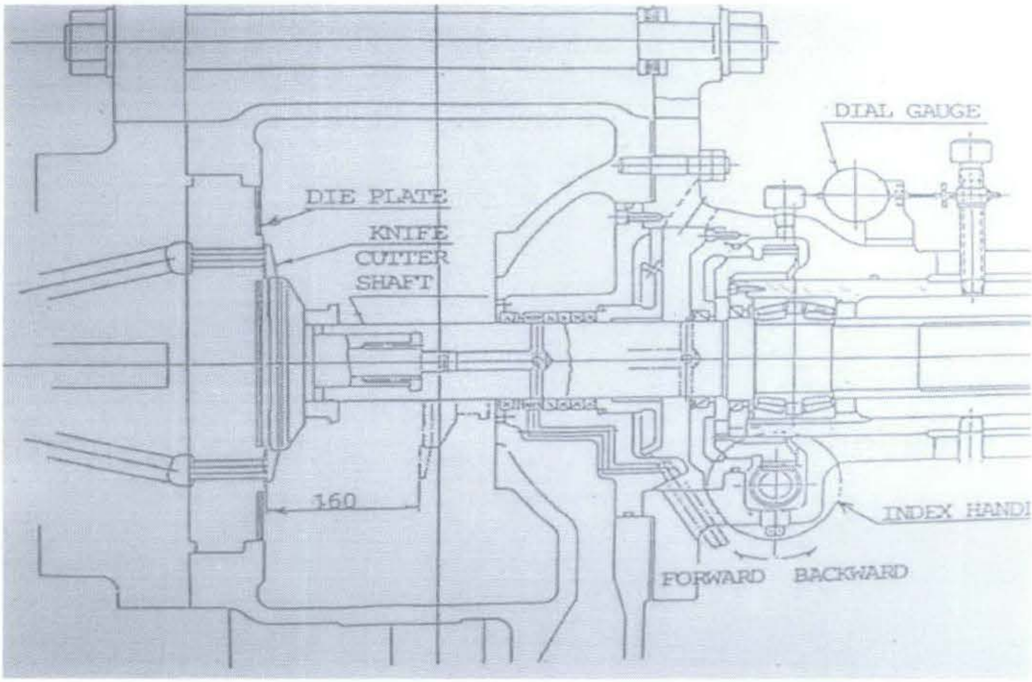


Figure 3: Detail view of the position of cutter blades and the die plate[1].

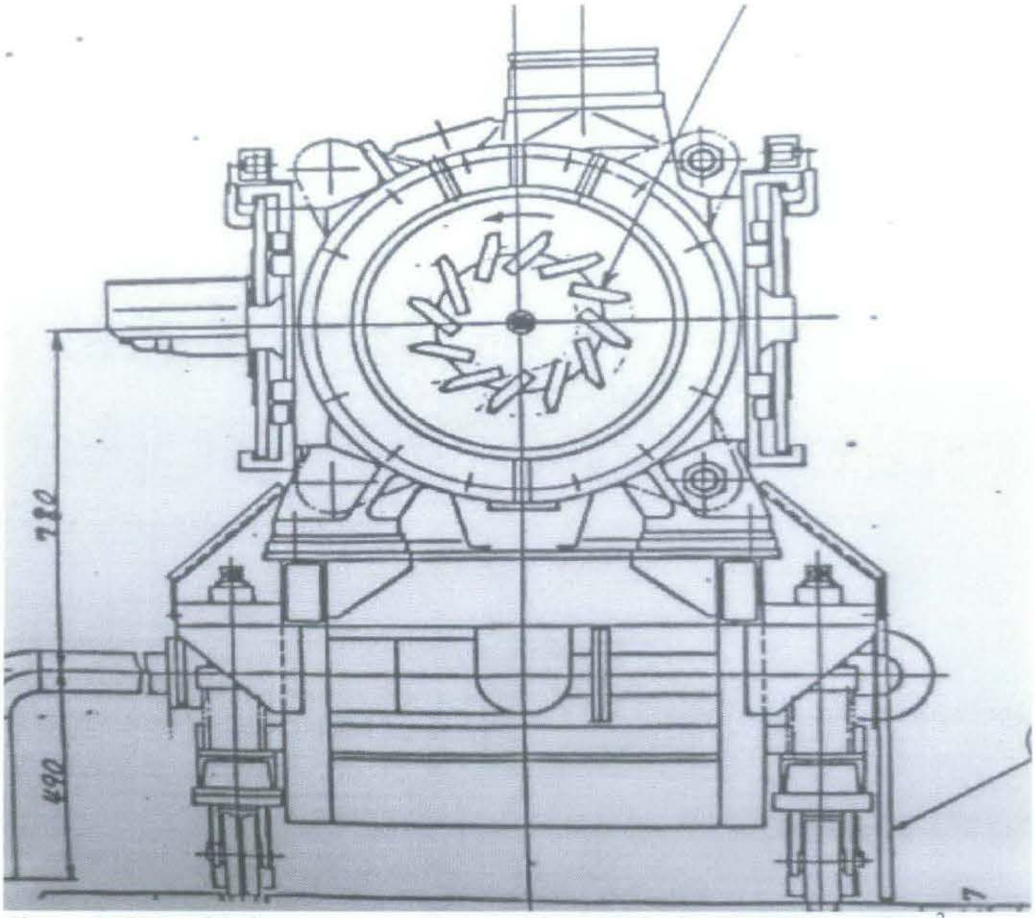


Figure 4: Cutter blades rotor on pelletizer drive attached to the drive carriage[2].

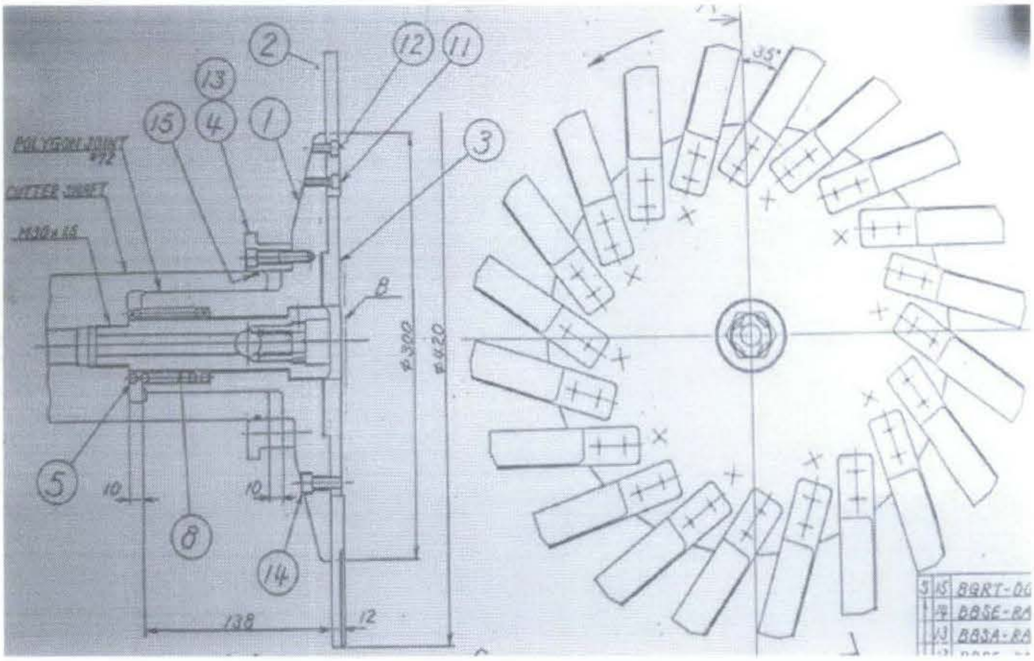


Figure 5: Cutter blades on pelletizer drive rotor assembly[2].

1.2 PROBLEM STATEMENT

Thorough visual inspection performed on the used cutter blades; there were obvious wearing and chipping marks on every cutter blades. Although the blades are usually discarded and replaced with the new set, we still need to know whether the cause of the failure comes from the blade itself or from an external source.

1.3 OBJECTIVE

The main objective of the study is to perform failure analysis on the cutter blades of Polypropylene pelletizer drive unit in order to find the root cause of the failure.

1.4 SCOPE OF STUDY

The scope of work for this project is to focus on failure analysis methods that involve metallographic inspections mechanical testing, fractography and root cause analysis. Metallographic inspection will check for grain boundaries and features of the sample at microscopic level to find out any sign of failures. Mechanical testing will check for Vickers hardness to determine its wear resistance. Fractography will check for metal failure propagation. Finally root cause analysis to come out with theory of how the failure occurs based on evidence and past history of any similar failure which has been recorded.

CHAPTER 2

LITERATURE REVIEW

2.1 CUTTING TOOL MATERIALS

The selection of the cutting tools materials for a particular application is among the most important factors in the machining process[3]. Consequently a cutting tool must possess the following characteristics: Hardness, particularly at elevated temperatures (hot hardness), so that the hardness, strength, and wear resistance of the tool are maintained during cutting operations.

Toughness, impact forces on the tool in interrupted cutting operations or due to vibration and chatter during machining do not chip or fracture the tool. Wear resistance, is an acceptable tool life is obtained before the tool is replaced. Inertness, for any adverse chemical reactions contributing to tool is avoided.

2.1.1 Carbon and Medium Alloy Steels

Inexpensive and easily shaped and sharpened, these steel do not have sufficient hot hardness and wear resistance for cutting at high speed, the hardness of the carbon steels decreases as the temperature increases[3]. Consequently, the use of these steels is limited to low speed cutting operations.

2.1.2 High Speed Steels (HSS)

These steels were developed for cutting at higher speeds. These steels are the most highly alloyed of the tool steels, can be hardened to various depth, have higher resistance to fracture, high toughness and good wear resistance. There are two basic types of HSS: molybdenum (M series, 10% molybdenum) and tungsten (T series, 12% to 18% tungsten). HSS can be coated to improve performance[3].

2.1.3 Cast Alloys

Cast Alloys have the following composition: 38% to 53% cobalt, 30% to 33% chromium, and 10% to 20% tungsten. Because of high hardness (typical 58 to 64HRC), they have good wear resistance and can maintain their hardness at elevated temperatures, they are not as tough as high speed steels and are sensitive to impact forces[3].

2.1.4 Tungsten Carbide

Tungsten carbide (WC) is a composite material consisting of tungsten-carbide particles bonded together in a cobalt matrix. These tools are manufactured with powder metallurgy techniques[3].

2.1.5 Titanium Carbide

Titanium carbide (TiC) has higher wear resistance than tungsten carbide but is not as tough. With a nickel-molybdenum as the matrix, TiC is suitable for machining hard materials, and for cutting at speeds higher than tungsten carbide[3].

2.1.6 Titanium Nitride Coating

Titanium nitride coatings have low friction coefficients, high hardness, resistance to high temperature, and good adhesion to substrate[3]. These coatings greatly improve the life of high speed steel tools, as well as the lives of carbide tools and cutters. Titanium coated tools usually gold in color.

2.1.7 Titanium Carbide Coating

Titanium carbide coatings on tungsten carbide tools have high flank resistance when machining abrasive material[3].

2.1.8 Ceramics (Al_2O_3) Coating

Ceramics coating are used because of their chemical inertness, low thermal conductivity, and resistance to high temperature, however oxide coatings generally bond weakly to the substrate[3].

2.1.9 Multiphase Coatings

The desirable properties of the coatings can be combined and optimize with the use of multiphase coatings. Carbide tools may available with two or three layers of coatings. For example, first layer TiC over the substrate, followed by Al_2O_3 and then TiN. The first layer should bond well with the substrate; the outer layer should resist wear and have low thermal conductivity. The intermediate layer should bond well and compatible with both layers[3].

2.1.10 Diamond Coated Tools

Polycrystalline diamond is used as a coating for cutting tools particularly on tungsten carbide and silicon nitride. Thin film diamond is deposited on substrate with PVD and CVD techniques. While thick film diamond are obtained by growing large sheet of pure diamond , which then is laser cut to shape and brazed to a carbide shank.

2.2 WEAR TYPES AND MECHANISM

In materials science, wear is the erosion of material from a solid surface by the action of another substance. The study of the processes of wear is part of the discipline of tribology. There are five principal wear processes: Adhesive wear, Abrasive wear, Surface fatigue, Fretting wear and Erosion wear

The definition of wear does not include loss of dimension from plastic deformation, although wear has occurred despite no material removal. This definition also fails to include impact wear, where there is no sliding motion, cavitation, where the counter body is a fluid, and corrosion, where the damage is due to chemical rather than mechanical action.

Wear can also be defined as a process in which interaction of the surfaces or bounding faces of a solid with its working environment results in dimensional loss of the solid, with or without loss of material. Aspects of the working environment which affect wear include loads such as unidirectional sliding, reciprocating, rolling, and impact loads, speed, temperature, type of counter body (solid, liquid, or gas), and type of contact (single phase or multiphase, in which the phases involved can be liquid plus solid particles plus gas bubbles).

2.2.1 Abrasive Wear

Abrasive wear occurs whenever a solid object is loaded against particles of a material that have equal or greater hardness. There are several different mechanisms of abrasive wear acting onto the surface, all of which have different characteristics.

2.2.2 Mechanism of Abrasive Wear

It was originally thought that abrasive wear by grits or hard asperities closely resembled cutting by a series of machine tools or a file. However, microscopic examination has revealed that the cutting process is only approximated by the sharpest grits and many other more indirect mechanisms are involved. The particles or grits may remove material by micro-cutting, micro-fracture, pull-out of individual grains[4] or accelerated fatigue by repeated deformation (Figure 6).

The first mechanism is cutting (Figure 6a), represent the classic model where a sharp grit or hard asperity cuts the softer surface. The material which is cut is removed as wear debris. When the abraded material is brittle, e.g. ceramic, fracture of the worn surface may occur (Figure 6b). In this instance wear debris is the result of crack convergence. When a ductile material is abraded by a blunt grit then cutting is unlikely and the worn surface is repeatedly deformed (Figure 6c). In this case wear debris is the result of metal fatigue.

The last mechanism is grain detachment or grain pull-out (Figure 6d). This mechanism applies mainly to the ceramics where the boundary between grains is relatively weak. In this mechanism the entire grain lost as wear debris.

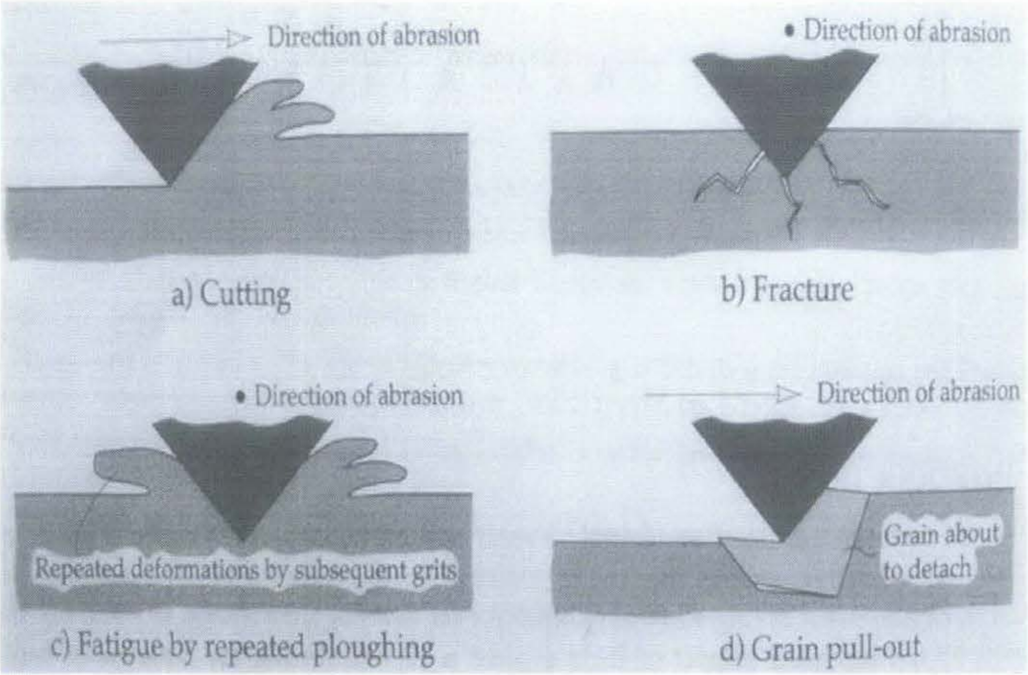


Figure 6: Mechanism of abrasive wear[4].

2.2.3 Cutting

Abrasive wear is relatively new since, like all forms of wear, the mechanisms of abrasive wear are hidden from view by the materials themselves. The development of the scanning electron microscope has provided a means of looking at some aspects of abrasive wear in closer detail. In one study[5] a rounded stylus was made to traverse a surface while under observation of SEM. In another study[6] a pin on disc wear rig was constructed to operate inside the SEM, to allow direct observations of wear. Two basic were revealed, a cutting mechanism and a wedge build up mechanism with flake like debris[5]. This latter mechanism, called ploughing was found to be less efficient mode of metal removal. In a separate study with a similar apparatus it was found that random plate-like debris ware formed by a stylus scratching cast iron[7].

The geometry of the grit also affects the mechanism of abrasive wear. It has been observed that a stylus with a fractured surface containing many micro-cutting edges removes far more material than unfractured pyramidal or spheroidal styluses[8]. Similarly, a grit originating from freshly fractured material has many more micro-cutting edges than a worn grit which has only rounded edges.

Beneath the surface of the abraded material, considerable plastic deformation occurs[9, 10]. This process is illustrated in Figure 7.

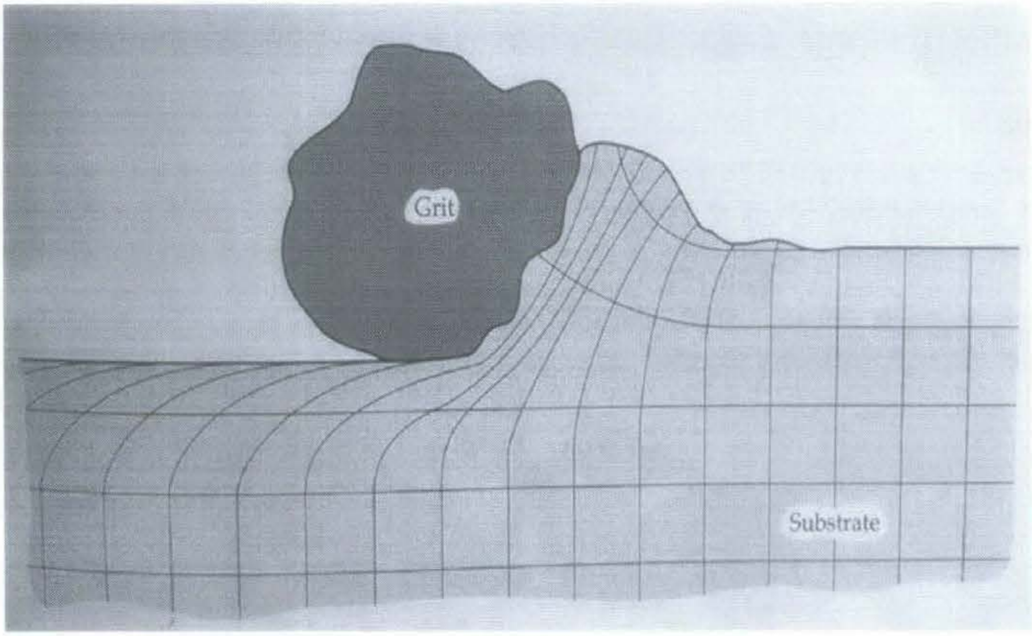


Figure 7: Subsurface deformation during passage of a grit[9].

2.2.4 Fatigue

The repeated strain by grits deforming the area on the surface of a material can also cause metal fatigue. Detailed evidence for sideways displacement of material and the subsequent fracture has been found[11]. Wear by repeated sideways displacement of material would also be a relatively mild or slow form of abrasive wear since repeated deformation is necessary to produce a wear particle.

2.2.5 Fracture

Visual evidence of abrasive wear by brittle fracture was found by studying the subsurface crack generation cause by sharp indenter on a brittle transparent solid[12] as illustrated in Figure 8.

There are three modes of cracking[12], vent cracks propagating at 30° to the surface, localized fragmentation, and deep median crack. When grits move successfully across the surface, the accumulation of cracks can result in the release of large quantities of material. Brittle fracture is favored by high loads acting on each grit, sharp edges on the grit, as well as brittleness of the substrate[13].

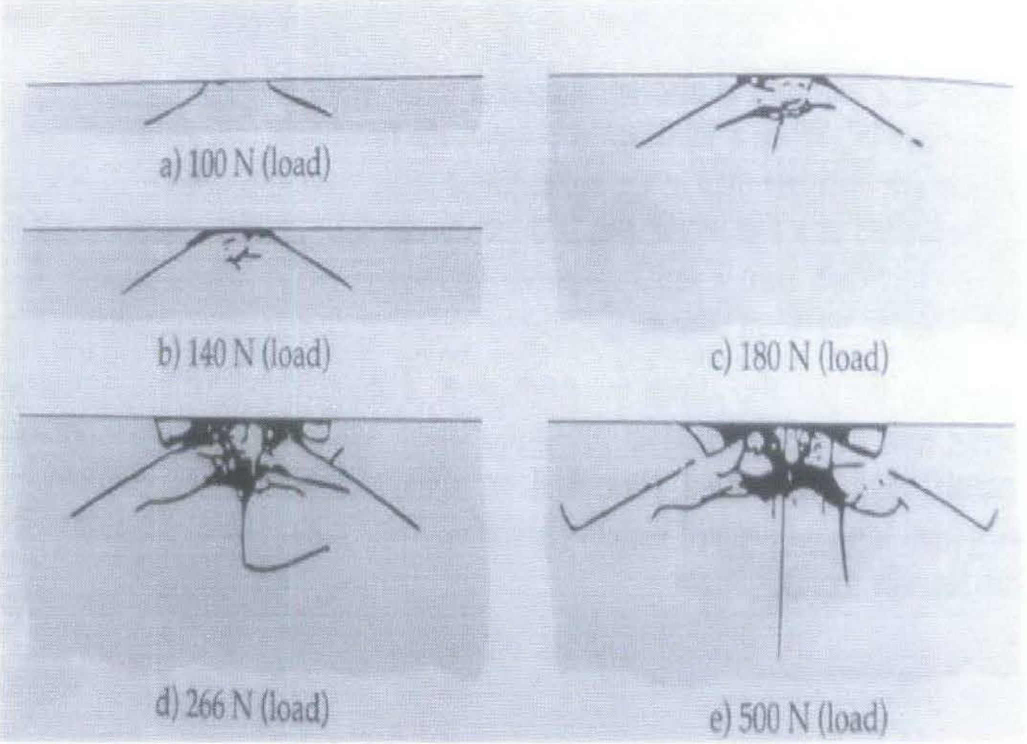


Figure 8: Generation of cracks under an indenter in brittle solid[12].

2.2.6 Grain Pull-Out

Grain detachment or pull-out is a relatively rare form of wear which is mainly found in ceramics. This mechanism of wear can become extremely rapid when inter-grain bonding is weak and grain size is large.

2.2.7 Modes of Abrasive Wear

The way the grit passes over the worn surface determines the nature of abrasive wear. There are two basic modes of abrasive wear which are two-body and three - body abrasive wear. Until recently these two modes are thought to be very similar, however some significance differences have been revealed[14]. The two-body and three-body modes of abrasive wear are illustrated in Figure 9.

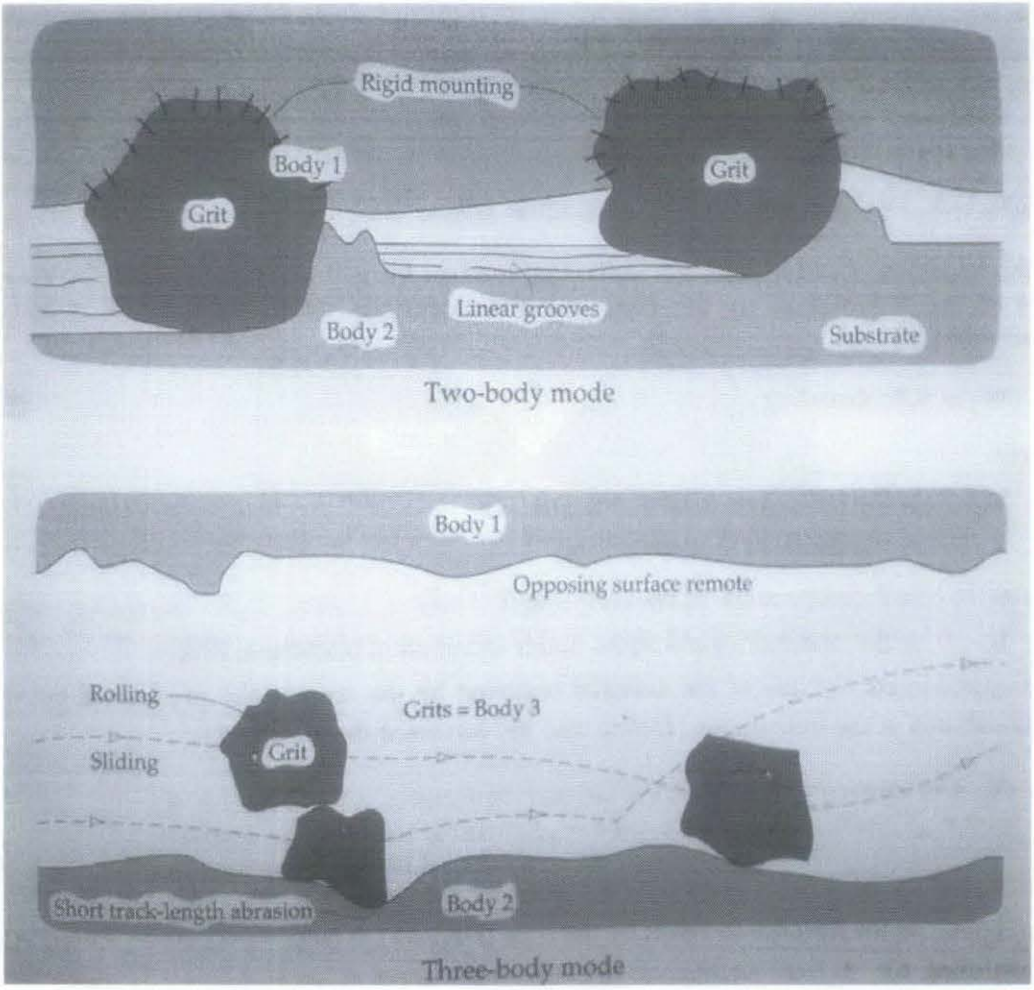


Figure 9: Two and three-body modes of abrasive wear[14].

2.2.8 Two-Body Abrasive Wear Mode

Two-body abrasive wear is exemplified by the action of sand paper on a surface. Hard asperities or rigidity held grits pass over the surface like a cutting tool. This mode of wear removes surface material much faster than the three-body wear. Two-body abrasive wear corresponding closely to the cutting tool model of material removal.

2.2.9 Three-Body Abrasive Wear Mode

In three-body abrasive wear the grits are free to roll as well as slide over the surface, since they are not hold rigidly. Three-body abrasive wear is ten times slower than two-body wear since it has to compete with other mechanism such as adhesive wear[15]. Properties such as hardness of the backing wheel, which forces the grits onto a particular surface, involves slower mechanisms of material removal, though very little is known about the mechanisms involved[16]. It appears that the worn material is not removed by a series of scratches as is the case with two-body abrasive wear. Instead, the worn surface displays a random topography suggesting gradual removal of surface layers by the successive contact of grits[17].

2.2.10 Erosive Wear

Erosive wear is caused by the impact of small particles of solid or fluid against the surface of an object[14]. Erosive wear occurs in machineries such as damage to compressor blades of a turbocharger when it ingested road debris, and the wear of pump impellers.

2.2.11 Mechanism of Erosive Wear

Erosive wear involves several wear mechanism which are largely controlled by the particle material, the angle of impingement, the impact velocity, and the particle size[15]. If the particle is hard and solid then it is possible that a process similar to abrasive wear will occur. Abrasion does not take place and the wears involved are the result of repetitive stresses on impact. Examples of erosion wear mechanism are shown in Figure 10.

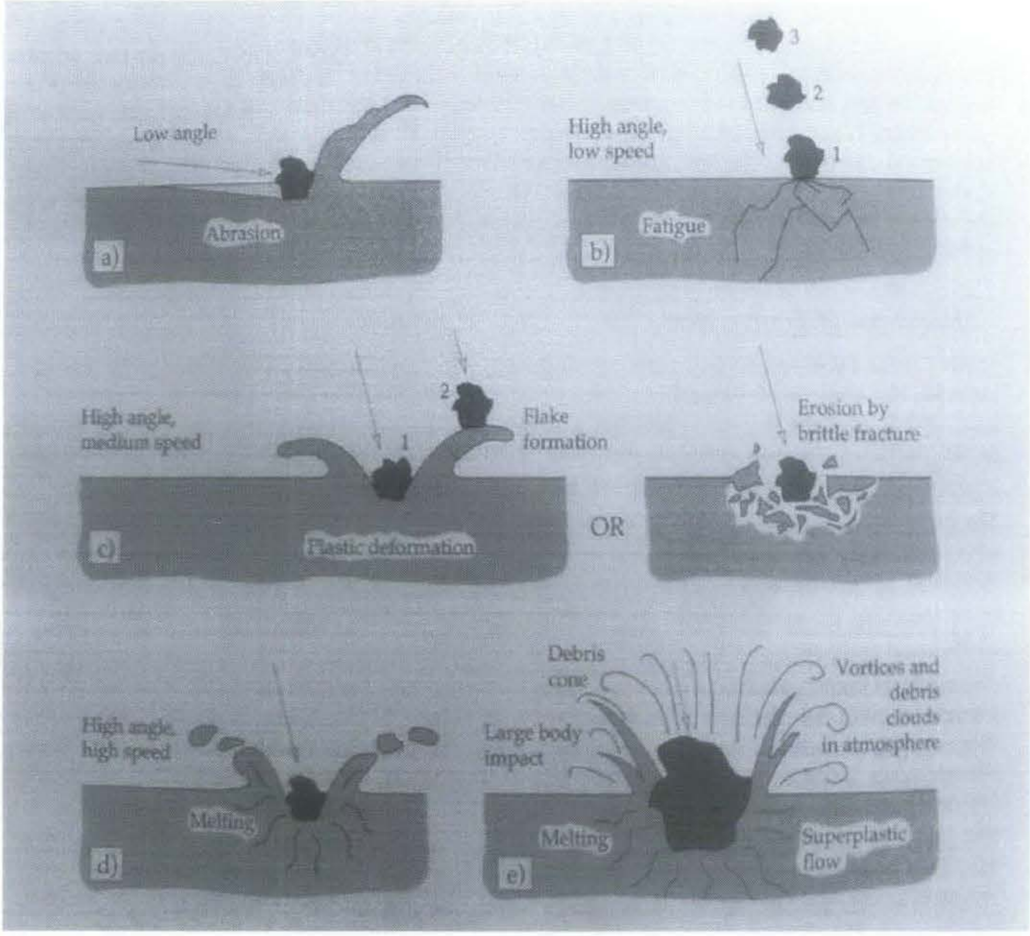


Figure 10: Mechanisms of erosion; a) abrasion at low impact angles, b) surface fatigue during low speed, high impingement angle impact, c) brittle fracture during medium speed, large impingement angle impact, d) surface melting at high impact speeds, e) macroscopic erosion with secondary effects[15].

2.2.12 Angle of Impingement

The angle of impingement is the angle between the eroded surface and the trajectory of the particle immediately before impact. A low angle of impingement favors wear processes similar to abrasive wear because the particles tend to track across the surface after impact.

2.2.13 Impact Velocity

The speed of the erosive particle has a very strong effect on the wear process. If the speed is very low then stresses at impact are insufficient for plastic deformation to occur and wear proceeds by surface fatigue. When the speed is increased, it is possible for the eroded material to deform plastically on particle impact, wear may occur by plastic repetitive plastic deformation. If the eroding particles are blunt or spherical then thin plates of worn material form on the worn surface as a result of extreme plastic deformation. If the particles are sharp then cutting or brittle fragmentation is more likely. Brittle materials on the other, wear by subsurface cracking. At very high particle speeds melting of the impacted surface might even occur.

2.2.14 Particles Size

The size of the particle is also of considerable relevance and most of the erosive wear problems involve particles between 5 - 500μm[15].

CHAPTER 3

METHODOLOGY

3.1 FAILURE ANALYSIS APPROACH

Failure analysis methods were utilized in this study. Several testing and examinations steps were used to study the failure of the blades.

3.1.1 Background Data and Sample Selection

At the beginning of the study, the author had collected the design and history data of the cutter blades. Design data collected consist of drawing design of the pelletizer assembly, pelletizer rotor assembly and operating manuals. The author manages to bring back a set of 20 used blades to study the failures.

3.1.2 Preliminary Inspection

Using visual inspection, preliminary examinations are done to determine the failures of the cutter blades. The condition of the specimens is determined, pictures of the specimen are taken and cleaning process is also done.

3.1.3 Microscopic Inspection

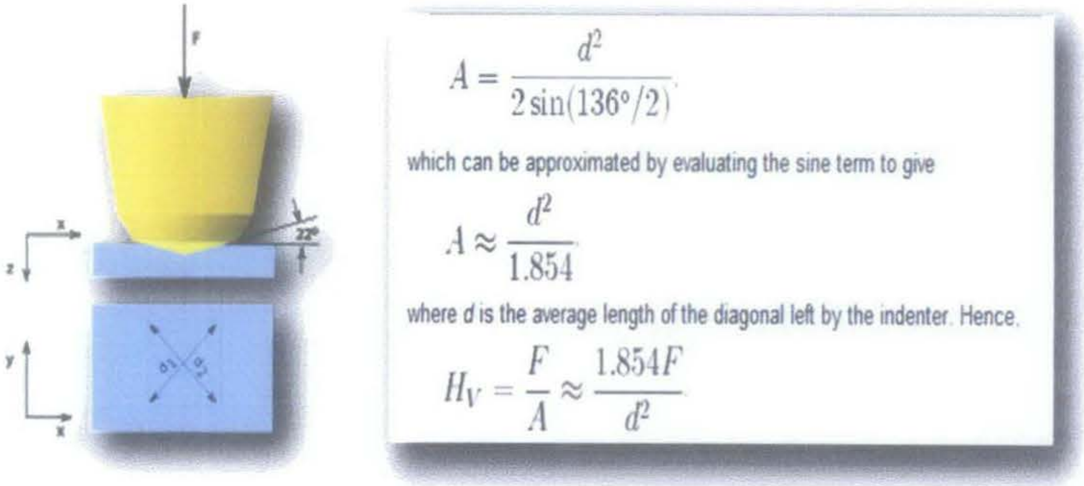
Sample is prepared for microscopic examination; it will need to be cut, mounted, grinded, polished and etched. The sample will be inspected for grain boundary under the optical microscope (Figure 11a) and scanning electron microscope (Figure 11b).

(a) (b)

Figure 11: Microscopic Inspection: a) Optical microscope. b) Scanning Electron Microscope (SEM)

3.1.4 Hardness Testing

The sample is cut into square and mounted in pressed berkelite, then grinded until flat surface is obtained. Sample was tested with indenter test machine to obtain the Vicker hardness reading. The Vickers Hardness measurement principle is shown in Figure 12.



$$A = \frac{d^2}{2\sin(136°/2)},$$

which can be approximated by evaluating the sine term to give

$$A \approx \frac{d^2}{1.854}$$

where d is the average length of the diagonal left by the indenter. Hence,

$$H_V = \frac{F}{A} \approx \frac{1.854F}{d^2}$$

Figure 12: Vickers Hardness measurement principle.

CHAPTER 4

RESULT AND DISCUSSION

4.1 RESULT

In this chapter, results obtained at each stage are recorded. The stages involved are Background data and sample selection, preliminary inspection, microscopic inspection and mechanical testing.

4.1.1 Background Data and Sample Selection

The author went to MTBE/POLYPROPYLENE (M) SDN. BHD and collected samples of failed cutter blades along with documents covered from manufacturer operating manuals to startup and shutdown procedure.

Based on the interview with the technician the failure was caused by the operating requirement of the pelletizing system which the blades must undergoes a process known as grinding. This process is to make sure an even contact surface between the blades and the die plate, both are made from titanium carbide. During operation or production, the blades must rotate and stay contact with the die plate.

The wear rate of the blades depends on how much the pelletizer drive is pushed forward against the die plate, the forward length depends on the polymer melt index. If the forward length is not enough, the polymer will produce tails and may covers the whole blades reducing cutting capability and may produce unwanted resin size.

This operating requirement make blades wear unavoidable and the blades are usually scheduled to be replaced every 2 – 3 month or when the allowable wear land reaches maximum of 4 mm. However, in uncertain event the blades chipped off during operation. This is the type of failure which needs attention throughout the study. Figure 13 and 14 shows the cutter blades mounted on its pelleter drive rotor.

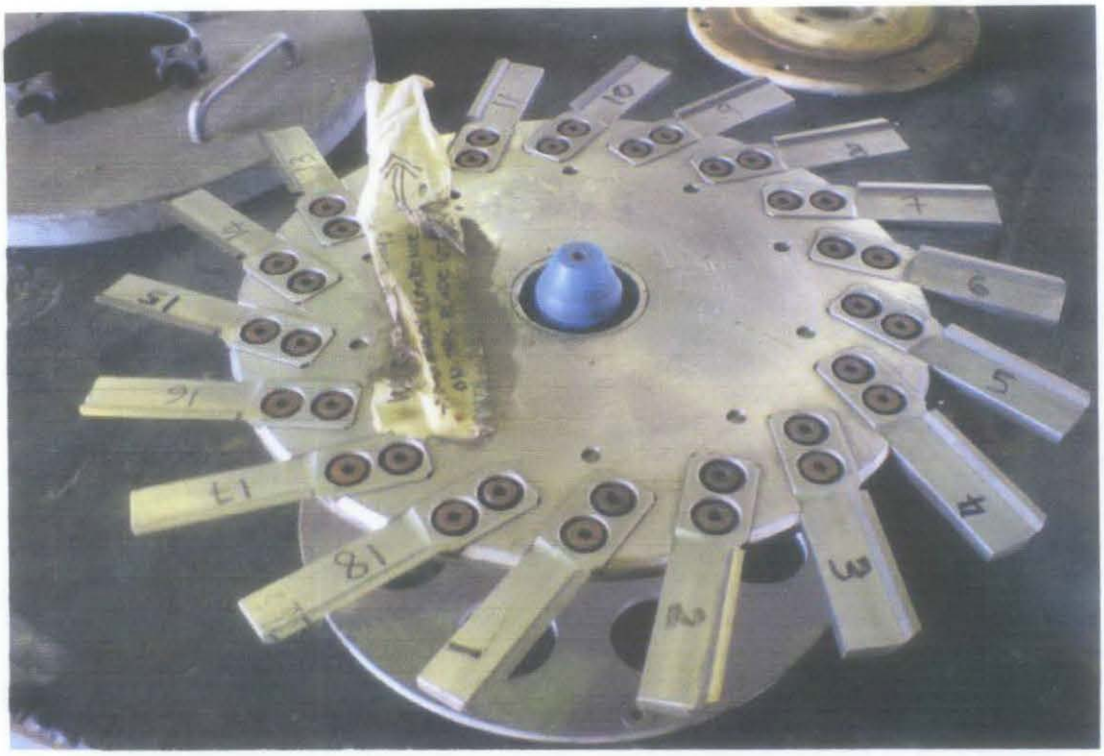


Figure 13: New cutter blades mounted on the pelletizer drive.

Figure 14: Close-up view of the cutter blade; titanium carbide tip (darker) bonded to stainless steel tip holder (lighter).

4.1.2 Preliminary Inspection

Preliminary examinations were carried out by using visual inspection on the failed cutter blades. All the samples randomly selected at the site are examined visually to find which have excessive wear and chipped part. Cutter blades which have obvious chipping marks are selected to be used in the study, Figure 15 to 19 shows the failed part at the blades.

Figure 15: Samples of the failed cutter blades; mixed of excessive wear and uneven wear land of cutter blades.

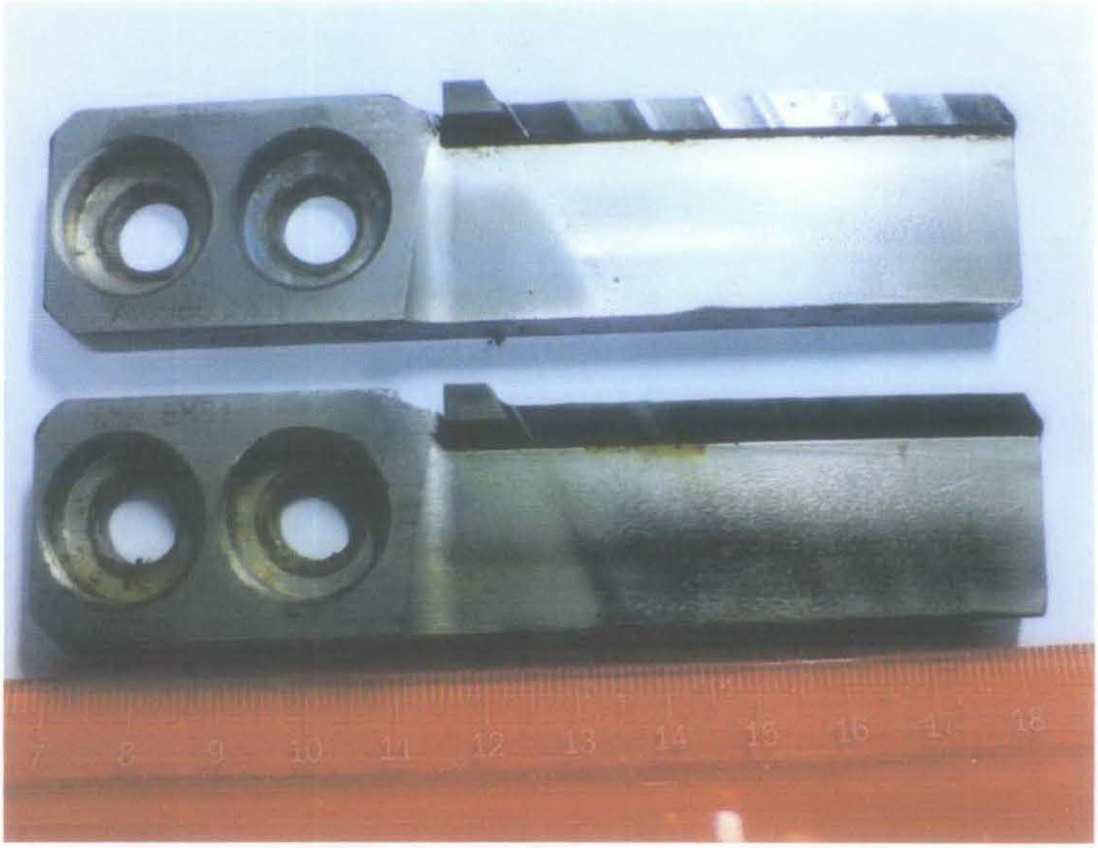


Figure 16: Uneven wear of the cutter blade.

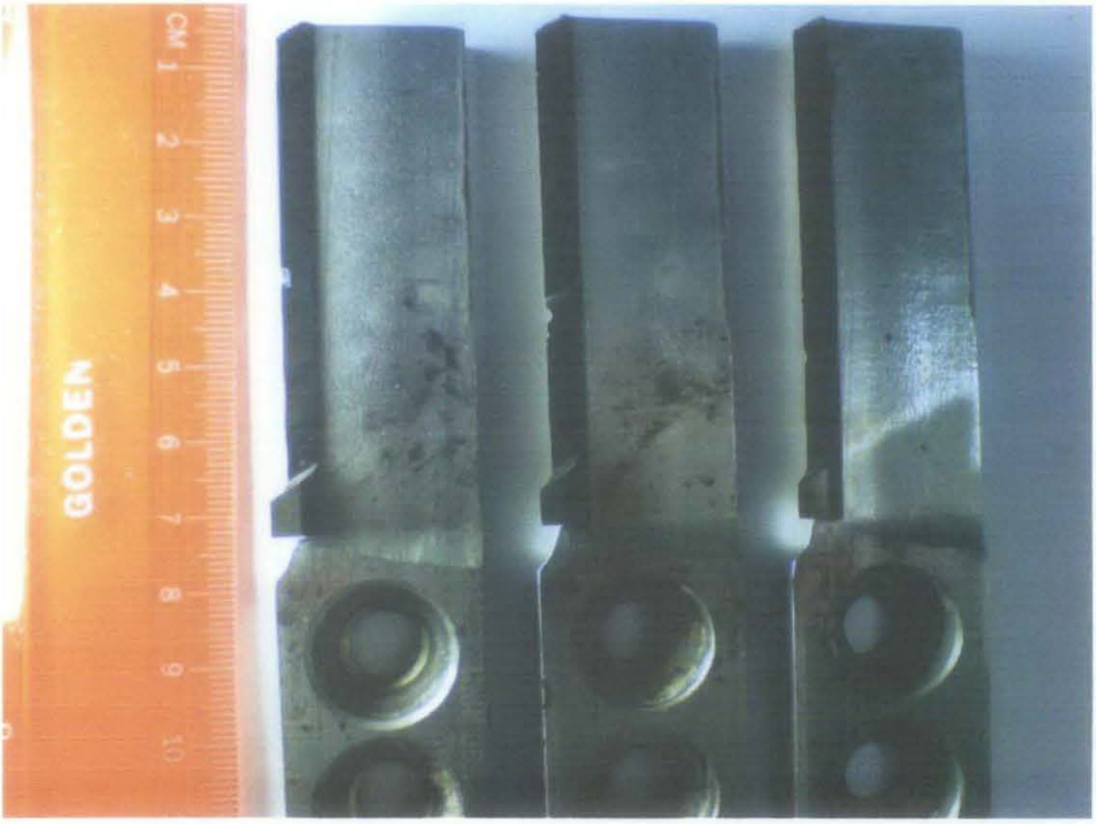


Figure 17: Chipped titanium carbide tip.

Figure 18: Close-up view of the chipped part.

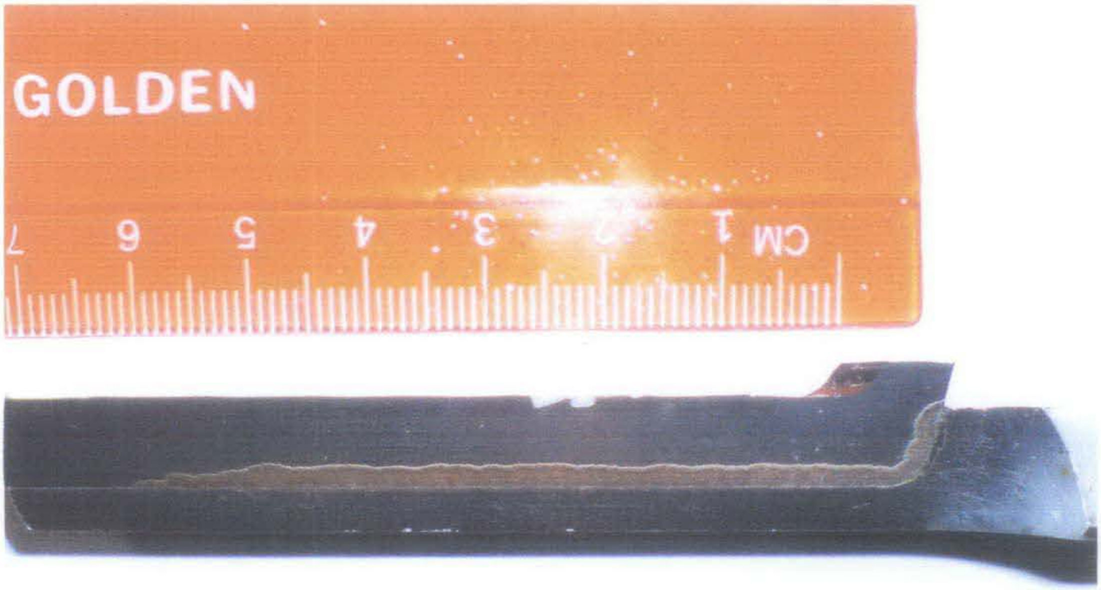


Figure 19: Top view of the chipped tip blade.

4.1.3 Microscopic Inspection

Result from the optical microscopic inspection at the cross-section of the tip shows it undergoes grain pull-out wear near the cutting surface (Figure 20 to 22).

Metallography inspection of TiC reveals the microstructure at different magnification, the TiC have many voids in its microstructure, small dark spots. These voids have an effect of reducing the strength of TiC tip (Figure 23 to 25).

Observation under the scanning electron microscope reveals its microstructure in finer details (Figure 26 to 28). Fractography of the failed tip shows it had been hit by debris along its cutting path and undergoes brittle fractures (Figure 29 to 31).

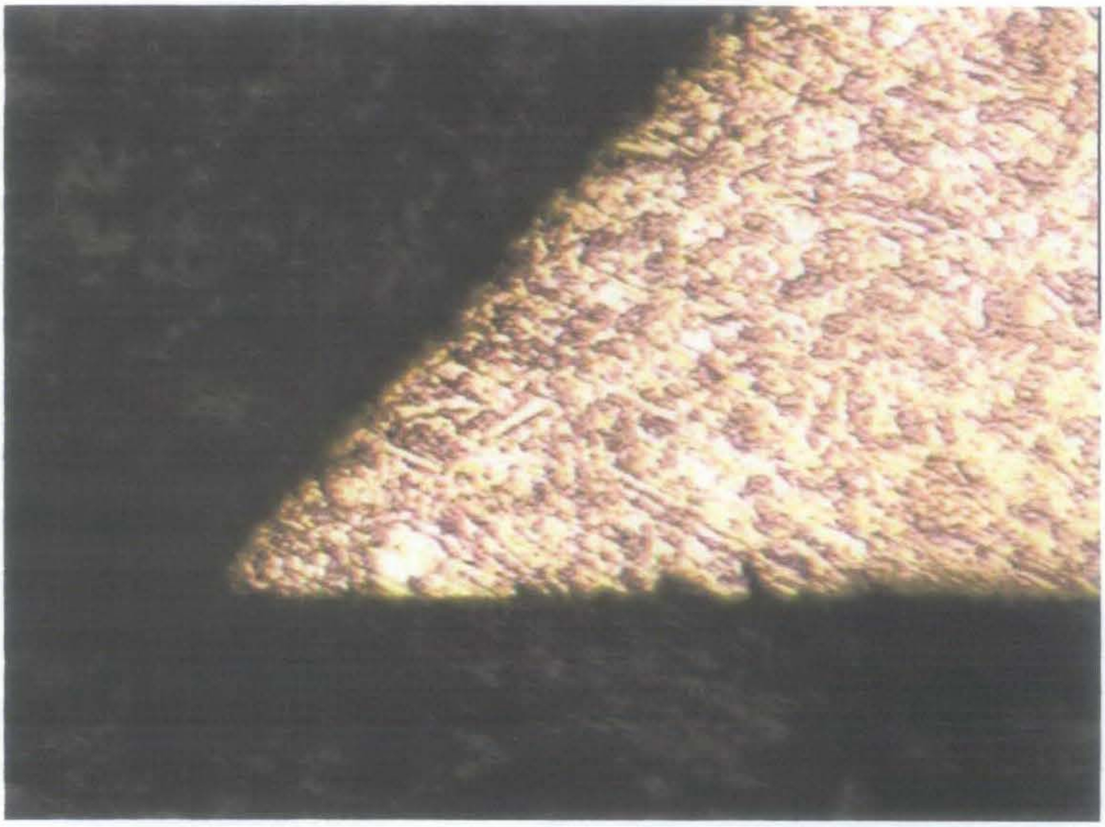


Figure 20: Cross section of the titanium carbide tip at magnification of 50X.

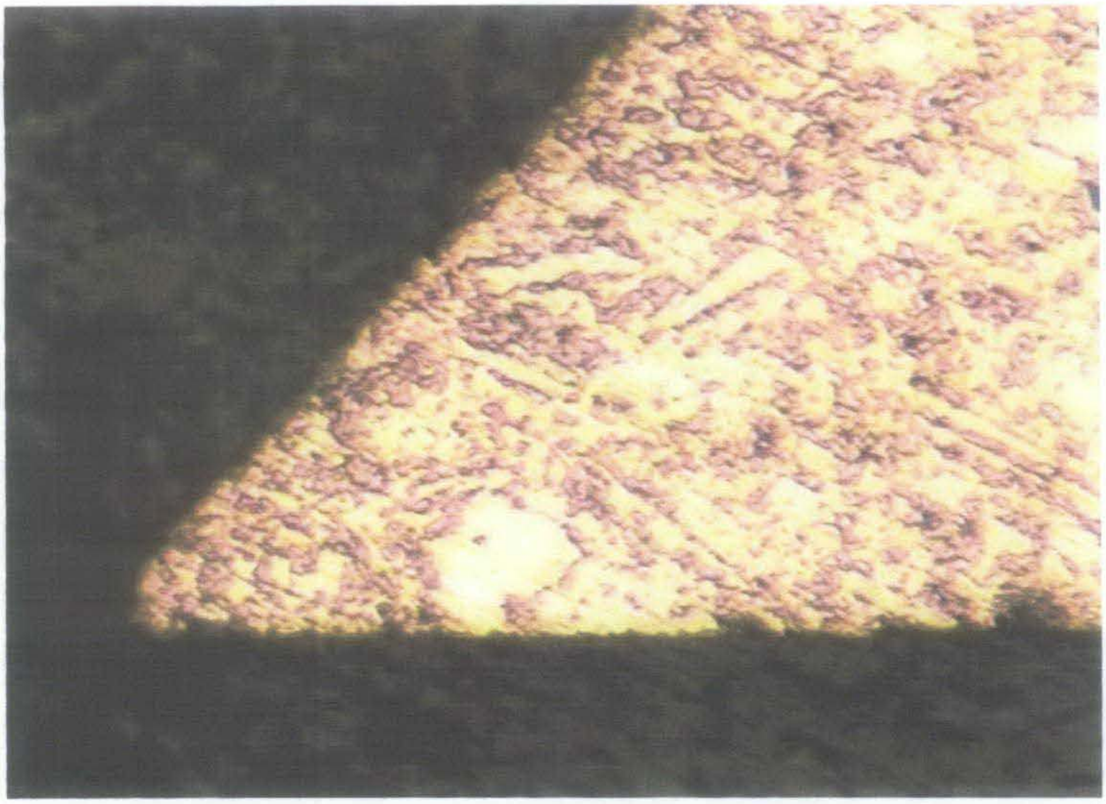


Figure 21: Titanium carbide tip at magnification of 100X.

Figure 22: Magnification of tip at 200X.

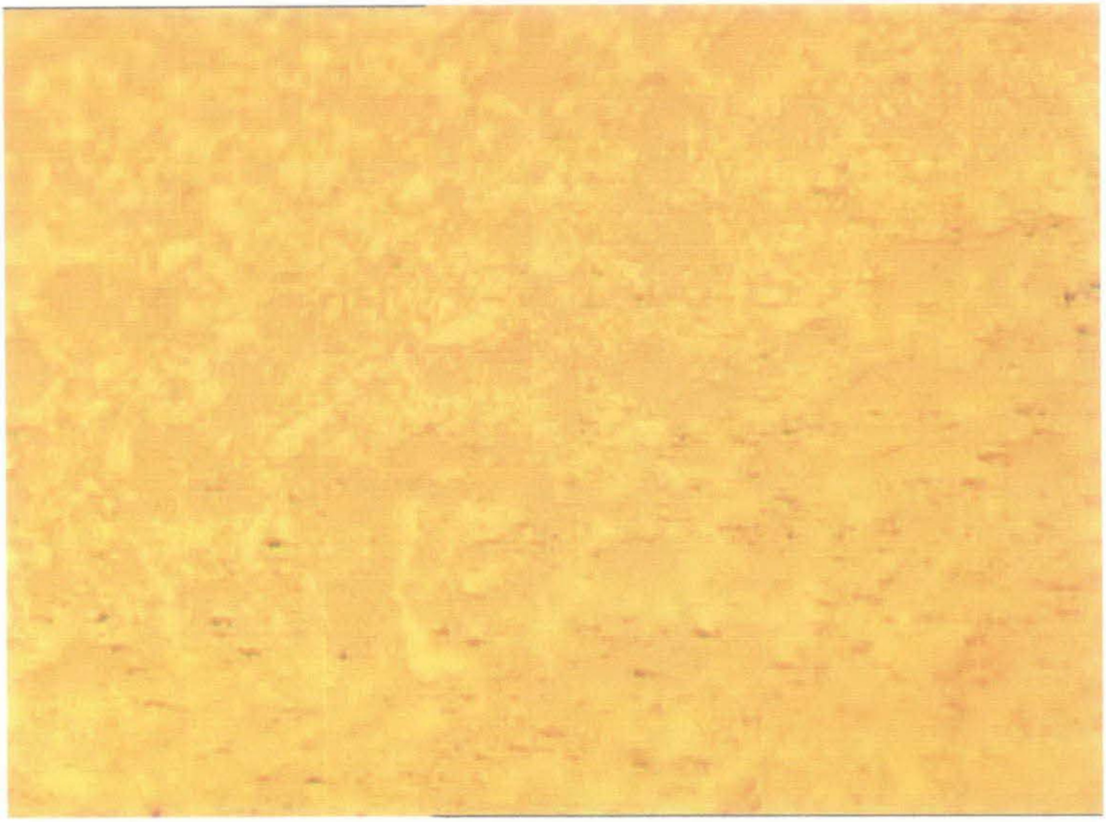


Figure 23: Microstructure of titanium carbide at 100X magnification.

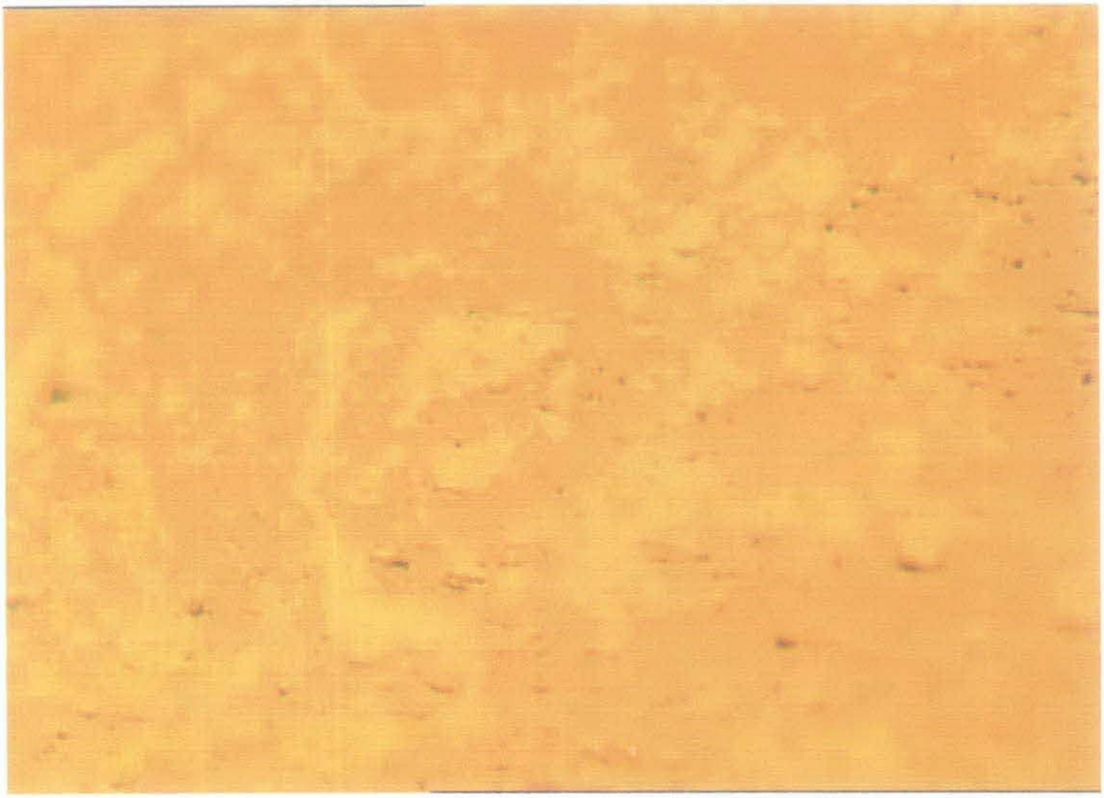


Figure 24: Microstructure of titanium carbide at 200X magnification.

Figure 25: Microstructure of titanium carbide at 500X magnification.

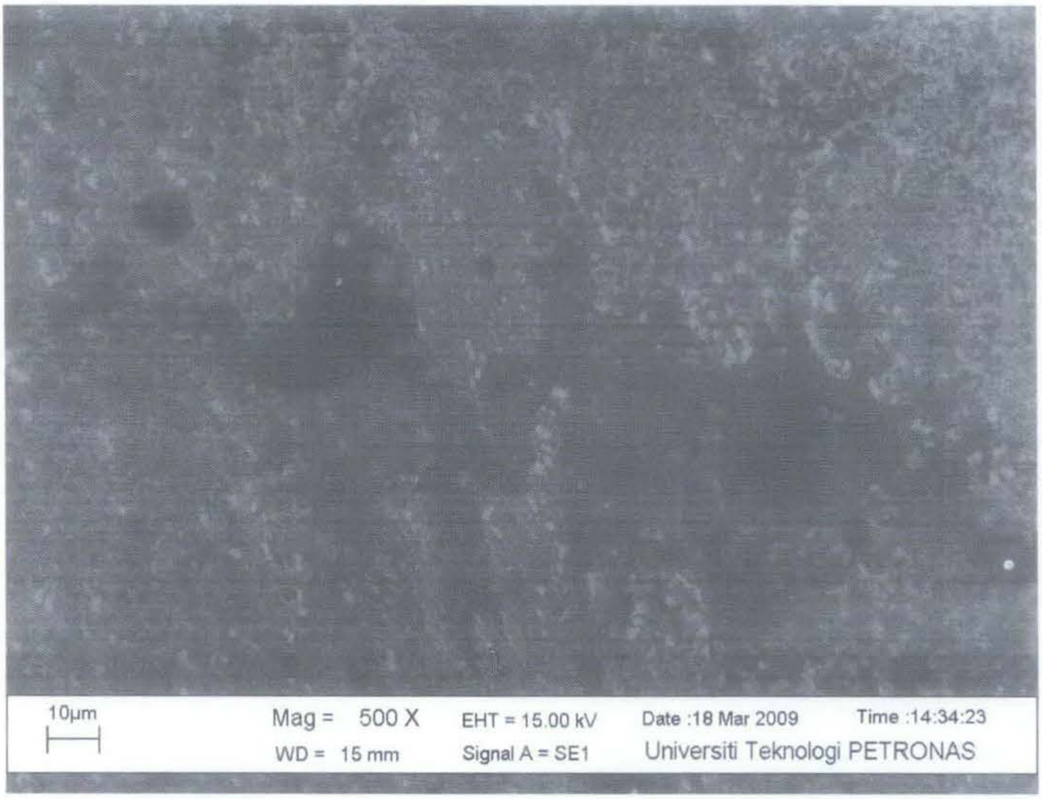


Figure 26: Titanium carbide microstructure observed under SEM at 500X.

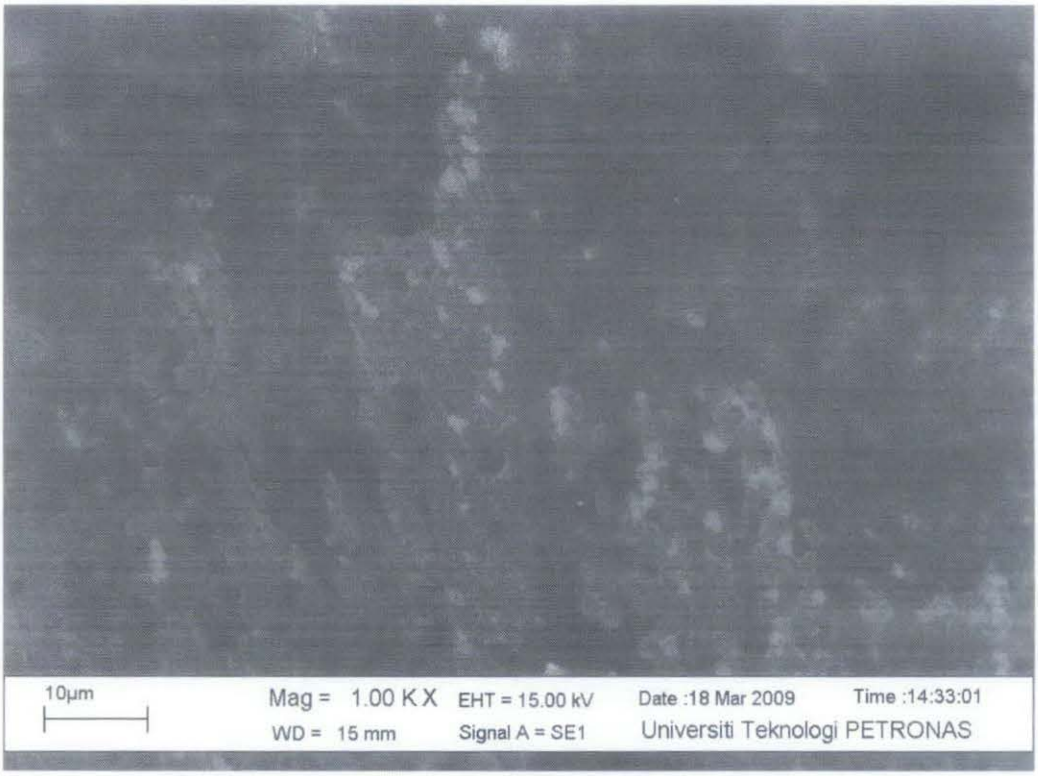


Figure 27: Titanium carbide microstructure observed under SEM at 1000X.

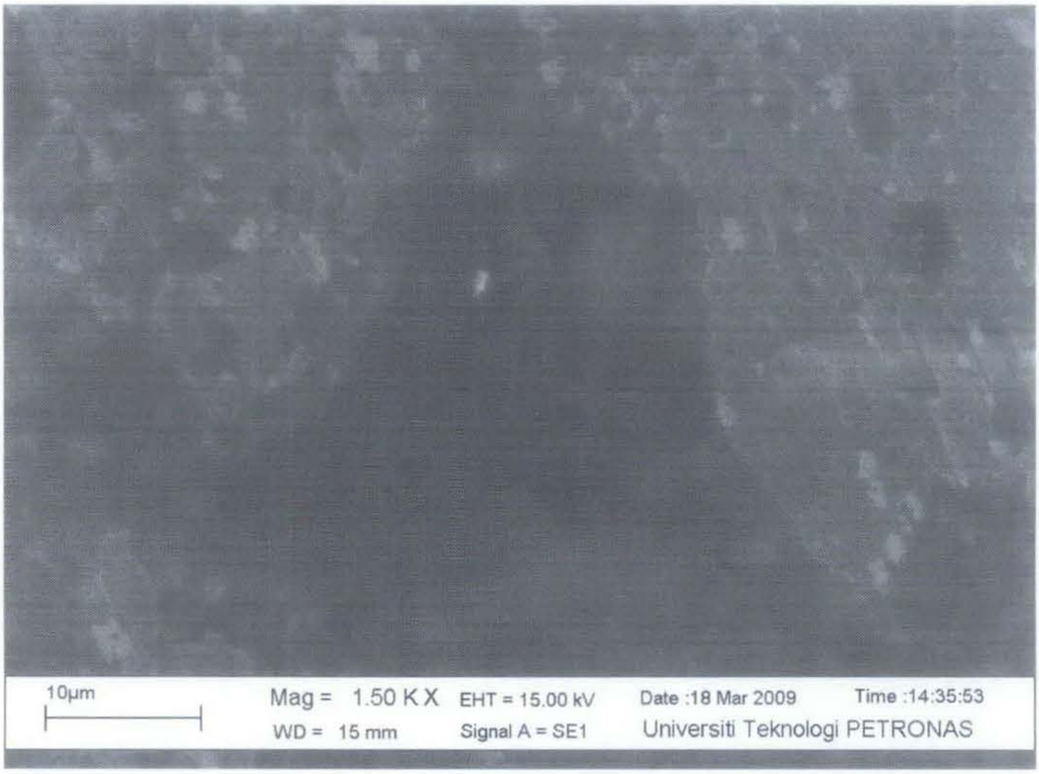
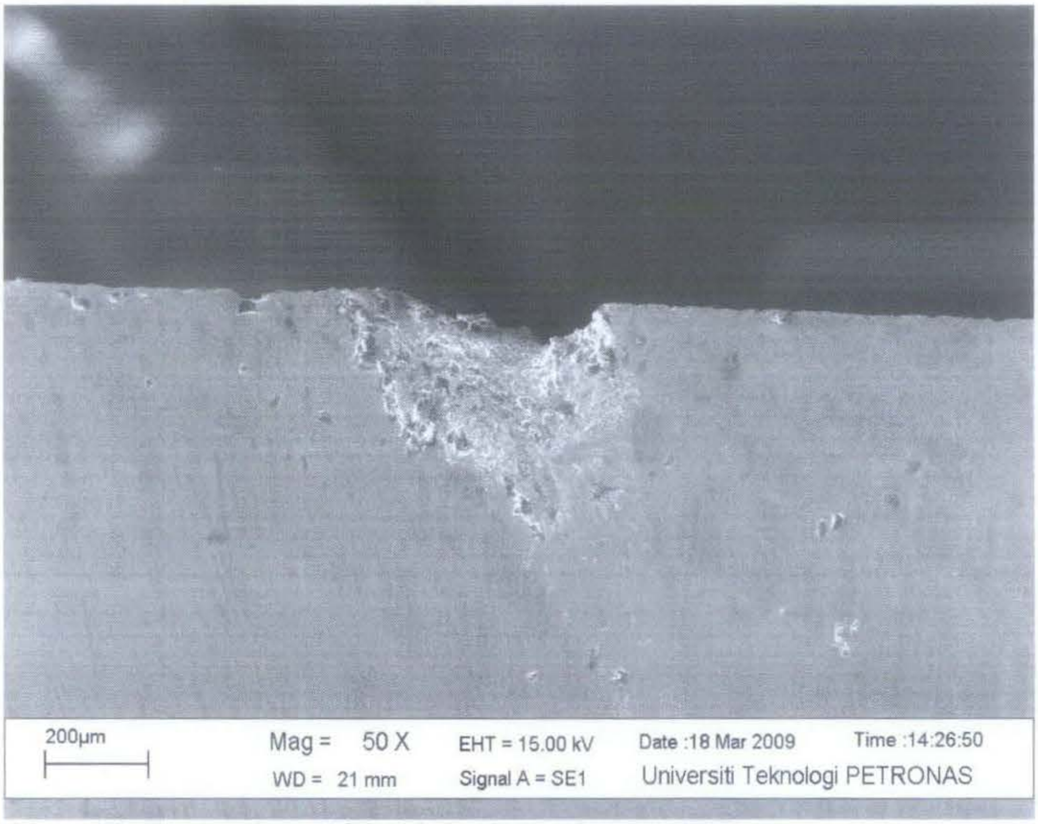


Figure 28: Titanium carbide microstructure observed under SEM at 1500X



.Figure 29: Fractured part of the blade observed under SEM.

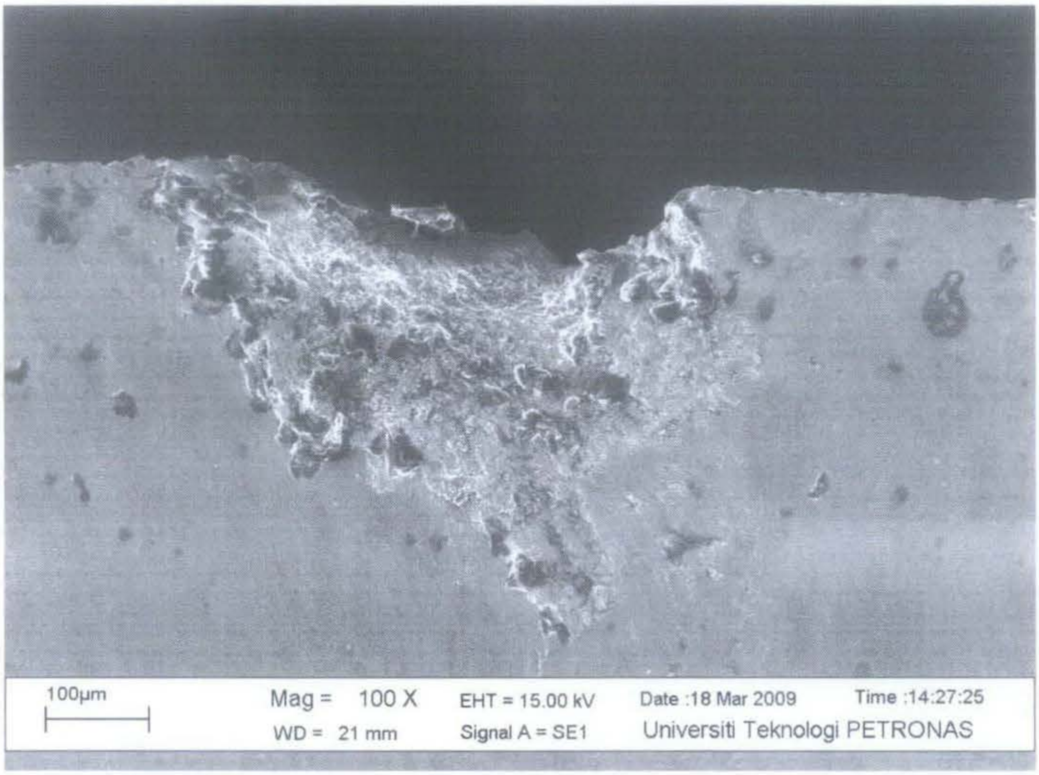


Figure 30: Tip fracture propagation is in line with cutting direction.

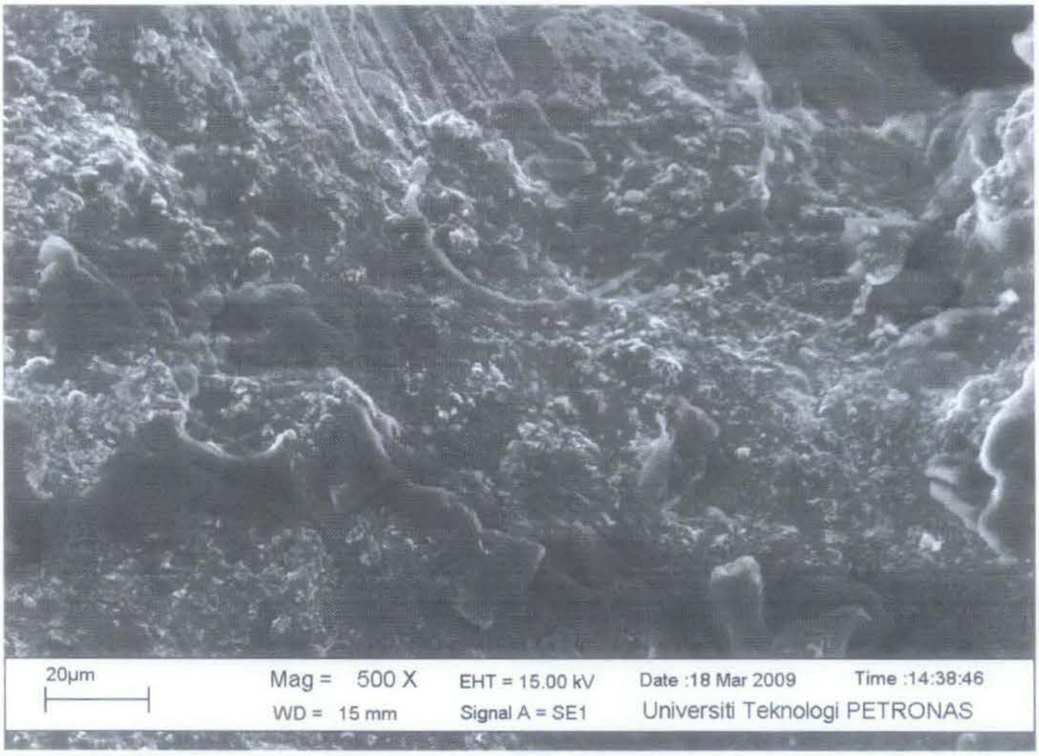


Figure 31: Magnification of the fractured area shows TiC undergoes brittle type fractures.

4.1.4 Hardness Testing.

Sample of the blade are taken to Vickers Hardness test machine to obtain its hardness. The test carried out using 3 different degree of force which is 200N, 500N and 1000N. The machine makes and indentation onto the surface and the user need to measure diagonal section of the resulting indentation using microscope. The result for the samples are shown in Table 1.

Table 1: Vickers Hardness Test Result

	F=200N			F=500N			F=1000N		
	1	2	3	1	2	3	1	2	3
d1(um)	18.99	19.65	21.7	34.93	38.34	35.25	48.33	50.58	48.46
d2(um)	20.36	21.8	21.67	33.36	36.32	35.97	46.65	48.62	48.05
Hv	958.1	863.5	788.7	795.3	654.8	731.2	822.2	753.8	796.5
Average	870.1			727.1			790.8		
	Hv=796								

4.2 DISCUSSION

Results based on the background and sample collection stage provide useful information about the failure of the cutter blades. It is manufactured by Kobe Steel Company or Kobelco in Japan. From the preliminary examinations, the cutter blades show severe wear, few blades are collected show some part had chipping marks.

During the commissioning stage of the pelletizer, it requires the blades to be grinded against the die plate and also during operation, thus wear is unavoidable. The manufacturer recommends the blades must be replaced at interval within 2 – 3 month of normal operation.

The blades chipped part indicates that possibilities that foreign particles carried along with cooling water may have come in between the rotating pelletizer. First impression the tip fractured when it collide heads on with the debris.

From the failure analysis study on to the blades, firstly mechanical testing which was conducted using Vickers Hardness test, the tip which is made from TiC shows an average Hv value of 796 (Table 1), which is very hard and brittle but high wear resistance. Evidence of wear resistance is that it must used to cut polymer while pressed at high force against TiC hardened die plate, and scheduled replace for 2 – 3 month.

TiC has very high wear resistance but low on impact resistance or toughness. Sudden impact on the tip can fracture it. Fractography of the blade tip observed from SEM, the tip break off consistent with brittle fracture, where the structure looks uneven, rough and follows the path of the objects which strike onto it.

CHAPTER5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The cutter blade tip is made from titanium carbide and manufactured by Kobe Steel Company Ltd. (Kobelco) of Japan. The samples indicate excessive wear and some of them had chipped tip.

The excessive wear on the cutter blades is suspected from poor operating procedure. During high melt index, polymer tends to produce tailings. To counter this problem the operator need to advance the pelleter rotor forward to the die plate. This resulting higher grinding force and higher wear rate.

Lack of proper monitoring of cooling water entering the chamber may have lead to the chipping of TiC tip, debris may have come in between the blades during operation and collide with the tip. During cleaning of the chamber, the author had found sand inside the chamber.

5.2 RECOMMENDATION

From this study, the author would recommend to continue using this type of blade but modify the incoming flow of cooling water by installing a strainer which can prevent debris from entering the chamber.

To reduce wear, the author suggests reducing grinding force of the blade against the die plate but allowing the blade to rotate at high rotational speed to avoid polymer tailing.

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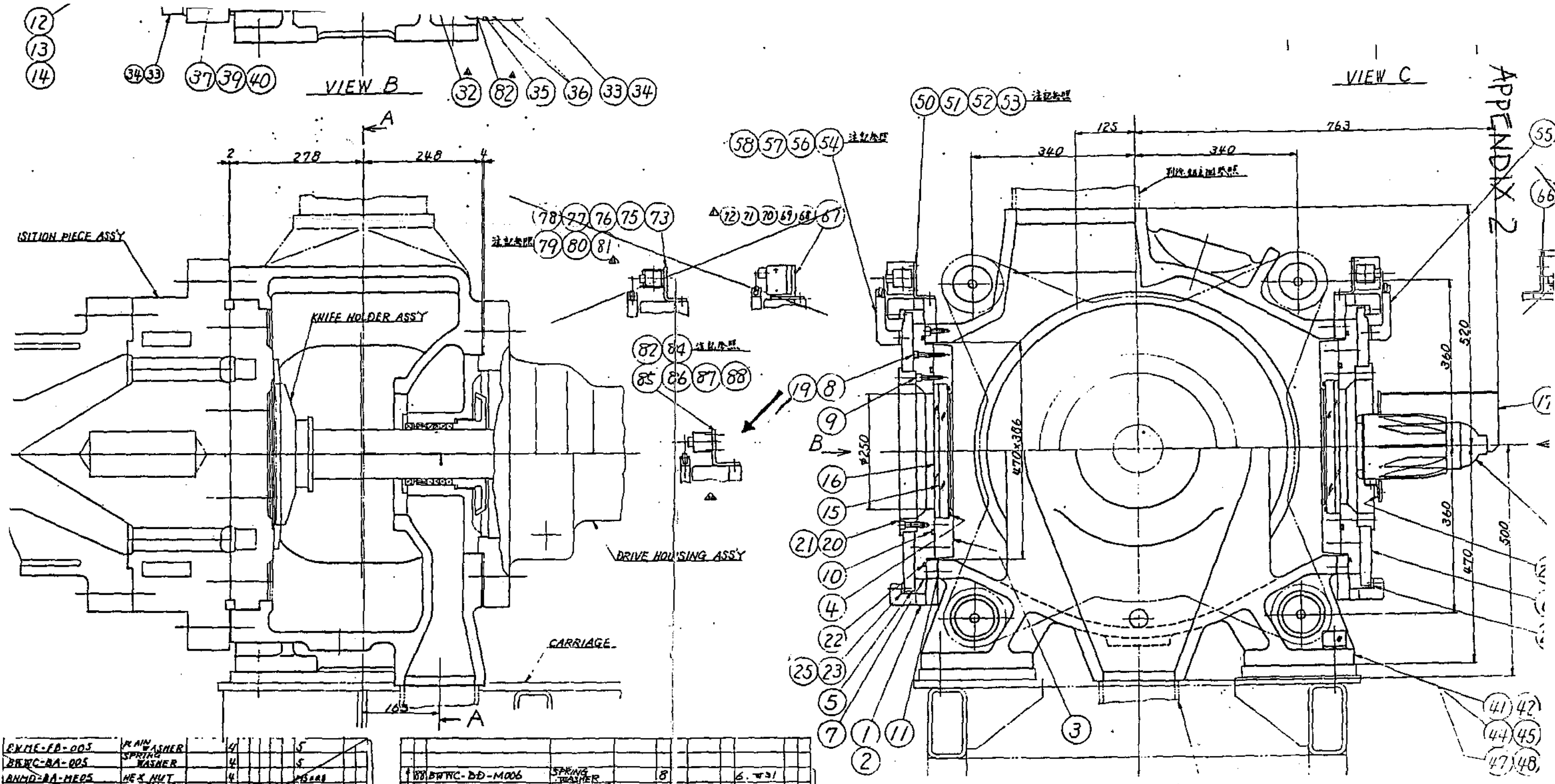
APPENDIX 1

(H- i)

	KOBE STEEL, LTD. KOBE JAPAN		PELLETER DATA SHEET	
1	CUSTOMER	TOYO ENGINEERING CORPORATION	SHEET NO.	1/1
2	LOCATION	MALYSIA	DATE	Jun. 28. 1991.
3		☒ INDOOR ☐ OUTDOOR	REV. DATE	LINE NO.
4	ITEM NO.	Z-7070		
5	SUPPLIER	KOBE STEEL, LTD.		
6	SERVICE	PELLETER		
7	TYPE	UNDER WATER PELLETER		
8	MODEL NO	UP-420		
9	DIE PLATE		MATERIAL	
10	TYPE	HEAT CHANNEL TYPE	DIE PLATE	STAINLESS STEEL
11	HOLE DIA	2.3 mm	DIE HOLDER	CARBON STEEL+CHROME PLATE
12	NO OF HOLES	560	WATER CHAMBER	CAST STAINLESS STEEL
13	SURFACE HARDENING	TITANIUM CARBIDE	DRIVE HOUSING	CAST STEEL
14	HEATING	HIGH PRESSURE STEAM	CUTTER SHAFT	STAINLESS STEEL
15	JACKET DESIGN PRESS.	5810 Kpa (59.3 kgf/cm^2)	KNIFE	TITANIUM CARBIDE
16	DIE HOLDER		KNIFE HOLDER	STAINLESS STEEL
17	HEATING	HIGH PRESSURE STEAM	KNIFE ADJUSTMENT	
18	JACKET DESIGN PRESS.	5810 Kpa (59.3 kgf/cm^2)	PARALLELISM	FOUR TIE RODS
19	CUTTER UNIT		CLEARANCE	FINE ADJUSTMENT MECHANISM
20	DRIVE MONITOR	90 kW	OPTION	
21	CUTTER SPEED	130 ~ 1300 rpm		
22	NO. OF KNIVES	20 pc's		
23	MOVING METHOD	AIR CYLINDER		
24	LUBE OIL SYATEM	OIL BATH		
25	COUPLING TYPE	SLIDE GEAR COUPLING		
26				
27				

APPENDIX 2



SECTION AA

EXME-FB-005	PLAIN WASHER		4				5
BWWC-BA-005	SPRING WASHER		4				5
ANMD-BA-ME05	HEX NUT		4				M5×08
EX-FGPIA#01	HEX SOCKET BOLT		4				M5×08×55
AWWC-BA-006	SPRING WASHER		4				6
BWME-FB-006	PLAIN WASHER		4				6
BBMD-BA-M006-016	HEX BOLT		4				M6×16
EX-FH28F#02	L/S BRACKET		1				
EX-FH28F#01	L/S BRACKET		1				
BWWC-BA-006	SPRING WASHER		4				6
AWME-FB-006	PLAIN WASHER		4				6
BBMD-BA-M006-016	HEX BOLT		4				M6×16
EX-EH30A#02	L/S TRIP PLATE		1				
EX-EH30A#01	L/S TRIP PLATE		1				
EX-FH01D#08	L/S BRACKET ASS'Y		1				

	88	BWWC-BD-M006	SPRING WASHER	8		6.×31	
	87	BBLK-RA-M006-020	HEX. SOCKET BOLT	8		M6×20	
	86	BWWC-BA-006	SPRING WASHER	4		6	
	85	BWME-FB-006	PLAIN WASHER	4		6	
	84	BDMD-BA-M006-016	HEX. BOLT	4		M6×16	
	82	EX-EH28K	L/S BRACKET	1			
	58	BWWC-BA-006	SPRING WASHER	4		6	
	57	BWME-FB-006	PLAIN WASHER	4		6	
	56	BBMD-BA-M006-016	HEX. BOLT	4		M6×16	
	55	EX-EH30A #02	L/S TRIP PLATE	1			
S	54	EX-EH30A #01	L/S TRIP PLATE	1			
RS		EX-FH01D #09	L/S BRACKET ASS'Y	1			

注記

1. 下記仕様ニ基ヅキ部品ヲ選定スル.
   - a：ウォーターチャンバーノ仕様ニヨリ#02, #03 又ハ #04 ヲ選定スル.
   - b：リミットスイッチノ仕様ニヨリ#05, #07, #08 又ハ #09 ヲ選定スル.
   - c：ラッチ機構ヲ採用スル場合 #06 ヲ選定スル.

R3

R2

R1