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AUTOMATION OF SMALL AND MEDIUM-SCALE INDUSTRIES

DP/ROK/87/001

REPUBLIC OF KOREA

Technical Report: Automation in various grinding applications and general machinery*

Prepared for the Government of the Republic of Korea
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of Normand M. Armstrong
Expert in grinding automation

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Engineering Industries Branch

United Nations Industrial Development Organization
Vienna

* This document has not been edited.

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TABLE OF CONENTS

INTRODUCTION

The mission began on Saturday September 16, 1989 at S.M.I.P.C. in Seoul, Korea with an introduction to some of the new members of the organization, who have recently joined the "Automation Department" as well as those that have been with the group for many years.

Since I have been part of S.M.I.P.C. for six years and K.O.P. T.E.C., prior to the merging of the two organizations for two years, the standard preliminaries and the scope and the working of the organization was keep at a minimal.

I was introduced to Mr. Lee, Ki-Don, a relatively new engineer with S.M.I.P.C. Mr. Lee was to be my liaison officer and translator for four weeks, representing three companies in Pusan.
Also met with my other liaison officer, Mr. Yoo, Jae-Kwon which I had the priveledge of working with in the past. Mr. Yoo would be the translator for the following three weeks, visiting four companies in the Seoul area.

Monday September 18, 1989 we went to the U.N.D.P. in Seoul and met with Mister Jacob Guijt, Resident Representative, United Nations Development Programme and Mister P.C. Park Programme Officer. They explained the program and the relationship between U.N.I.D.O. and S.M.I.P.C. They also expounded the importance on several small and medium size companies and the need for service of experts in the field of automation.

I was told that the companies were in need of automation in various grinding applications and general machining.
This has been my field of expertise as well as being familiar with some of the companies.

The actual working period began Monday September 18, 1989 after I returnd to S.M.I.P.C. from U.N.D.P. and ended Saturday November 4th., covering a period of seven weeks with visits to seven different companies, addresing several problems during each visits, spanning a wide variety of problems.

During this period I worked with Mr. K.D. Lee, Mr. J.K. Yoo and Mr. D.J. Chang (Mr. Chang replaced Mr. Yoo for two days, due to prior commitments). These engineers were my translators and partners during my entire stay in Korea.

These gentlemen were great assets, notonly to me, but to the companies we visited and to S.M.I.P.C. I was very impressed with them in the english language, but especially with their knowledge as engineers in the field of manufacturing. This made, what could have been a difficult task, rather a very enjoyable and productive mission. It was proven by the appreciation indicated to us by various company president, wishing further assistance in the near future.

The automation department in S.M.I.P.C. headed by the very capable Chief of Engineer, Mister Nam, Sang- Moo, is extremely appreciated and respected by the small and medium companies. Mr. Nam's relentless efforts and enthusiastic attitude has reflected itself thruout all the engineers under his supervision. It is gratifying and gives a worth of accomplishment, when working with him and his staff.

As in the past I have enjoyed working with my Mr. Lee, Mr. Yoo and Mr. Chang. I am also looking forward in returning on November 17, 1989 for four weeks, thru S.M.I.P.C.

Prior to leaving Korea, I had a meeting with Mister Jacob Guijt and Mister P.C. Park at the U.N.D.P. office. We discussed my mission during the past seven weeks and the accomplishments that had been made.

Some of the companies requested that I assist them in acquiring brochures and information on a variety of products. From machinery equipment, machine tools to inspection equipment. I told them that I would try and bring back as much information as I could on return visit on November 17th. Whatever information I could not get, I would call Mr. Park of the S.M.I.P.C. office in chicago and pursue the remaining.

I was quite sadden with the news given to me by Mr. Jacob Guijt, on the temporary cancellation of activity between U.N.I.D.O. and S.M.I.P.C. due to the interpretation within their contract. The assistance that U.N.I.D.O. has given to the small and medium industries will enhance their knowledge and productivity, to a level of competitiveness in the world market, thus making Korea a highly industrious country.

I hope that in the near future U.N.I.D.O. and S.M.I.P.C. will mutually resolve and or rectify any differences, which I feel quite confident.

My meeting with Mister Guijt and Mr. Park was enjoyable and informative. I was very impressed Mister Guijt activity in Korea which I read thru the Korean news paper.

ITINERARY.

Date	Day	Work Class	Name of Company	Location	Contents
9-15	Fri.	Arrive		Seoul	P.M.
9-16	Sat.	Preparation	S.M.I.P.C.	Seoul	
9-17	Sun.	Rest		Seoul	
9-18	Mon.	Meeting	UNDP/SMIPC	Seoul	Report to U.N.D.P. Discuss problem
9-19	Tue.	Meeting	Buram Eng	Chung Ju	Video cassette Guide Pole & Tape Guides
9-20	Wed.	Consult	Buram Eng	Chung Ju	Discuss problem
9-21	Thur	Consult	Buram Eng.	Chung Ju	C'less grinding
9-22	Fri.	Class	Buram Eng	Chung Ju	Q.C. & Production
9-23	Sat.	Other	S.M.I.P.C.	Seoul	Summarize Visits
9-24	Sun.	Travel	Seoul to Pusan		
9-25	Mon.	Meeting	Shin Heung	Pusan	Grinding
9-26	Tue.	Meeting	Shin Ah	Pusan	Grinding
9-27	Wed	Consult	Shin Heung	Pusan	Discuss problems
9-28	Thur	Consult	Shin Heung	Pusan	Seminar
9-29	Fri.	Consult	Shin Ah	Pusan	Discuss problems & short Seminar
9-30	Sat.	Travel	Pusan to Seoul.		
10-1	Sun.	Rest			
10-2	Mon.	Other	S.M.I.P.C.	Seoul	Report
10-3	Tue.	Other	S.M.I.P.C.	Seoul	Report.
10-4	Wed	Consult	Buram Eng.	Chung Ju	Grinding.
10-5	Thur.	Class	Buram Eng.	Chung Ju	Production grinding
10-6	Fri.	Consult	Buram Eng.	Chung Ju	Grinding theory, principle & application.
10-7	Sat.	Other		Seoul	Report
10-8	Sun.	Rest		Seoul	
10-9	Mon.	Other	S.M.I.P.C.	Seoul	Report
10-10	Tue.	Consult	Buram Eng.	Chung Ju	Grinding
10-11	Wed.	Consult	Buram Eng	Chung Ju.	Grinding
10-12	Thur.	Consult	Buram Eng	Chung Ju	Grinding
10-13	Fri.	Meeting	Buram Eng	Chung Ju	Snmmarize
10-14	Sat.	Other	S.M.I.P.C.	Seoul	Report
10-15	Sun	Rest		Seoul	
10-16	Mon.	Meeting	Micron Precision	Seoul	Discuss Problems
10-17	Tue.	Meeting	Jae Young.	Guro	Tool room grinding
10-18	Wed	Meeting	Dong Po.	Inchon	Poduction grinding

10-19	Thur.	Consult	Micron Precision	Seoul	Related problems.
10-20	Fri.	Seminar	Micron Precision	Seoul	Grinding theory principles and applications
10-21	Sat.	Other	S M I.P C	Seoul	Report.
10-22	Sun.	Rest		Seoul	
10-23	Mon.	Consult	Jae Young	Guro	Grinding.
10-24	Tue.	Consult	Jae Young	Guro	Seminar.
10-25	Wed.	Consult	Jae Young	Guro	Discuss problems
10-26	Thur.	Consult	Jae Young	Guro	Summarize.
10-27	Fri.	Seminar	Dong Bo	Inchon	Grinding theory principles and applications.
10-28	Sat.	Other	S.M.I.P.C.	Seoul	Report.
10-29	Sun.	Rest		Seoul	
10-30	Mon.	Consult	Dong Bo.	Inchon	Discuss problems
10-31	Tue.	Consult	Wooshin	Banwol	Rotary grinding
11-1	Wed.	Seminar	Wooshin	Banwol	Grinding theory principles and applications.
11-2	Thur.	Consult	Jae Young	Guro	Grinding results
11-3	Fri	Other	SMIPC/UNDP	Seoul	Final report
11-4	Sat	Depart	Travel to U S A		

An account of the Companies visited, the problems presented/discussed and the advisory recommendations

BURAM ENGINEERING CO., LTD.
Chung Ju, Korea.

(Products:- Guide poles and tape guides for Video cassettes.)

We met with Mr. Y.S Kim the President of the Company. Since I have assisted this Company previously for grinding technology Mr. Kim received us warmly and enthusiasticly

Buram Engineering, since my last visit of March 1988 have relocated from Kimpo to the present address and have built new facilities The relocation is quite far in distance and due to this reason, only eight (8) members of the prior workforce, which include management and workers, remain with the Company.

The Company has serious problems, beginning with his top management and his workers in the grinding section. Mainly due to lack of knowledge and experience.

Some of the Company's major products, are guide pins and guide poles for Video cassettes,which they have sold to domestic and foreign customers. This product is very critical in a high quality and super finish on the outer dimension. Therefore it is necessary for the personnel to be highly qualified and knowledgeable.

We met with the following personnel:-
Mr. Kim Quality Control Manager.
Mr. Bang Production Manager.
Mr. Lee Asst. Production Manager.
Mr. Cho Grinding Section Foreman.

We held meetings with the managers of various sections. During these meetings the President Mr. Kim was also present.

During our meeting with the Quality Control Manager Mr. Kim, we learned that he was educated and had knowledge of quality control but lacked experience I advised Mr. Kim what should be done to achieve proper quality control in their products and should also educate his workers in the process My liaison officer, Mr. K.D. Lee is very knowledgeable and has a background in quality control through his preious employment, he was very helpful

In the appendix attached to this report, copy No 16 indicates quality control report for the product. Also a daily quality control report for in-process inspection by Q.C. staff. See copy No 12 in the appendix.
A class was held in measurements with a micrometer. Mr. Kim the Q.C. manager and four other inspectors attended the class. I found these instructions and education very necessary because of the fact that many thousands of parts of different products, had been shipped to different customers and had been rejected and returned to the company. None of the above inspections had been performed, consequently it has been very costly for Puram Engineering.

The next day a meeting was held with the Production Department, Mr. Bang the production manager and his assistant Mr. Lee.

They did not have any Production Standards, therefore in the appendix No 3 is included a Production Standard Form for the guide poles for a centerless grinding operation.

In order to give them any final and/or specific instructions in the grinding of parts, it was important to aquire more information on the raw material, equipment, production standard and the grinding process.

The raw material is shipped to a vendor to be cut-off into finished lengths, then return them to Puram Engineering Co.

The first process within Puram Engineering Co. is as follows:-
1. Tube sizing inner diameter.
2. Countersink both ends. (These two processes are done under automation.)
3. Tumbling of parts to remove any burrs and cleaning.

The second process performed in the grinding section consists of:-
1. Rough grinding.
2. Semi-finish grinding.
3. Super-finish in a lapping machine.

The above processes were my suggestions made during a previous visit. However management and operators, decided to change the process and eliminate one grinding operation. This was proven to be a wrong decision and results were costly to the Company due to inferior components being produced.
Lack of experience and knowledge was the most responsible factor, rather than the process.
The grinding wheel was certainly the wrong specification for the amount of stock to be removed, using a GC180L7V22 grinding wheel for one grinding operation. The specification GC120L7V22 is to be utilized for excessive stock removal.
The grinding wheel was also improperly balanced.
Their process caused them many problems:-
1. Inconsistency of required diameter control.
2. Inconsistency of required surface finish.
3. Result - bad grinding for the following operation, super-finish

Our next step was to show them the proper process of balancing a grinding wheel. (When a new wheel is being replaced.)

1. Remove the counterweights from the flange
2. Remove the flange (only) from the hub.
3. Replace the grinding wheel.
4. Remount the flange onto the hub.
5. Truing of the grinding wheel.
6. Dismount wheel and hub as a unit.
7. Place balancing arbor into hub.
8. Balance the grinding wheel (with 2 counterweights.)
9. Remount wheel and hub onto spindle.
10. Dressing of the grinding wheel for operation.

Once the balancing of the grinding wheel was completed, we uncovered a problem with the grinding wheel spindle. The bearings needed to be adjusted, which were creating a vibration in the machine and resulted in bad grinding.
The manager Mr. Bang and the foreman Mr. Cho did adjust the bearings and the machine was in good working condition.

This indicated another problem within the Company lack of proper maintenance. The workers were not familiar with the proper setting of the machine. See Appendix Item No 8a and Item No 10
With a set up bar, the foreman was able to set the machine

It was impossible for us to see any results on this visit due to the lack of time, but we would be returning on October 4th 1989 for further assistance.

When we returned to the Company, we wanted to see the results of our September visit.
To our suprise, we were told, the shop foreman Mr. Cho was no longer with the Company, due to personal and family reasons and commitments. Mr. Cho was one of the original workers and had the most knowledge in grinding. This was a great loss for the Company.
He was replaced by Mr Jee as the centerless grinding department foreman. Mr. Jee has only been with the Company for thirteen months, therefore limiting his grinding knowledge and experience.

The results of the grinding of guide poles on the machine on which we had assisted them was good, however the parts failed to pass inspection after super-finishing due to an inferior surface finish.

Our next step was to work with the inspection department, for in-process inspection. I chose one of the inspection girls, a Miss Kim, and proceeded to give her instructions and a process. Her duties were as follows:-

1. Inspect the guide poles from each machine,
   a) One micrometer to be utilized by both the inspector and the machine operator, this would eliminate variable readings that they were getting from different micrometers

b)Follow the production standards that I had initiated. See Appendix No12
Separation of parts was important due to the inconsistency of guide pole diameter before super-finishing

2 Daily log is to be completed for sizes and surface finish on various operations. The completion of log sheets would show variations or consistency in sizes and surface finish.

3. An identification card to be placed on the pieces in each basket. The purpose is to sort out the variation of sizes for the following operation.

4. For the guide poles, three different operations:-

a) Rough grinding.
b) Semi-finish grinding.
c) Super-finish lapping machine.

We met with the President Mr. Kim on a daily basis to give an update report of our activities. He was well aware of the problems which we were having

At this point I considered it in the Company's best interest to hold a seminar on Grinding theory, principle and application
See appendix (Items are numerated as follows.)

1. Wheel selection.
2a. Trouble shooting guide-Centerless grinding
2b. Continuation
3. Storage safety.
4. Balancing grinding wheel.
5a. How centerless grinding works.
5b. Continuation.
5c. Grinding fluids and advantages of centerless grinding
6. Blade selection.
7a. Fluid flow.
7b. The basic functions of grinding fluids
8a. Setting the work blades.
8b. Continuation.
9a. Truing and dressing wheels
9b Continuation.
10. Aligning the work guides.
11a. Truing angle setting.
11b. Truing angle and feed rates.

A question and answer period was held after the seminar. It was proven to be very educational and gave a deeper knowledge which would assist them to resolve future problems.

At one point during the seminar I wrote on the blackboard:-

"WHERE THERE IS A WILL - THERE IS A WAY"
"POSITIVE THINKING"

These statements were translated by my liaison officer Mr. Lee. He also exlpained to them they would learn to resolve their problems. In many cases a process of illumination would give them the final answer so long as proper records were maintained.

In the final few days we tried to implement the education and instructions given to them. It is not .lways easy for one to change to new applications and ideas. but I found them willing and eager to try.

We set up a new inspection area for Miss Kim to base herself, adjacent to the grinding machines and the super-finishing machines. This comprised an inspection bench with her inspection equipment, including an air gage.
We later noticed the air gage needed maintenance work itself. We obtained an electronic gage from the Kimpo plant, this arrived on the last day of our visit. It proved to be quite helpful and showed that we had yet another problem. The super-finish lapping machines were not set properly and lack of stock removal was a major cause for final finish operation. Various stones were changed and pressure to the machine, along with an oil mixture change. Last minute inspection was done prior to our leaving the Company and the results were good.

During our last meeting with President Mr. Kim, he told us how pleased he was and as a result of this report he has requested through U.N.D.P. and S.M.I.P.C. for further assistance.

I have found Mr. Kim very eager for his managers and workers to learn and aquire greater knowledge in the grinding field.

Grinding comprises approximately 75% (seventy-five per cent) of his work load, therefore it is imperative for all his employees to be knowledgeable in grinding.

Mr. Kim has made requests for my returning to give assistance for periods of 3 (three) to 6 (six) months. I have told Mr Kim that I would be eager and pleased to assist him and his employees.

Mr Lee. K.D. The liaison officer for S.M.I.P.C. has been a great asset to Buram Engineering, S.M.I.P.C. and myself

SHIN HEUNG PRECISION MACHINERY.
Pusan, Korea.

President:- Mr Lee, Jung Oun
Director :- Mr. Um, Do-Hyun
Manager Technical Department:- Mr. Choi, Sung-Tae.
Section Chief, Production Department 2:- Mr Cho, Jae-Bok

S.M.I.P.C. Liaison Officer:- Mr Lee, Ki-Don.

Shin Heung is a company that I visited in March 1988, at which time I gave them technical assistance with their grinding problems, process and automation.

Mr. Lee and I returned to the company for further assistance, due to the replacement of managers as well as to upgrade the technical knowledge of grinding, it's process and automation. I did however meet with some of the personnel that I had met previously

Mr. Choi the manager of the Technical Department, was the main spokesperson for the Company. He was quite well versed in the English language, which I only found out on the last day at the Company, and he was also a fairly new arrival, and he was not present on my last visit

During the meeting which took place on our arrival, I asked Mr. Choi to give me a list of the problems where we could assist them

His request was as follows:-

1. Equipment Control (maintenance)
2. Surface scratches (Product:- shock absorber for the Festiva vehicle of Ford Motor Co.)
   Operation:- centerless grinding.
   Type of scratches:- a) Spiral marks
   b) Longitude scratches.
3. Coolant discoloration during the centerless grinding of shafts after plating
4. Surface roughness should not exceed Rmax .45 finish. Present finish was Rmax .65.
5. Out of roundness of Piston Rods, part No. AP010-40820, diameter 18mm. (Drawing part of the appendix, listed as item No.17).

After we received the list we toured their grinding department in order to uncover any of the problems which they had given us.

We met with the grinding department supervisor and some of the workers that were present during my previous visit.

In response to the problem areas, that were encountered during the tour of their facility.

1. Their first problem is certainly maintenance negligence on their part. They do not have any maintenance program, such as preventative maintenance check list thru-out the entire factory. the only time a manual is taken out, is when they have a problem.
   We highlited a program that would require them to perform this preventative maintenance program, which would occur periodically during a calendar or fiscal year. A record log should also be kept to ensure it's completion.
2. The second problem is inter-related between equipment problem, which was not properly maintained and various other grinding operations and set-up.
   Problem No. 2 and problem No. 5 on surface scratches and out of roundness. These problems could be attested by the above problem, also by other means such as;
   a) Spiral scratches or chatter marks: these problems were pointed out to the operator and management and were explained on how to rectify these problems: See appendix item No's 2a and 2b of Trouble Shooting Guide.
   b) Longitude scratches was also explained, how to rectify and shown in the appendix item No. 2a under Work Rest Blade, in chatter marks and feed lines

3&4. These problems were part of the same product and the same grinding operation, which was listed under coolant discoloration and surface roughness
   Time at the Company did not permit me to perform the proper experiments, that were needed to get any results However I did suggest that they perform different tests, such as aquire other manufacturers coolants, since proper coolant plays a major role in the surface finishes Other grinding applications could very well enter into the problem

5 Problem No 5. out of roundness, could very well be attested thru problem No 1 and No.2 See appendix No 2b under Out of Round Work "Problem" "Probable cause" and "Things to check."
   In this Company's case, I found a machine problem with the regulating wheel drive, incorrect center height and wrong regulating wheel specification
   During my last visit to this company. I had suggested a different wheel specification. from A180P72 to an A80P72 A difference of 100 grain size, this would give it more control to the regulating of the product. The operation was rough grinding of piston rods, thus requiring more stock removal and controlling more of the speed and feed of the parts
   The same specification wheel was being utilized for all three operations. First rough grinding, second mi-finish and the third operation, super finish, all in centerless grindi:
   I pointed out to them, the necessity of using different specifications

We spoke very little of automation, due to the problems they had incurred. We did however speak on automatic feed rollers on a different product in another department. This would enhance to the already automatic roller feed they presently have.

The duration for technical assistance was rather minimal, therefore we decided it would be advantageous, to give them further education on grinding theory, principle and application.

A seminar was given on the following subject: See appendix items No. 1 thru 11. A question and answer period was also provided at the end of the seminar.

Shin Heung Company and it's officers and members accepted our technical and education assistance in great aspiration.

As of this report, the Shin Heung Company is requesting further assistance in grinding and automation through S.M.I.P.C. and the U.N.D.P. office.

It is always very rewarding and a pleasure in giving technical assistance to people and companies who are so eager in furthering their knowledge and position in the market world.

SHIN AH CO., LTD.
Pusan, Korea.

President:- Mr. Kim, Sang-Kya.
General Affairs Manager:- Mr. Choi, J.B.
Production Manager:- Mr. Choi, Hyun-Ho

S.M.I.P.C. Liaison Officer:- Mr.Lee, Ki-Don.

Upon our arrival at the company, Mr. Lee and I met with the above named officers.
We discussed with them, of my schedule which would be for only two (2) days, September 26th and September 29th.

We began discussing a problem with one of their major products, the mainshaft for sewing machines, part No. B23-0005, this particular drawing belongs to Daewoo Heavy Industries Ltd. (Said drawing was given to me for the purpose of studying the product as well as to be used as an insert in my report.)

Shin Ah Co. is a vendor for other major manufacturers such as, Hankuk, Myong Sung and other companies

The product varies slightly from one company to the others, but basically are all similar.

The greatest problem according to them, was out of roundness during the centerless grinding operation. In inspection the parts should have read 4/1000 mm in tolerance but actually reading within 4/100mm out of roundness
After examining the part, I told them, there could be many reasons which could cause the out of roundness. The part itself has interrupted cuts, flat milled areas and oil holes. Also many causes could arise from the grinding operation.
The following are causes for out of roundness:-

1. Excessive ovalization of the pieces before grinding.
2. Excessive grinding (infeed)
3. Incorrect position of the blade (support)
4. Grinding wheel too hard.
5. Irregular or insufficient supply of coolant.
6. Axis of the work located too high (therefore insufficient pressure and irregular drive.)
7. Axis of the piece too low and too close to the centerline of the wheels
8. Irregular movements due either to the condition of the wheel, or to it's drive mechanism.
9. Defective spindle (especially play.)
10. Feed wheel out of truth.

Due to all of these reasons, I therefore suugested that it would be necessary for me to observe the operation in order to determine the causes through process of elimination.

It was at this time, we were told that the grinding wheel motor had been sent out to an electrical repair shop. They were expecting the motor to be repaired and installed prior to our next visit on Friday September 29th

We had a tour of the facility and then proceeded to the centerless grinder in question, which is the larger of the two centerless grinding machines.
The grinders, from my experience, are quite old and lack of the new and modern technology. No manuals were provided with the machines when they were purchased as used equipment.
As I examined the grinder, even without a motor, I found many problem areas:-
1. The grinding wheel, improperly balanced.
2. The support blade was too wide for the parts being ground, causing the pieces to ride too high on the blade causing the carbide tip to chip.
3. The center height was too low and too close to the centerline of the wheels.
4. Feed angle of the regulating wheel was set at 0.5 degrees but the dressing angle was unknown, due to the absence of degree indicator.

We proceeded to instruct them how to rectify their problems
1. Balancing of the grinding wheel in the following manner
   a) Remove counterweights from the flange.
   b) Remove flange (only) from the hub
   c) Replace the grinding wheel.
   d) Re-mount the flange onto hub
   e) Truing of the grinding wheel.
   f) Dismount wheel and hub as a unit
   g) Place balancing arbor into hub and onto balancing stand.
   h) Balance the grinding wheel (with 2 counterweights)
   i) Re-mount wheel and hub (balanced)
   j) Dress the grinding wheel for operation.

See attached picture 4a and 4b of the appendix.
2. The thickness of the product is 14.72mm diameter and the thickness of the blade was approximately 13mm

RECOMMENDED

Diameter of work.	Thickness of blade
6 mm	3 mm
6 - 7 mm	4 mm
7 - 9 mm	5 mm
9 - 11 mm	7 mm
11- 13 mm	9 mm
13- 16 mm	11mm
16mm and over	17mm

3. Their actual centerheight was too low at 248.5mm, it should be increased to 257.5mm.
4 When I return on Friday, I would assist and instruct them to attain proper alignment.

On Friday September 29, 1989, we returned to the Company
They had received the repaired motor and it was installed
We, however encountered further problems. The drive "Vee" belts from the motor to the spindle were of varying lengths, causing excessive vibration to the spindle head and on to the grinding wheel. Approximately two or three belts out of eight were of the same length. This had to be rectified. Other vibration was being caused to the grinder by the regulating wheel motor, which needed repair (badly worn bearings.) Also the hydraulic system was located inside the grinding machine and it contributed to the vibration within the machine. Among the three areas causing vibration, it is impossible to attain good grinding. Therefore I suggested to them to have the problems resolved and to remove the hydraulic system from within the machine and set it aside on support pads to eliminate local vibration.

They asked that I assist them in getting the proper dressing angle on the regulating wheel. We started by using an indicator. It was a must that we set the wheel at 0 degree angle on the dressing unit. First we had to set the form unit attachment to 0 degrees then set the dressing angle to 0 degrees. Once this was completed then we would be able to attach degree indicators to the machine and get the proper dressing angle - but further problems, since the regulating wheel motor had bearing problems, we could not attain proper dressing R.P.M., to counter the problem we had to dress the wheel at extremely slow feed, and that meant extensive waist of time, but it was the only way to properly dress the wheel unless they could have the motor repaired first. Since this could not be done in an expeditious manner, we decided to go to the Presidents office and discuss their problems at length.

Mr. Choi the Production Manager told me of another problem with the grinder. The machine being old in age and technology, it was impossible to set the dressing feed angle over one (1) degree, due to the manufacturers design. I suggested to Mr. Choi that he could obtain the proper dressing angle by making a cut-out above the regulating wheel housing with an abraisive cut-off saw.

In the meeting we discussed grinding theory, principle and application.

In the appendix are specifics of our discussions as follows:-

1. Wheel selection.
2a. Trouble shooting guide.
2b. Trouble shooting guide.
3. Storage safety.
4a. Balance grinding wheel.
4b. Balancing stand.
5a. How centerless grinding works.
5b. Continued.
5c. Grinding fluids and advantages of centerless grinding.
6. Blade selection.
7a. Fluid flow.
7b. The basic function of grinding fluids.
8. Setting the work blade.
9a. Truing, dressing wheels.
9b. Balancing.
10. Aligning the work guides

11a. Truing feed wheel.
11b. Truing (angle feed rate)
11c. Calculating truing angle.
11d. Continued (11c and 11d if appropriate to the machine.)

The officers and personnel of Shin Ah Co. showed enthusiasm, concern and determination in acheiving a quality product.

They were very pleased with our assistance and expressed their feeling and also asked if I could return to their factory.

We acknowledged by saying that we would be eager to give them further assistance in grinding as well as introduce automation.

With U.N.I.D.O. and S.M.I.P.C.'s assistance I am quite confident that this company could do well with their product.

MICRON PRECISION CO. LTD.
Seoul, Korea.

President:- Mr. Lee, Jung-Woo
Plant Manager:- Mr. Lee, Boo-Kil.
Section Chief:- Mr. Kim

S.M.I.P.C. Liaison Officer:- Mr. Yoo, Jae-Kwon.

Micron Precision Co., Ltd. is a manufacturer of quick change mold, flashless mold and trim/form die set. Furnishing products to local and overseas companies such as Anam, Samsung Electronics, Motorola Korea for domestic and Japanese mold manufacturers, Motorola in the Philippines, Hong Kong and the U.S.A. for exports.

The purpose for my visit was to give them assistance in their grinding department, to better their quality and production.

Once we toured their manufacturing plant, I observed the grinding on different machines

My first observation was on a Woojin surface grinder. The operator was grinding knockout pins. The operation was outer dimension step grinding, held in a 'V' block rotary type holder. Every diameter required extensive set up to attain the centerline of the work. The problem was out of roundness and eccentricity of the ground diameter to the diameter being held in the holder.
First I inspected the machine and found excessive vibration from the spindle head. To resolve the problem, the grinding wheel needed balancing, therefore I demonstrated the proper manner in balancing a wheel, with the following process (when a new wheel is being replaced.)

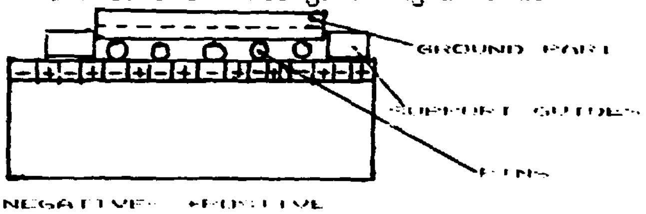
1. Remove the counterweights from the flange.
2. Remove the flange from the hub.
3. Replace the grinding wheel.
4. Remount the flange onto hub
5. Truing of the grinding wheel outer diameter and both sides of the wheel.
6. Dismount wheel and hub as a unit
7. Place balancing arbor into hub
8. Balance the grinding wheel (with 2 counterweights.)
9. Remount wheel and hub onto spindle
10. Dressing of the grinding wheel for operation.

Once this was completed, the operator re-ground the part that showed .016" out of roundness. Results, .0003" - .0004" also still out of round. Then I was shown the loose play in the holding fixture.

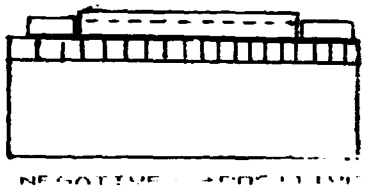
My recommendation to the President was a 5C shank rotary holder. This would replace their holder with excessive play and it would eliminate the long process of setting up for various diameters. Resolve, better quality and more production. See appendix (Jerico) literature on tool holders.

The shop foreman gave us a list of problems in the grinding department:-

1. The horizontal plane of flat ground parts on a magnetic chuck
   Resolve:
   Whether the parts were out of flatness before or after the grinding operation. The following sketches show the method used to rectify the problem on a surface grinding machine.



SKETCH No.1



SKETCH No.2

MAGNETIC CHUCK

Sketch No 1 shows round pins (preferably stainless steel due to the magnetic chucks). The pins are positioned on the negative flow of electricity or magnetism of the chuck, eliminating any current flow contact. Place the out of plane parts onto the pins, affix support guides tightly around the part, leaving no space between the part and the guides or shims. the part will not move while being ground. The current to the magnetic chuck is then applied. After properly grinding the part flat on one side the horizontal plane on the ground part will be true. The purpose of the pins is to stop the magnetism of the chuck to draw the part. Once this has been completed the operator can the grind the opposite side, (shown in sketch No 2) Again properly grind the second side making the horizontal plane on both sides run true.

2. Surface scratches on flat pieces ground on the surface grinder
   Resolve:-
   The surface scratches were resolved and explained thru the seminar.
3. Vibration from the machine during the grinding operation.
   Resolve:-
   Thru the balancing of the grinding wheel and explained in the seminar and a demonstration.
4. Heat occurs while grinding of certain parts (D-2 materials).
   These parts need to be ground in a different manner to which they were using, which was a smaller grinding wheel, in order to cover the grinding surface area.
   Resolve:-
   Use the sine block and vise attachment which they presently have. Place the attachment at a 45 degree angle, fasten the work piece on to it, then dress the 180mm diameter wheel also at a 45 degree angle. This setting will enable them to grind the part with proper surface feet per minute, (SFPM) with a softer grade of wheel, from a "J" designation to an "H". Also coolant should be used during the grinding, to maintain proper surface finish and dimensional accuracy.

Several other problems were given and assistance asked for, in most cases they will be able to resolve them thru the seminar.

The seminar which was held, is highlited as part of the appendix under sections:-
1. Wheel markings and selections
1a & b Trouble shooting guide.
3. Wheel storage.
4. Balancing wheel and stand
7. Grinding fluids.
9b & c Truing and dressing grinding wheels.
A question and answer period was held immediately after the seminar

Grinding material was made available to them, by having the following books copied:-

Norton Company:- Surface grinding
Norton:- Grinding abraisives and grinding wheels
Norton:- Mold, profiled contour wood sanding.
Society of Manufacturing Engineer (SME)
Technical papers.
Maris Company Basic precision surface grinding
Jerico:- Versa tool.
Federal (Gauges) Dimensional Quality Control Primer
Section 13 Coolants role in creep-feed grinding
(appendix)
Section 12 Production trial run to standard.

Areas of Problems that were not covered or resolved during the seminar, were such as:-
1. Travedial indicator for down feed surface grinding
2. Optical view attachment for precision form grinding.
3. Radius form attachment. (section 14)

The President Mr. Lee would like to receive more information on the optical view attachment. When I return to the U.S.A., I will aquire literature and price on different models.

During my stay at the Company I have found the workers willing and eager to learn. They showed good attitude, which is why to my estimation, they rank in the highest percentage in knowledge and capability throughout the small and medium industries in Korea. These qualities may be attributed to them through the guidance of their department foreman.

This Company will certainly make a difference in the quality product produced in Korea.

JAE YOUNG PRECISION MOLDS MFG. CO. INC
Seoul, Korea

President:-Mr. Kim, Hak-Kwon.
Managing Director:- Mr. Park, Soon-Hwang.
Sales Manager:- Mr. Kim, Byung-Sik
Section Foreman:- Mr. Myung, Sung-Chun.

The Company is in the business of mold design and manufacture. In the process of building a new plant and should be transfering to the new facility by March 1990.

They gave me a tour of their present facility and I was quite impressed with the equipment, thru-out various departments, although the grinding section which I gave technical assistance to, does need to have some of their machines upgraded.

The problem in this Company is somewhat similar to some of the other companies which I gave technical assistance to, grinding theory, principle and application. In many cases the basic fundamentals of grinding. In this instance, as I toured the grinding department, the first problem that I noticed was the vibration from the spindle head, created by an improperly balanced wheel. Therefore my first duty was to show them how to properly balance a grinding wheel in the following manner. (When a new wheel is being replaced.)

1. Remove the counterweights from the flange
2. Remove the flange from the hub
3. Replace the grinding wheel.
4. Remount flange onto hub.
5. Truing of the grinding wheel (see section 9c of the appendix.)
6. Dismount the wheel and hub as a unit
7. Place balancing arbor into hub and onto stand
8. Balance the wheel (see section 4 of the appendix.)
9. Remount wheel and hub onto the spindle
10. Dressing of the wheel for operation.

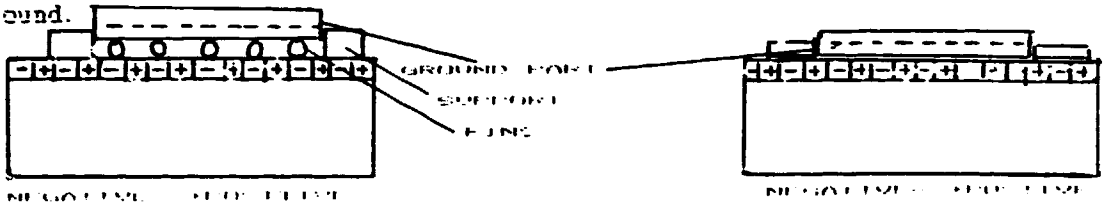
A balanced wheel is very essential in grinding and it's equipment. Without balancing their grinding wheel it has created two major problems for this Company. First, the results of bad grinding surfaces, due to the vibration and secondly, destroying the accuracy of the machine, due to worn spindle, created also by the vibration of the wheel.

On Monday when we returned to the Company, we held a grinding seminar and a question and answer period which lasted till the end of the day.
The seminar included the following topics which are in sections part of the appendix.

Section 1. Wheel marking and selection.
2. Identifying and correcting surface grinding problems
4. Balancing of the grinding wheel.
3 Wheel storage.
7b Grinding fluids.
9c. Truing the wheels
15 Single point diamond dressing

We were able to resolve many of the problems, through the participation of all the grinding section workers, as well as some of their vendors and also including two mechanical engineers from one of their major customers

Some of the problems were the grinding of thin flat pieces that were slightly bent. Because of the magnetic chucks, the problem would return once the parts were ground.



MAGNETIC CHUCK

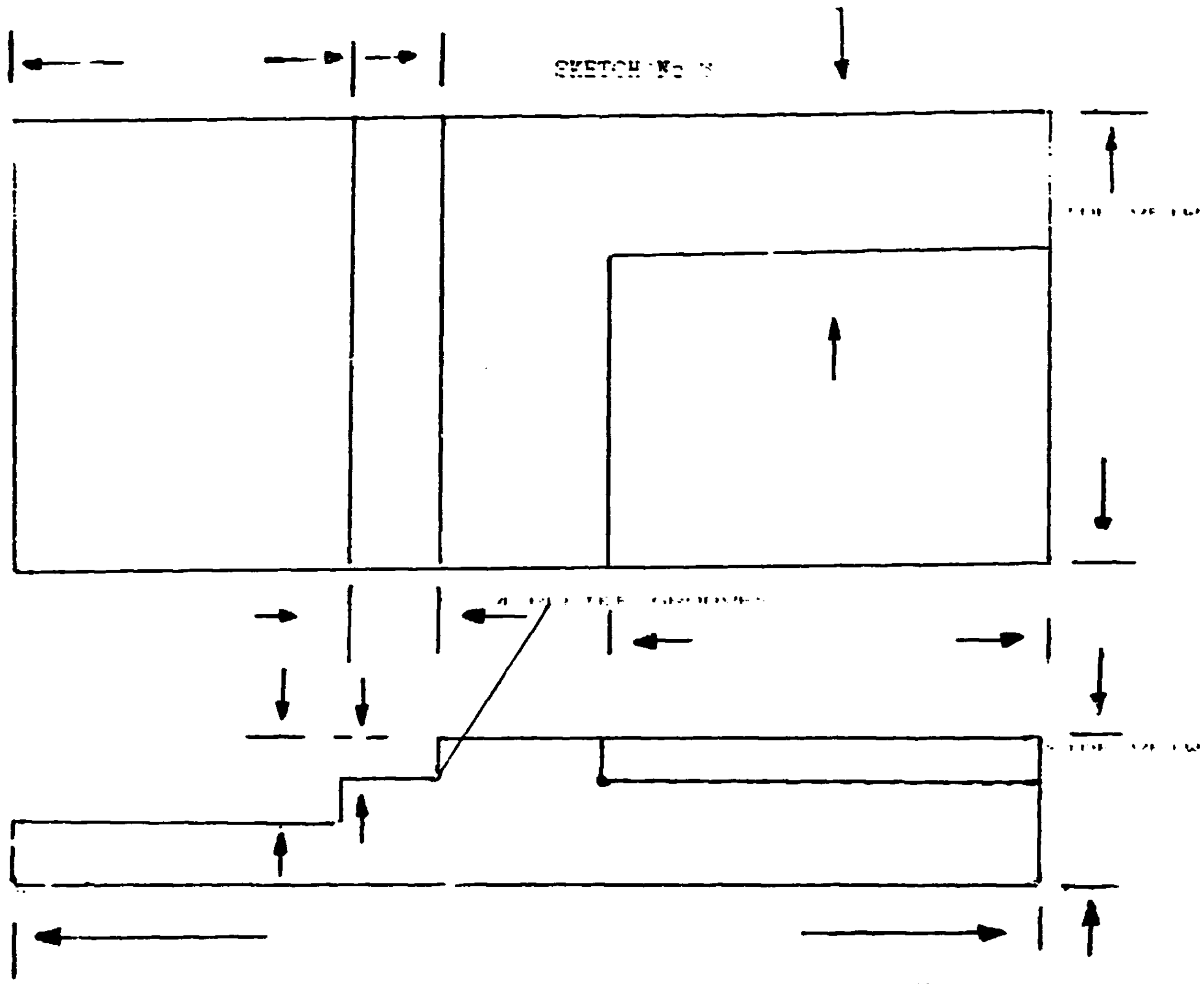
SKETCH No. 1. SKETCH No. 2.

The sketches show the method used to rectify the problem on a surface grinding machine.
Sketch No. 1 shows the round pins (preferably stainless steel) positioned on the negative portion of the magnetic chuck, (eliminating any current flow.) Place the part on the pins, then affix support guides tightly around the part. The part will not move while being ground. Once the part has been ground flat, then the second operation can proceed on sketch No. 2 without the operation with the pins. Thus the horizontal plane of both sides will run true.

Heat from grinding wheel can cause the parts to bow, due to improper selection of the wheel such as too hard a grade. In this case they were using a "K" grade and I suggested they try an "H" or "I" grade.

The Company purchasing Agent was asked to aquire different wheels of various grades and structure, such as WA60H7V, WA60I7V, to name a few. These wheels are to experiment in trial runs, (see section 12 of the appendix) in order to get the proper wheel for the required surface finish and dimensional accuracy. However the Purchasing Agent was told that the manufacturers did not produce any other grades other than a "K" wheel. The Section Foreman took it upon himself and called another manufacturer. He gave them the specification he wanted and was advised that they were available. The President of Dae Sung Co., Mr. Kim Duck-Soo, a grinding wheel manufacturer, personally hand carried the wheels to Sae young Co. also a representative of the EHWA diamond wheel manufacturer brought a sample CBN wheel. We gave him a particular wheel specification. SLEN100V3 which represent the grinding of D2 material, 80/100 grain size with a medium grade at 100 concentration with 3mm depth of cutting grain in a vitrified bond.
The wheels should have been received before my next visit on November 2nd

SKETCH No



INSPECTION FIXTURE WITH HEIGHT GAGE FOR SQUARENESS

PRODUCTION TRIAL RUN TO STANDARD

Wheel Manufacturer	Wheel Specification	Stock Removal	Grind Wet	Grind Dry	Results

"Surface"

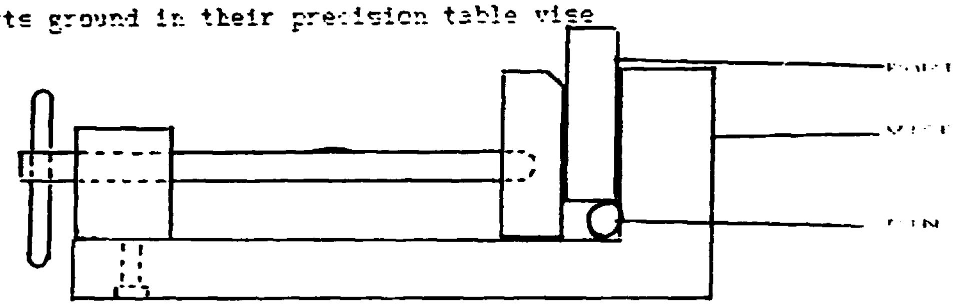
Rough grinding or excessive stock removal wheel specification WA46H7V. However should this wheel have too large a grain size or should the grade be too soft, it is recommended that they should change, but only one specification at any one time.

For finish grinding the specification should be WA80H7V Same applies to above recommendation. CBN wheels can also be recommended for some applications

Sketch No. 3 of the appendix illustrates an inspection fixture with a height gage to inspect the squareness of parts of different dimensions. The reason for omitting any dimensions on the sketch, was because I suggested that they use an average of the sizes which they are grinding.

Sketch No.7 of the appendix includes a recommendation of a "Production Trial Run to Standard" form to be utilized once they receive all the wheels. This will enable them to determine the proper wheel specification for the various types of material for their product.

Sketch NO. 5 is to indicate the possibility of grinding flat and to a squareness, parts ground in their precision table vise.



SKETCH No. 5.

The purpose of the pin is to eliminate any flaw in the vise, which could cause out-of squareness.

The Company has requested information on various types of truing devises for contour dressing for all of the applications and some could involve optical view equipment.

I find the knowledge of the people in the grinding section quite up todate, and would certainly classify them at the top of any company of their size. I also find a positive attitude, especially with management.

DONG BO CO., LTD
Dond-Ka, Inchon, Korea.

President:- Mr. Kim, Jae-Kyung,
SR. Director:- Mr. Yum, Young-Chul.
Managing Director of Engineering:- Mr. Kim, Joo-Yub
Production Manager:- Mr. Shon, Jeong-Sam.

S.M.I.P.C. Liaison Officer:- Mr. Yoo, Jae-Kwon.

The Dong Bo Co., Ltd. was previously known as Dong Sin Industrial Co., Ltd a manufacturer of automotive parts for the Korean auto makers.

My first visit to this Company was in 1982, at a different location and operating on a smaller scale.

Once the tour of the factory was completed we returned to the grinding section, mainly centerless grinding and cylindrical grinding. They requested assistance in centerless grinding due to irregular surface finish, such as nicks, scratches and chatter marks. My first reaction is to inspect the equipment relative to the problem. In this case the chatter marks could be from vibration of the machine caused by an unbalanced grinding wheel and the nicks and scratches could be caused by the filth surrounding the grinding operation.

At another centerless grinding machine, the operator was grinding sleeves (one of the many sizes shown in the drawing attached to this report.) Slight wheel marks were showing on the last end of piece leaving between the wheels.

Since the operator was not using a set up bar to set the machine properly, I suggested that I would instruct him with the proper procedure. (Illustrated on section 10 of the appendix.) It was difficult and lengthy, because they are doing thru grinding in an infeed machine. Attached to this report, shows sketch No.1 as an infeed grinder and sketch No 2 as a thru-feed grinder. Illustration shows the reason, why, it is difficult to set the machine, because of the relationship between the support attachment and the regulating wheel. To have a constant straightness, the support fixture and the regulating wheel must be on the same axis.

They were still having a slight problem, therefore I suggested that the operator balance the grinding wheel.

Time did not permit us to give them any further assistance on the 18th October but would be returning of the 27th.

Upon our returning to the Company our schedule was to instruct them to properly balance different grinding wheels, but the process is similar in all machines in the following manner; (when a new wheel is being replaced.)

1. Remove the counterweights from the flange
2. Remove the flange (only) from the hub
3. Replace the grinding wheel.
4. Remount flange onto the hub
5. Truing of the grinding wheel.
6. Dismount wheel and hub as a unit.
7. Place balancing arbor into hub
8. Balance the wheel (with 2 counterweights.)
9. Remount wheel and hub onto spindle
10. Dressing of the wheel for operation.

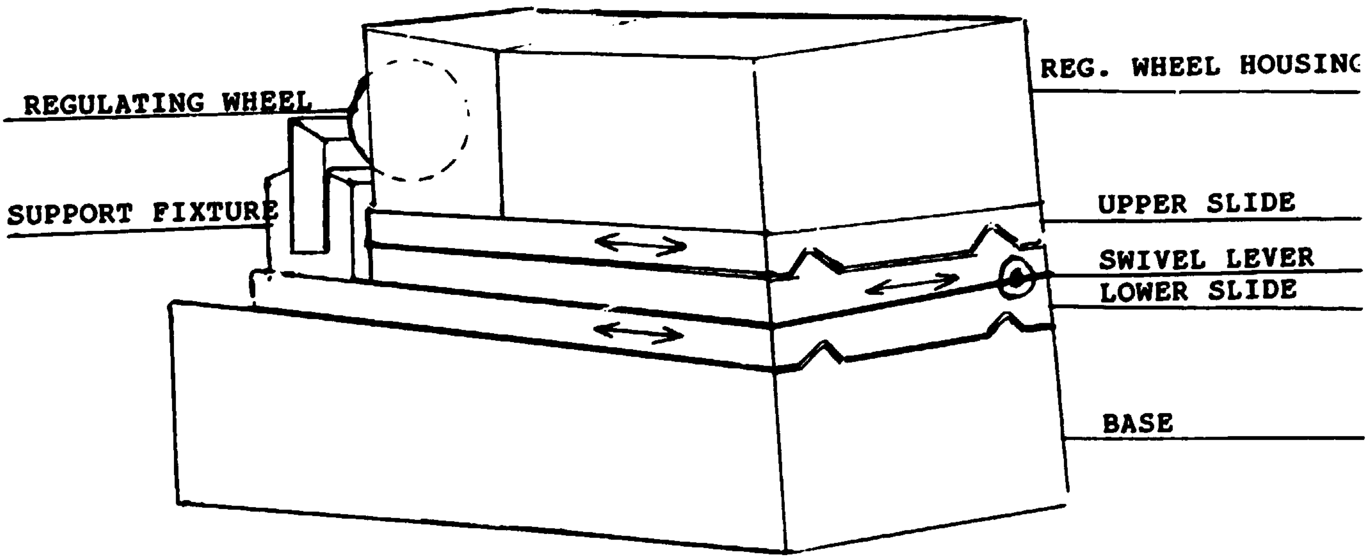
Both centerless and cylindrical wheels were balanced.

Our next schedule for the day, was a seminar which included the following sections part of the appendix;

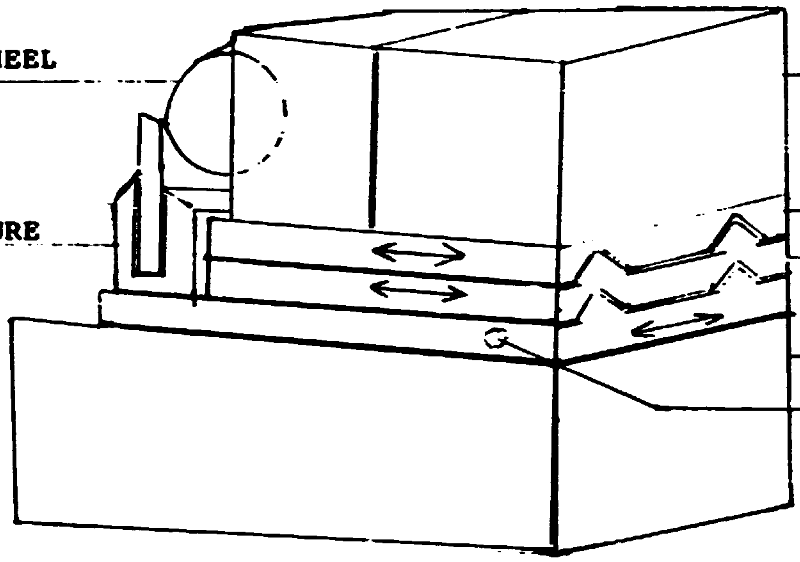
Section 1. Wheel marking and selections.
- 2a&b Trouble shooting guide
- 3. Storage of wheels and safety
- 4. Balancing wheels and stand
- 5a,b&c How centerless grinding works, grinding fluids and advantage of centerless grinding.
- 6 Blade selection
- 7a&b Fluid flow and basic function of grinding fluids
- 8a&b Setting the work blade
- 9a,b&c Truing and dressing wheels
- 10. Aligning the work guides
- 11a&b Truing the feed wheel.

A question and answer period was held after the seminar. In depth discussion about the feasability of setting thru-feed work on an in-feed grinder and illustrating the difference of one machine as opposed to the other, shown with sketch No. 1 and sketch No. 2 of this report. Also discussed was the set-over dressing unit on the regulating wheel. One machine has the unit and the remaining machines do not. Therefore, I had to teach them the difference for the proper set-up and good quality grinding procedure.

SKETCH #1 **INFEED CENTERLESS GRINDER**



SKETCH #2 THRU-FEED GRINDER



The Dong Bo Company will be moving into a new facility in March of 1990. Once they move, they would like to automate their machines to increase productivity and reduce manpower.

We discussed the layout which they had made of the new factory and asked if I had any suggestions. I did suggest the placement of a few departments for better material flow, also a separation in the concrete floor to eliminate vibration from one department to another.

Since each piece of machinery on the layout plan were magnetic, I was able to position various grinders in the Grinding Department. This would prepare its location and would enable me to better assist them in automating the machines and reduce manpower.

Prior to leaving, we toured the Screw Machine Department. I was able to make a few suggestions; one that would eliminate a secondary operation by using a recess tool. I told them that I would bring one back from the USA on my next visit. It seems that they do not have such a tool in Korea.

The company was very pleased with my assistance and have requested thru SMIPC that I return.

WOOSHIK INDUSTRIAL MACHINERY
Banwol, Korea.

President:- Mr. Lee, Jun-Yung.
Director:- Mr. Um, Chul

S.M.I.P.C. Liaison Officer:- Mr. Yoo, Jae, Kwon
Mr. Chang, D. I.

The Wooshin Company manufacture mold bases, located in the Banwol area.
The purpose of my visit at this Company is to eleviate problems in surface grinding. Their equipment consists of one Iki Kawa rotary surface grinder, two Whachon reciprical surface grinders, one cylindrical and one internal grinder.

Upon completing our factory tour, the Director Mr. Um asked that I help them resolve the problem with their rotary surface grinding.
Their problem was inaccuracy with the dimensions as well as parallelism in various sizes.

In order to identify the problem, it was necessary to proceed by inspecting, first the equipment. In this case it was the inaccuracy of the magnetic chuck which was caused by the out-of-squareness of the grinding head to the surface of the magnetic chuck. The chuck had been ground and given it a convex shape to the surface, therefore when grinding the parts, the same shape would be transfered.

To re-true for proper squareness, it was necessary to indicate the head to the chuck. This was done by adjusting the screws of the head, than grind the surface of the magnetic chuck.

When we left that evening, the operator was still grinding the magnetic chuck.

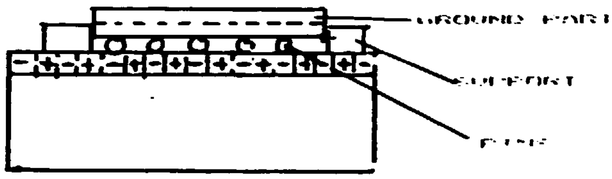
On our arrival the following morning we immediately went to that machine to get the results, but due to production requirements, it was more important to them to proceed with the grinding of parts. They told us that through my assistance, they knew what the problem was and would be able to rectify the situation.

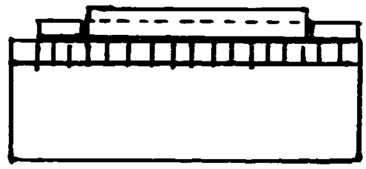
The Director Mr. Um asked if we could give them a seminar.
Mr. Chang assisted me with the seminar on grinding theory, principle and application.
In the appendix various sections elaborate on the subjects covered during the seminar as follows:-

Section	1.	Wheel markings and selections.
"	3	Storage safety
"	4a&b	Balancing stand and balancing method.
"	7b	Grinding fluids
"	9c	Truing the wheel.
"	2a	Identify and correcting surface grinding problems
"	15	Single point diamond dressing

A question and answer period was held after the seminar.

The questions ranged from grinding methods to grinding problems and fixtures Grinding of thin flat pieces that were slightly bent due to the magnetic chucks, the problem would return once the parts were ground.



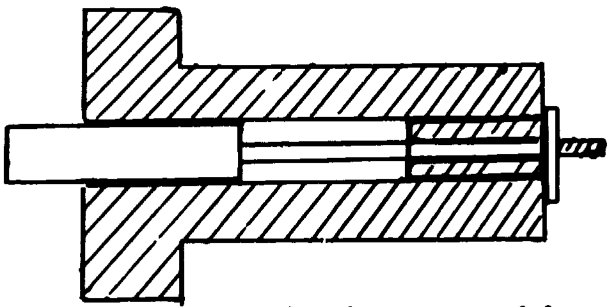


MAGNETIC CHUCK

SKETCH No 1 SKETCH No.2

The sketches show the method used to rectify the problem on a surface grinding machine.
Sketch No.1, shows the round pins (preferably stainless steel) positioned on the negative portion of the chuck, (eliminating any current flow) Place the part on the pins, then affix support guides tightly around the parts The part will not move while being ground. Once the part has been ground flat, then the second operation can proceed by reversing the part, (illustrated on sketch No.2) without the seperation with the pins Thus the horizontal plane of both sides will run true
Heat from grinding wheel can cause the parts to bow, due to improper selection of the wheel, such as, too hard of grade or improper coolant flow

A grinding fixture for cylindrical grinding of sleeve



This fixture from past experience has been sucessful.

The Wooshin Company show willingness to improve themselves and the end result will show in their product. I find that this Company has a good future in the Korean and International markets.

IV. GENERAL WHEEL SELECTION DATA

There are five basic variables in a grinding wheel: (1) abrasive type, (2) grain size, (3) grade, (4) structure (grain spacing), and (5) bond type. The general rules listed below can be used as a guide in selecting starting specifications.

Variable	Factors Influencing Selection	General Rules
1. Abrasive Type	Type of Workpiece Material	Aluminum Oxide type for steel and steel alloys. Tough abrasives for softer materials. More friable abrasive for hard and heat sensitive materials.
		Silicon carbide type for hard and brittle materials like cemented carbides, ceramic and glass. Also, cast iron and non-ferrous soft materials like aluminum, brass, plastics, rubber.
2. Grain Size	Type of Workpiece Material	Coarser grain size for soft materials. Finer grain size for hard, brittle material.
	Stock Removal	Coarsest grain size consistent with finished desired. On very hard material - coarser grains will not penetrate and fine grain size is required. Majority of production applications are in 46-120 grain size range.
	Finished Requirement	Fine grain size with light grinding pressures produce best finish.
	Form Holding	Fine grain size holds best corner radii in infeed grinding.
3. Grade (Hardness)	Type of Workpiece Material	Hard materials and heat sensitive materials require softer grades. Softer materials permit harder grades to be used.
	Area of Contact	As the diameter of the part becomes smaller, so too is the area of contact reduced. Harder grades can be used. Larger diameter parts require softer grades.
	Ratio: Wheel Speed Work Speed	The lower the ratio-the harder the "grinding grade".
	Form Holding	Harder grades will hold the best corner radii in infeed grinding.
	Finish	Too soft a grade produces poor finish.
	Grade Range	Majority of production applications call for vitirified bonds J thru N; resinoid bonds O thru T.
4. Structure (Grain Spacing) Dense-Open 5 - 12	Type of Workpiece Material	Soft and stringy materials require more chip clearance. Use higher (more open) structure. Generally speaking, for best efficiency, use lowest (most dense) structure consistent with good grinding action.
	Area of Contact	Use higher structures for large areas of contact.
	Structure Range	5-8 most common in production work.
5. Bond	Type of Operation	Vitrified bonded wheels are best for precision thru-feed and infeed applications.
		Resinoid bonds apply for heavy stock removal in thru-feed applications. Rubber and resinoid bonds are used for low micro-inch finishes in thru-feed grinding.

TROUBLE SHOOTING GUIDE – CENTERLESS GRINDING APPLICATIONS

Problem	Probable Cause	Things To Check
Chatter Marks	Machine Vibration	1. Is everything tightened down on setup? 2. Check tilt angle, swivel angle and "set-over" of diamond on regulating wheel. Also review height of work above center. Do these have the proper relationship to insure appropriate contact of work, work rest blade and regulating wheel? Check machine manufacturer's handbook of recommendations for correct set-up. 3. Check work rest blade. Is it rigid? Is it straight and level. Is it set too high above center? Is the blade angle too steep? Is the blade too thin for the job? Is it warped? Does it need regrinding? 4. Can you feel vibration in wheel drive? Are drive belts loose? Are they a matched set? 5. Is there slippage or excessive back-lash in the regulating wheel drive? 6. Are truing diamonds dull or loose in holders?
	Grinding Wheel	1. Is wheel grade too hard? Fine chatter and bright finish. 2. Is wheel face conditioning too fine or too slow? 3. Is wheel grade too soft? Due to wheel breakdown, the chatter will be rough and surface finish will be poor. 4. Is the wheel feed too heavy? Recondition wheel-face and take a lighter cut. 5. Is wheel out-of-balance?
	Work	1. Is the work uniform coming to machine? Is it straight? Is it excessively out-of-round?
Burn	Grinding Wheel	1. Too hard a grade or too fine a grit size. Wheel face is glazed over and dull. 2. Wheel face is conditioned too fine or too slow.
	Grinding Fluid	1. Insufficient volume or wrong type of fluid. 2. Fluid is dirty or not up to proper concentration. 3. Fluid nozzle not adjusted properly to work.
	Operation	1. Too heavy a cut.
Feed Lines	Grinding Wheel	1. Wheel not relieved on exit side. Sharp corner digs in. 2. Wheel too fine in grain size or too h[illegible] a grade? 3. Wheel face is conditioned too fine or too slow?
	Work Rest Blade	1. Metal build-up on blade? 2. Sharp corners on blade? 3. Warped blade? 4. Wrong work blade material or design?
	Work Guides	1. Not in proper alignment with regulating wheel. 2. On bar fixtures - excessive pressure or misalignment of rollers.
	Machine	1. Alignment of grinding wheel spindle with regulating wheel spindle.
	Regulating Wheel	1. Speed too slow.
	Burn	1. May be burn marks. See Section on burn.

Annex 2B

TROUBLE SHOOTING GUIDE – CENTERLESS GRINDING APPLICATIONS (Continued)

Problem	Probable Cause	Things To Check
Out of Round Work	Machine	1. Slippage or excessive backlash in regulating wheel drive. 2. Work rest blade angle not strong enough or excessively worn or warped. 3. Is work set above center and have all the set-up adjustments been properly made?
	Grinding Wheel	1. Too hard a grade - excessive grinding pressures. 2. Wheel face is conditioned too fine or too slow. 3. Too soft a grade - excessive wheel breakdown.
	Work	1. Excessively-out-of-round and insufficient stock to grind. 2. Non-uniform work.
	Regulating Wheel	1. Speed too slow.
Flat Spots	INTERRUPTION IN WORK ROTATION	
	Machine	1. Slippage in regulating wheel drive.
	Work Rest Blade	1. Too sharp an angle or improper material in blade. 2. Misalignment or set too high.
	Work	1. Too heavy for machine. 2. Distorted or crooked parts. 3. Parts not uniform in diameter.
	Regulating Wheel	1. Speed too slow. 2. Improper truing - Check tilt angle, swivel angle and "set-over" of diamond. 3. Glaze on surface. 4. Improper specification - too hard.
Random Scratches in Work	CONTAMINATION	
	Grinding Fluid	1. Dirt and other foreign material being recirculated.
	Grinding Wheel.	1. Loose grain caught between wheel and work. 2. Loading of wheel with metal.
	Regulating Wheel	1. Foreign material imbedded in rubber bond.
Taper,	MISALIGNMENT	
	Machine	1. Misalignment of grinding wheel spindle with regulating wheel spindle.
	Work Guides	1. Misalignment.
	Work Rest Blade	1. Misalignment; worn or not level
	Grinding Wheel	1. Trued with a taper. Check alignment of grinding wheel truing slide.
	Regulating Wheel	1. Improper truing. Check tilt angle, swivel angle, and "set-over" of diamond.

STORAGE SAFETY

Grinding wheels are valuable cutting tools and should be given the same care as expensive milling cutters. They can best be stored in racks in a central storage area or tool crib and their supervision should be assigned to an individual who has been carefully instructed in the care and handling of wheels.

Actual storage should be undertaken following these rules:

a. Most straight wheels six inches in diameter and larger and tapered wheels are best supported on edge in racks. Storage racks should be made to provide two-point cradle support for the wheel to prevent rolling. Install partitions to prevent the wheels from tipping over.

b. Wheels less than six inches in diameter, flaring cups and dish wheels are best stored flat with a cushioning material (such as corrugated paperboard) between them.

c. Thin organic bonded wheels such as cut-off wheels should be laid flat on a horizontal surface. A heavy steel plate makes a good foundation for stacking. Locate the wheels away from excessive heat to prevent warpage.

d. Very large wheels can be stored in their original containers.

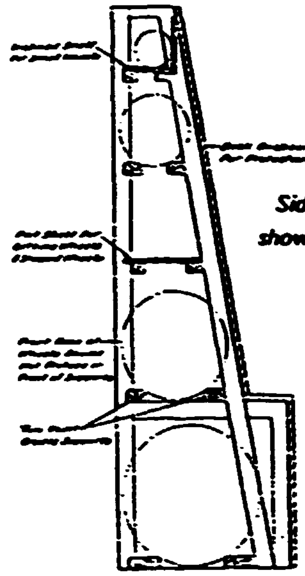
e. Small wheels are best stored in bins or drawers as their sizes make normal rack storage difficult.

f. Large flaring cup wheels can be placed flat on a sturdy horizontal shelf — alternating their position so they will be stacked base against base and face against face.

g. Cylinder wheels and large, straight cup wheels may be stacked on the flat side with a cushioning material between them. They may also be stored in racks similar to those used for large straight wheels.

h. Wheels with tapered sides are best stored on edge. If stored flat, they should not be stacked more than a few high.

Typical wheel storage arrangement.



Side view of storage rack showing shelf and support arrangements.

MACHINE SAFETY

STORAGE — on jobs where wheels are frequently changed for use with different types of work pieces, it is advisable to install a rack at the machine to facilitate storage problems. When a wheel is removed from a machine, immediate attention should be given to returning it to the storage rack or to the tool crib.

Avoid stacking wheels on the floor in the shop where they can come in contact with oil or be struck by passing vehicles.

MOUNTING WHEEL - prior to mounting, every wheel should be visually inspected. An operator should look for a loose or shifted bushing, particularly in a wheel that has been rebushed or remounted. Also, see that the bushing does not extend beyond the sides of the wheel.

Most wheels such as straight wheels are mounted between flanges which are relieved in the center to assure that the bearing surface will be on the outer unrelieved area of the flange.

Notable exceptions include nut inserted portable cup wheels which should be mounted on a flat unrelieved back flange (to avoid pulling nut out of wheel).

Raised hub disc wheels are mounted in a special adaptor.

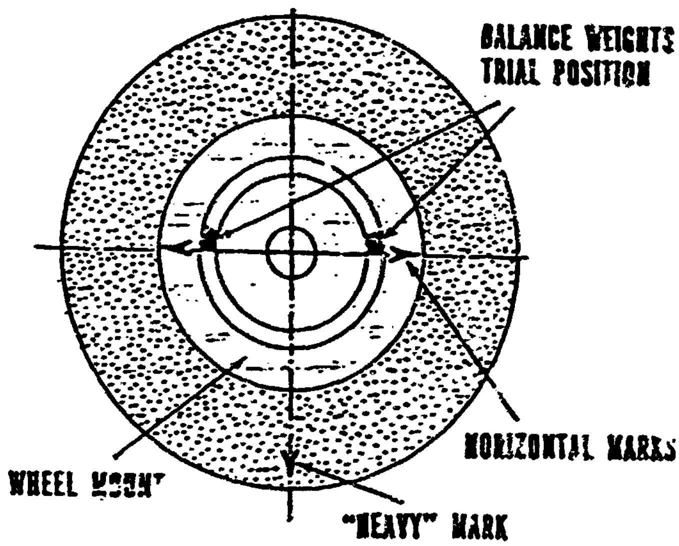
When mounting between flanges, the inner and outer flanges should be exactly the same diameter and should run perfectly true. They should not be less than one-third the diameter of the wheel.

For more detailed information on flanges, refer to the American Standard Safety Code B7.1, Section 5.

BLOTTERS

Blotters or flange facing of compressible material should cover the entire contact area of wheel flanges.

Draw a line horizontally through the axis on the mount or the wheel. Insert the two weights placing them at an equal distance from and above the horizontal line. Repeat the test for balance again, rechecking the wheel's heavy point. If it should again be at the original mark, move the two weights closer together toward the top. Should it be opposite the original mark, move the weights further apart toward the horizontal axis line.



At some point between the top and horizontal line, the proper balance should be located. If this is not the case, it is an indication that the wheel is too far out-of-balance for normal corrective measures and third or fourth balance weights should be applied.

Automatic Balancing — Some machines are equipped with automatic balancing which permits dynamic-balancing on the spindle without the need for removing the wheels from the machine. Also, there are other types of dynamic balancing equipment which record imbalance while the wheel is mounted on the machine spindle. Balance weights on the wheel mount can then be adjusted to bring the wheel into proper balance.

How centerless grinding works

The grinding wheel (A) normally rotates at 6500 surface feet per minute (s.f.p.m.), however, some wheels can be used at speeds from 6,000 to 12,000 (s.f.p.m.). **The feed wheel (B)** turns in the same direction, but at a greatly reduced rate—36 to 900 s.f.p.m. The **workpiece (C)** rides free between the two wheels, and therefore rotates in the opposite direction. Cutting pressure developed by the grinding wheel forces the workpiece downward, but it is held in place by the **work support blade (D)**, and against the feed wheel.

Feed wheels are most often rubber-bond abrasive wheels, made for frictional characteristics. These wheels determine the constant rate at which the workpiece revolves, with the peripheral speed of the workpiece being equal to the peripheral speed of the feed wheel (Fig. 1).

Achieving accurate workpiece roundness. In centerless grinding, the position of the workpiece is governed by the position of the work blade. If the blade is flat-topped, and set so that the centerline of the workpiece is in the same plane as the centers of the grinding and feed wheels, a constant diameter cross-section will be ground, but it will not necessarily be cylindrical. Here's why. Any high spot on the surface of the workpiece, as it comes into contact with the feed wheel, will cause the workpiece to be pushed toward the grinding wheel, thus grinding a low spot on the opposite side. Figure 2 shows this happening.

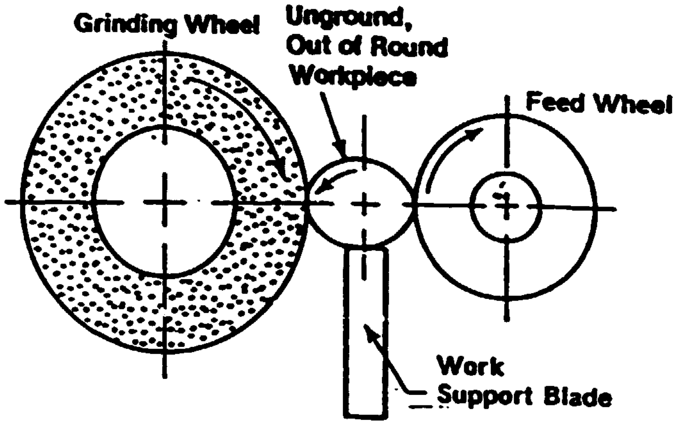
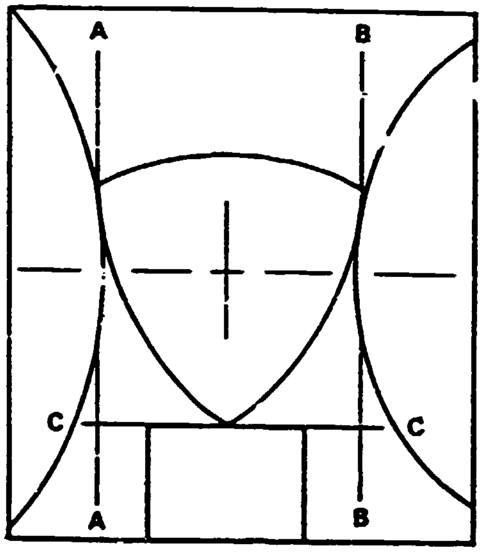


Figure 2. Problems caused by centerless grinding with flat-top blade and wheels on common center.



Trilobular workpiece cross-section.

With a common centerline on work and both wheels, this error is accentuated with every revolution of the workpiece, until, in extreme cases, a trilobular workpiece cross-section results. It has a constant diameter, but it's not round.

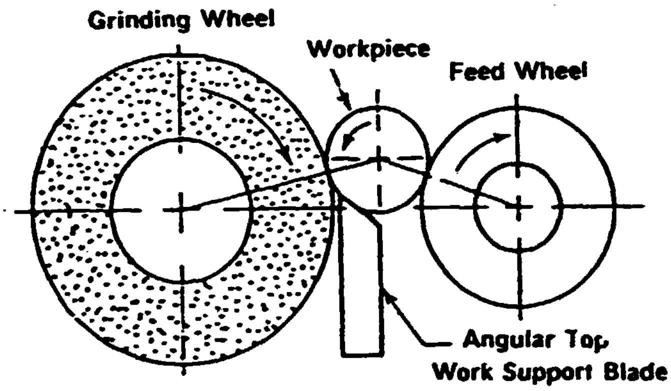
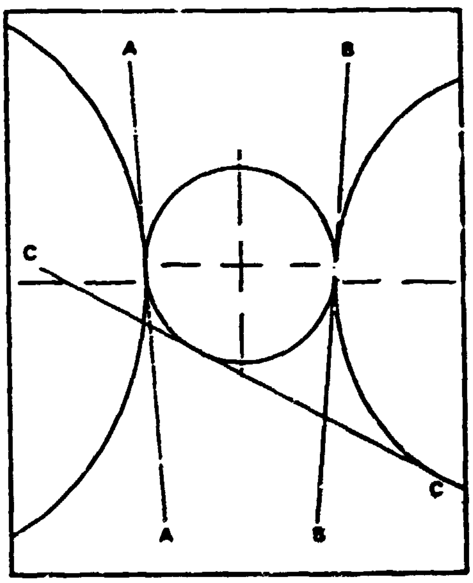


Figure 3. Proper set-up of centerless grinding with angular-topped blade, work above center of wheels.



This problem is corrected by making two changes. First, the work blade is raised, to make the centerline of the workpiece higher than the common centerlines of the grinding wheel and feed wheel. Now, when a high spot on the workpiece contacts the feed wheel, the corresponding low spot ground will not be directly opposite. The top illustration in Figure 3 shows this. Instead of making the error greater with each revolution, it will be progressively diminished, and roundness will be quickly achieved. The other change involves making the top of the work blade angular, instead of flat-topped. Look at the second illustration in Figure 2. The wheel surfaces plus the flat-topped blade make 3 sides of a square (A—A, B—B, C—C), which accounts for the resulting triangular cross-section.

Raising the work blade, and making the top of the blade angular, changes the shape of the space occupied by the workpiece, effectively damping out the effects of high-spot errors. These changes are diagrammed in the second illustration in Figure 3.

Generally speaking, the higher the work is raised above the wheel centerline, the quicker a cylindrical shape will be obtained. Roundness will also be achieved faster when the workpiece rotates at a relatively fast speed. However, if raised too high, chatter on the workpiece can occur.

Grinding fluids

In centerless grinding, fluids play an important role in producing acceptable parts. In addition to the normal functions of keeping the temperature of the workpiece steady and washing away chips, fluids perform some special functions. These include keeping the work blade and guide clean and well lubricated as well as keeping the workpiece free of rust and stains.

Advantages of centerless grinding

The development of centerless grinding machines has made it possible to efficiently and economically grind all types of workpieces to a high degree of accuracy, at high volume production rates. Some of the major advantages of centerless grinding are:

- It is an almost continuous process, since very little time is required to put workpieces into grinding position in the machine, once it has been set up. No chucking is required.
- Workpieces are rigidly supported under the entire length of the grinding cut. This means that heavier cuts can be made without concern for distortion from wheel pressure.
- There is no end pressure from centers created on the workpiece during grinding. This makes it possible to grind long, brittle or easily distorted parts on centerless grinders.
- Because the workpiece floats through the grinding operation and is self-centered, less stock is usually removed to achieve the desired finished diameter. This represents savings in time, material, grinding wheel wear and power.
- Material removal takes place on the diameter of the workpiece instead of the radius. Thus, the effects of errors in set-up or wheel wear are cut in half. Centerless grinding makes possible very accurate control of size and surface finish in the workpiece.
- Once the machine has been properly set up, operation is not a highly skilled job and machine maintenance requirements are minimal.

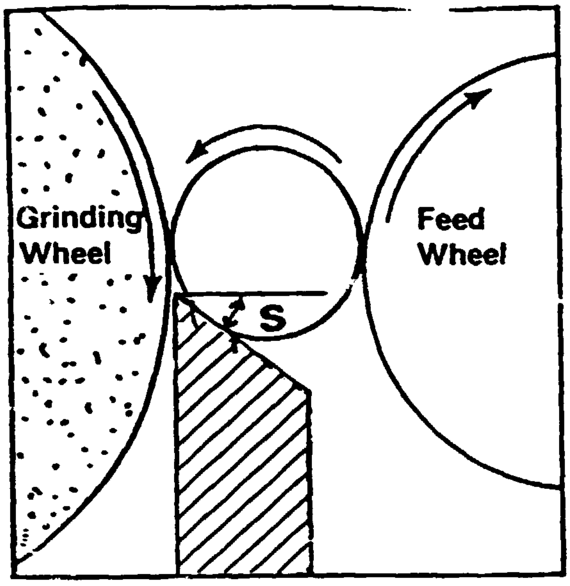


Figure 10. Work support blade.

Top angle(s in Fig. 10) of the blade is also important, to maintain the optimum pressure during grinding. The pressure of the work on the blade results from the weight of the workpiece and the working pressure of the grinding wheel. This pressure pushes the work against the feed wheel, and increases as the top angle of the blade gets steeper.

blade with a 30° top angle will be satisfactory. However, if the application calls for broad-faced grinding wheels, correspondingly long work blades will be needed. Because long, narrow blades tend to deflect easily, they cannot hold the work steady, and may cause chatter marks on the workpiece.

It has been found that reducing the top angle on long blades produces the effect of added strength, and effectively eliminates chatter. In cases such as this, the top angle is usually 20° or 25°

The top angle of the work blade should also be reduced when grinding large-diameter workpieces, to offset the heavier pressure of the larger part. The ideal top angle will assure cylindrical workpieces, without chatter-causing deflections.

Diameter of the work (mm/in.)	Thickness of the blade (mm/in.)
6 / ¼"	3 / ⅛"
6-7 / 5/16"	4 / 3/16"
7-9 / ⅜"	5 / ¼"
9-11 / 7/16"	7 / 5/16"
11-13 / ½"	9 / ⅜"
13-16 / ⅝"	11 / 7/16"
16 and over / ⅝" and up	14 / 9/16"

To obtain minimal out-of-round conditions it is essential that the feed wheel be applied uniformly all along the generating line of the grinding wheel. In order to obtain this result, the axes of the two wheels must be located in two vertical planes that are perfectly parallel.

Aligning only the feed wheel without simultaneously aligning the guides would be insufficient, and the ability to hold the out-of-round tolerance would be lost. This is why on certain machines the guides are fixed on the feed wheel carriage and the whole assembly pivots, allowing the correct contact between work and grinding wheel.

Improper fluid flow **Proper fluid flow**

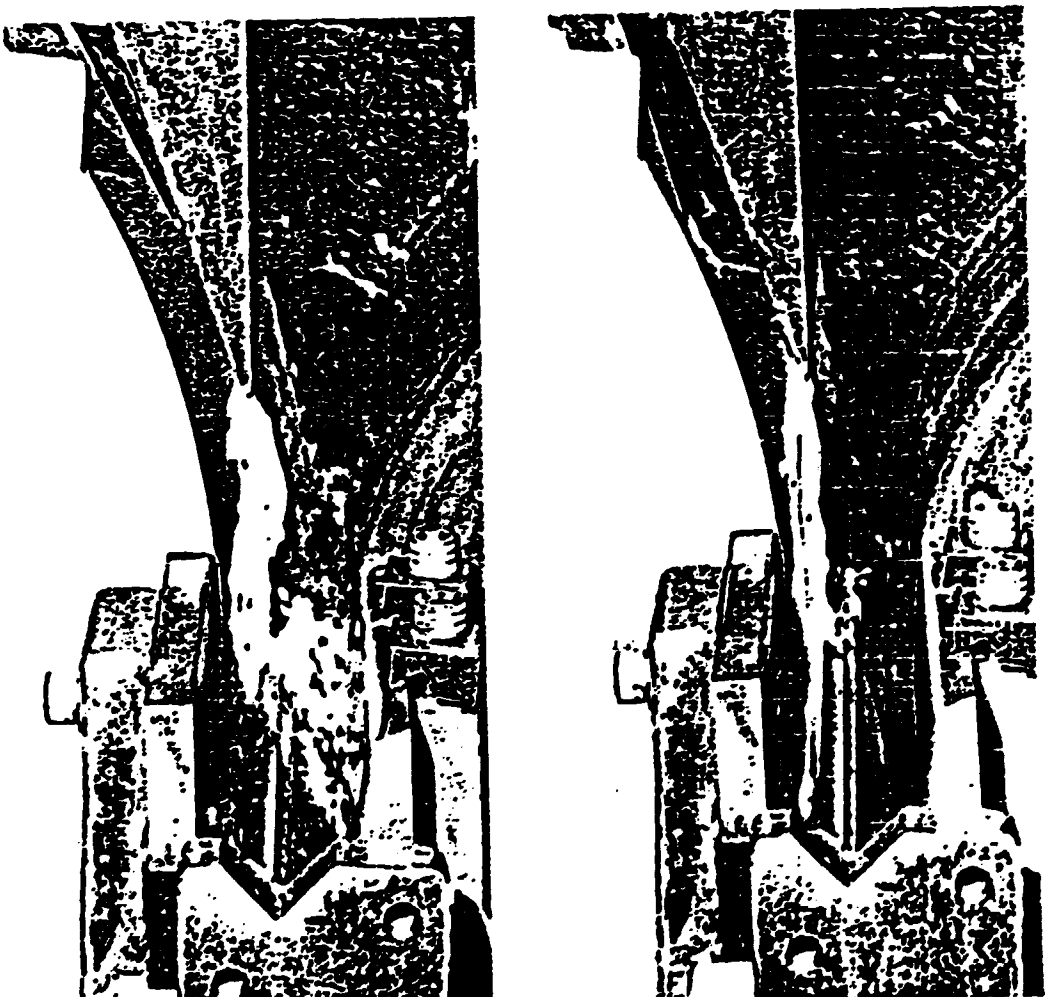


Figure 16A. Proper fluid flow is obtained when scraper is against the wheel, this breaks up peripheral airstream so fluid can maintain a steady flow between work piece and grinding wheel.

Coolants

Coolants used for centerless grinding are rust inhibitors, detergent types, water-soluble oils, or straight oils. Water soluble oils are the most popular because they cover a broad variety of applications and lubricate the top of the work rest blade. Dilution should be as recommended by the manufacturer. By experience, a good proportion is 20 parts water to 1 part of oil for general use. Special formulations are available for grinding soft materials, such as aluminum.

It pays to keep a record of the exact coolant mixture used for each job. Sometimes it is necessary, or at least desirable, to change the type of coolant whenever one type of grinding wheel or material is changed for another type.

The basic functions of grinding fluids are:

1. To prevent distortion or metallurgical damage to the part by holding the temperature steady. In order to maintain a uniform temperature, a heavy flow of fluid is needed.
2. Act as a lubricator, reducing the friction between the wheel and the workpiece.
3. To wash away chips of metal and abrasive particles which would otherwise mar the workpiece surface and load the grinding wheel face.
4. To keep the work blade and guides clean and well lubricated.

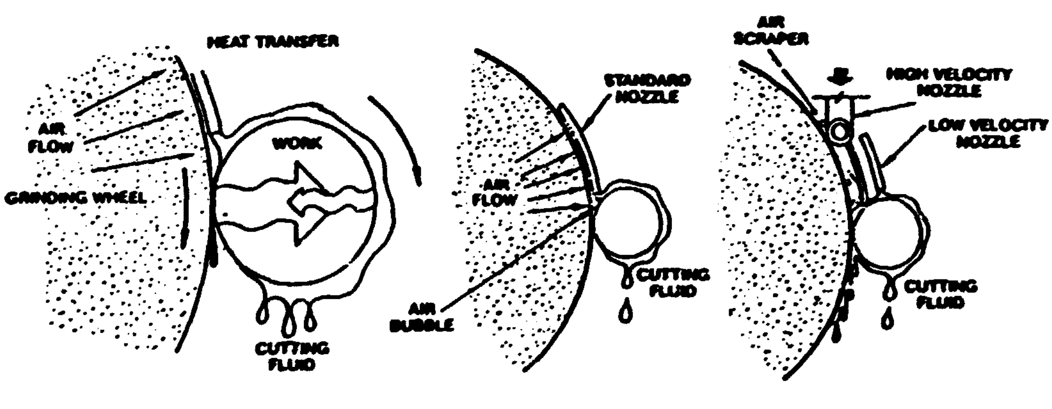
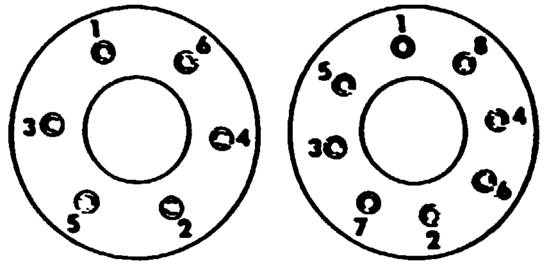


Figure 17. Coolant provides lubrication, cleaning and cooling action.



Order of Tightening 1-2-3-4-5-6   Order of Tightening 1-2-3-4-5-6-7-8

Figure 16B. Sequence of tightening screws on multiple screw flanges.

1. **Setting the work blade** Fig. 18 shows the relative positions of the grinding wheel, feed wheel, work support blade and work-piece. The height of the work blade should be adjusted so that the distance H above the center line of the grinding and regulating wheels is roughly one-half the work-piece diameter. This rule applies to work up to about 1" diameter. For larger workpieces, the distance H usually does not exceed ¾".

Position of work rest is set so grinding is done above center line of grinding and feed wheels.

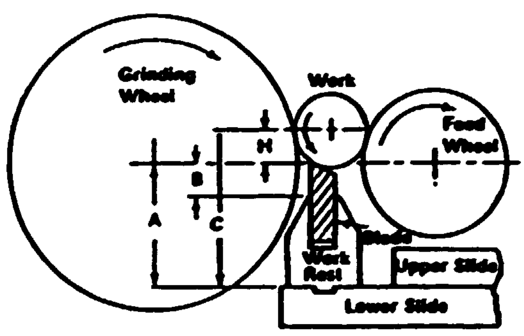
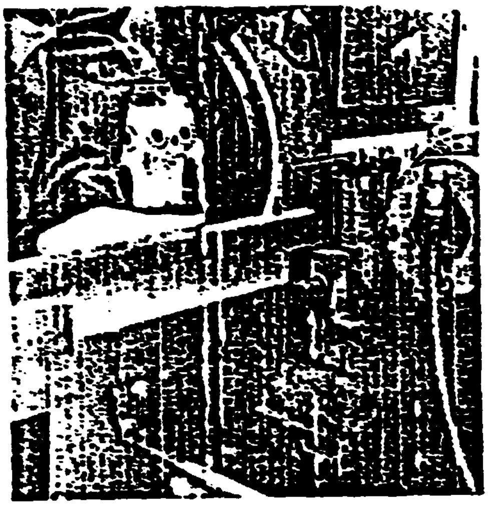


Figure 18. Relative positions of wheels and work blade for average throughfeed grinding jobs. A—distance from lower slide to center line of wheels. Refer to the machine operator's manual for "A" dimension. B—distance from top of work rest to centerline of wheels. C—distance from lower slide to center of work. D—distance of work center above (sometimes below) center line of wheels.

Setting the work too high above the center line of the wheels may cause chatter and bouncing. The wheels would have a tendency to squeeze the work upward and out of contact with the work blade, perhaps many times a second. Hence, the presence of chatter marks can be an indication that the work is set too high.

Setting the work too low must also be guarded against as this can cause it to come out of round (See page 4). A good method for checking roundness of centerless

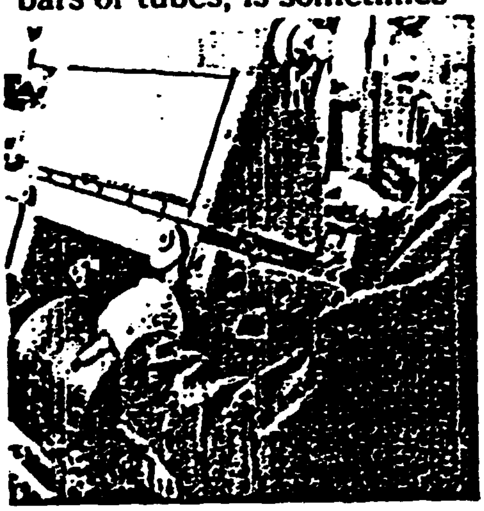


Work blade being set in work rest.

ground work is with a "V" block and dial indicator.

Generally the higher above the center line of the wheels the work is placed, the faster the rounding up action will be.

Long work with slight bends or kinks, such as long steel bars or tubes, is sometimes



Adjusting the tilt of the feed wheel head. Rate of the throughfeed is a function of the workpiece feed wheel head tilt.

purposely ground slightly below the center line of the wheels. While contrary to the usual practice, this setup can prevent whipping or chattering which might result where the kinks or bends have not been entirely removed in the straightening operation.

The wheels tend to hold the bar firmly down on the blade. It is very important, however, that long bars be straightened before being fed through the centerless grinder.

2. **Positioning the work on the blade**

   The work should contact the work support blade approximately ⅔ of the way up the beveled face. On one popular make machine, this adjustment is made by first loosening the upper slide clamp and tightening the lower slide clamp. With the workpiece resting on the blade, advance the feed wheel slowly, pushing the work up the bevel until the point of contact reaches above the middle of the blade (about ⅔ the way up). Then clamp the upper slide to the lower and unlock the lower slide so that both slides will move as a unit in compensating for grinding wheel wear.

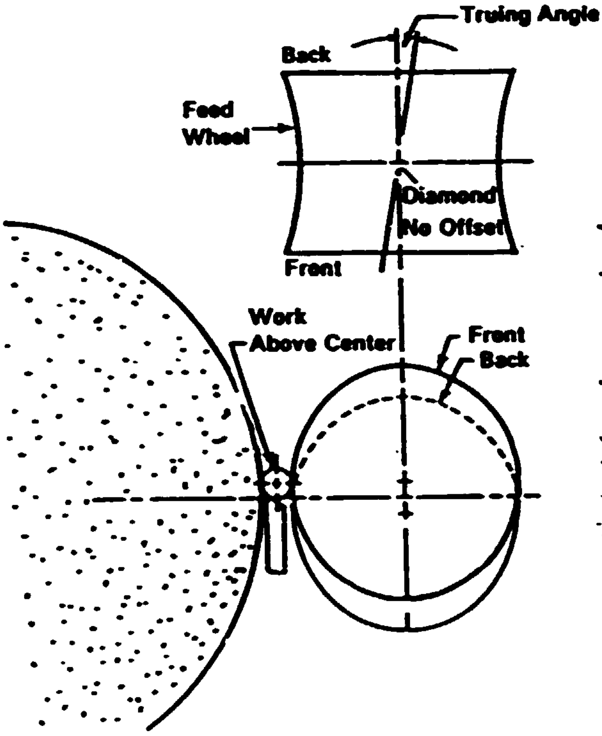


Figure 24a. With the diamond set to the truing angle but not offset, only the front portion of the wheel contacts the part.

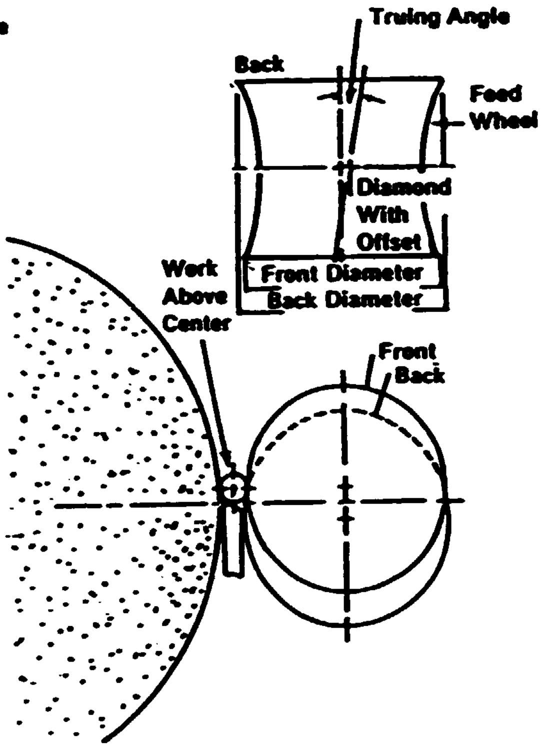


Figure 24b. With the diamond offset, the front of the feed wheel is decreased, producing a straight line of contact.

Truing the feed wheel

Since the feed wheel generally is set at an angle of inclination when centerless grinding, the truing procedure differs from that used for the grinding wheel. The feed wheel must be trued so that the work while passing between the wheels makes a straight line of contact with the wheel face. The function of a standard feed wheel truing unit is to make the diamond follow the same line of contact with the wheel as that which is followed by the workpiece. Four important factors must be considered when truing the feed wheel:

- The angle of inclination of the feed wheel.
- The truing angle of the feed wheel slide, which produces straight line contact between the feed wheel and the workpiece.
- The location of the center of the work in relation to the center of the grinding and feed wheels.
- The amount of diamond setover required to compensate for the height at which the part is being ground.

Truing, Dressing and Balancing

Definitions—Truing and dressing of wheels are operations whose aims, methods and effects often overlap. The main distinction is in their basic purposes.

Dressing a wheel is an operation performed on the wheel face to restore or change its cutting action. Truing, which may be done simultaneously with dressing, is necessary to restore concentricity, square up the wheel face, or restore it to a particular profile which the wheel is supposed to grind into the work.

Dressing is necessary because the abrasive grains in the wheel must be exposed. (Fig. 23) There must also be adequate clearance between grains, and between the bond and the workpiece (the latter clearance diminishes as the wheel dulls). Clearance between grains may be lost through loading of the wheel face with chips cut from the work, whereupon the wheel glazes and dressing is required.

Truing to square up the wheel face or round either its front or rear edges is a fairly simple procedure. Somewhat more complex is truing to impart a specific profile to the wheel. Modern centerless grinders have a variety of attachments for wheel truing. This condensed booklet does not permit a detailed discussion of these.

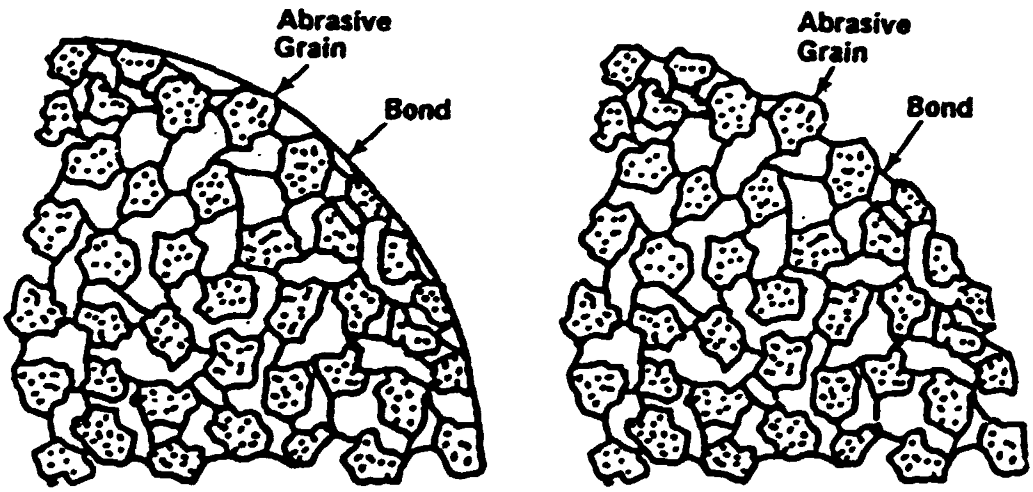


Figure 23. After dressing, loaded material has been removed from around the abrasive grains and their cutting edges are exposed for effective cutting action.

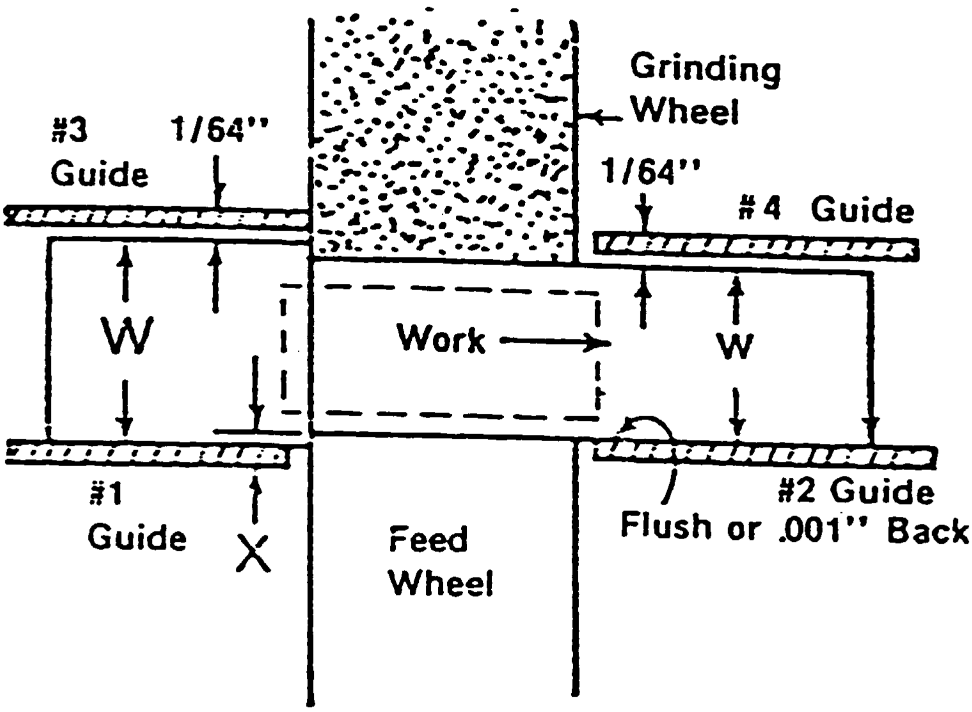


Figure 19. W = work diameter before grinding; w = work diameter after grinding; x or distance of #1 guide behind face of feed wheel = $\frac{W-w}{2}$ or ½ of index feed.

	TRUING ANGLE SETTING										
	7°	6° 10'	6° 10'	6° 20'	6° 25'	6° 30'	6° 35'	6° 45'	6° 50'	6° 55'	6° 55'
	6°	5° 15'	5° 15'	5° 25'	5° 30'	5° 35'	5° 40'	5° 45'	5° 55'	5° 55'	5° 55'
Work	5°	4° 20'	4° 25'	4° 30'	4° 35'	4° 40'	4° 40'	4° 50'	4° 55'	5°	5°
Feed	4°	3° 30'	3° 30'	3° 35'	3° 40'	3° 45'	3° 45'	3° 50'	3° 55'	4°	4°
Angle	3°	2° 35'	2° 40'	2° 40'	2° 45'	2° 50'	2° 50'	2° 55'	2° 55'	3°	3°
	2°	1° 45'	1° 45'	1° 50'	1° 50'	1° 50'	1° 55'	1° 55'	2°	2°	2°
	1°	50'	50'	55'	55'	55'	55'	55'	1°	1°	1°
RATIO $\frac{D}{d}$		3	3.5	4	5	6	7	12	18	24	48
	1/8"	7/64"	7/64"	7/64"	7/64"	7/64"	1/8"	1/8"	1/8"	1/8"	1/8"
	1/4"	7/32"	7/32"	7/32"	15/64"	15/64"	15/64"	15/64"	1/4"	1/4"	1/4"
Work	3/8"	21/64"	21/64"	11/32"	11/32"	11/32"	23/64"	23/64"	23/64"	3/8"	3/8"
Height	1/2"	7/16"	7/16"	29/64"	29/64"	15/32"	15/32"	31/64"	31/64"	1/2"	1/2"
Above	5/8"	35/64"	35/64"	9/16"	37/64"	37/64"	19/32"	19/32"	39/64"	5/8"	5/8"
Center	3/4"	21/32"	21/32"	43/64"	11/16"	45/64"	45/64"	23/32"	47/64"	47/64"	47/64"
	7/8"	3/4"	49/64"	25/32"	51/64"	13/16"	53/64'	27/32"	55/64"	55/64"	55/64"
	1"	55/64"	7/8"	29/32"	59/64"	15/16"	15/16"	61/64"	63/64"	63/64"	63/64"
	Diamond Set-Over										

Figure 25

feed wheel. By adjusting the diamond set-over (offset) an amount nearly equal to the height that the part is above the centerline of the wheels, the deepest portion of the concave surface can be shifted toward the front of the feed wheel, Figure 24b. This makes the front portion of the wheel smaller, and the point of contact is shifted up to compensate for the height the part is above center.

Calculating the truing angle and diamond set-over

To accurately determine the truing angle and the amount the diamond holder should be set-over, the ratio between the feed wheel and work diameters must be found:

$\frac{D}{d}$ where D = feed wheel diameter, and
d = workpiece diameter.

After this ratio has been established, use Table Fig. 25 to find the truing angle and the amount of diamond set-over. Since the types and models of centerless grinders and truing equipment may vary with manufacturers, it is wise to consult the operator's manual for truing feed wheels. Always use the highest feed wheel speed available for the truing process. The rate of travel of the diamond across the regulating wheel face is usually one to two inches per minute for final passes.

PRODUCTION TRIAL RUN TO STANDARD

Wheel Manufacturer	Wheel Specification	Stock Removal	Grind Wet	Grind Dry	Results

"Surface"

Rough grinding or excessive stock removal wheel specification WA46H7V. However should this wheel have too large a grain size or should the grade be too soft, it is recommended that they should change, but only one specification at any one time.

For finish grinding the specification should be WA80H7V. Same applies to above recommendation. CBH wheels can also be recommended for some applications

Coolant's Role In Creep-Feed Grinding

Coolant plays a more significant role in the success of a creep-feed grinding operation than it does in conventional grinding. More conditions must be controlled.

By PAUL GIBBEE, Product Manager
Abrasives Marketing Group
Norton Company
Worcester, Massachusetts

Creep-feed grinding can provide significant increases in productivity and improvements in workpiece quality. But to realize these benefits, the grinding system must be optimized. Effective coolant techniques, always important in grinding operations, are critical in creep-feed grinding because of the increased area of wheel/workpiece contact and the high metal removal rate, and because the system is usually used for the difficult-to-grind materials.

Just using large quantities of coolant is not enough. Proper coolant application for creep-feed grinding also involves the coolant flow rate, pressure, total capacity, concentration, temperature, pH level, cleanliness and nozzle design.

The coolant must be directed at the intersection of the wheel and the workpiece. There must be enough pressure to clear the wheel face of swarf and there must be enough velocity to overcome the peripheral speed of the grinding wheel.

As a general rule, the flow rate should be two to three times the horsepower of the machine, or a minimum of 80 to 100 gallons per minute (gpm). The capacity of the coolant system should be no less than five times the gpm, and the pressure should be 80 to 120 psi. This combination of flow rate and pressure allows the coolant to overcome the peripheral speed of the wheel and enhance swarf removal.

Having enough total capacity assures that the coolant entering the arc of contact is clean. Dirty coolant drags swarf through the grinding zone. This can load the wheel face, making the wheel act softer, displacing coolant, and creating a higher likelihood of burning the workpiece.

Nozzle Design

A smooth, regularly shaped orifice is necessary for a successful coolant nozzle. Irregular, handmade nozzles hammered to shape can create distribution and velocity problems, and contribute to erratic coolant application as well as thermal damage.

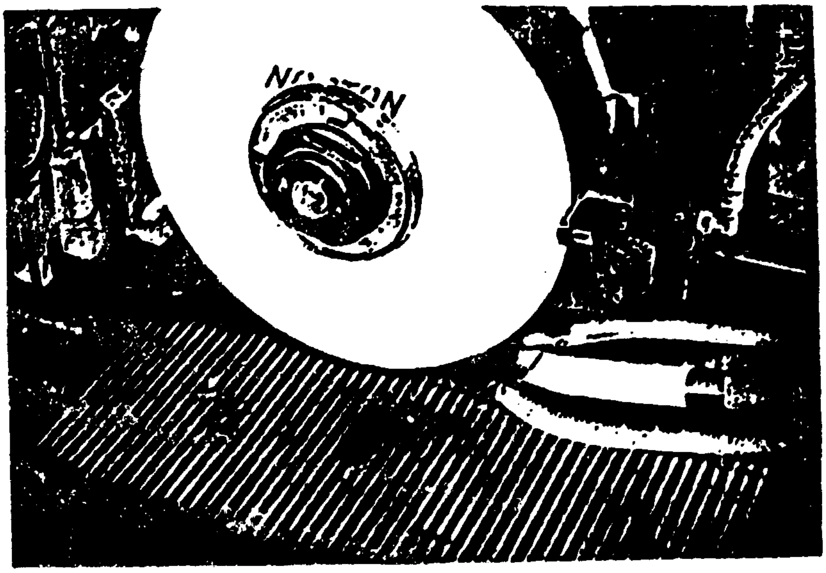
Highly effective nozzles can be slightly narrower than the wheel due to the fanning effect as the high-pressure coolant exits the nozzle. Orifice heights from ⅛ to ¼ inch are common, based on flow rate and pressure.

Coolant Application

There are two basic coolant application methods: the scraper or shoe, and the jet system. Both have benefits and drawbacks.

The jet system, shown in Figure 1, is found in the majority of shops. Coolant, at pressures of 80 to 120 psi, is pumped through the nozzle into the acute angle formed by the intersection of the wheel and the workpiece. Nozzle distance, location and angle are critical. Best results are achieved when the nozzle is ½ to 1 inch away from the grinding wheel/workpiece interface, and positioned to bisect the acute angle formed by the wheel and the workpiece.

To maintain the angle at the end of the cut, use a form coupon as shown in Figure 2. This serves as a funnel for the coolant, and prevents chatter and dry grinding as the

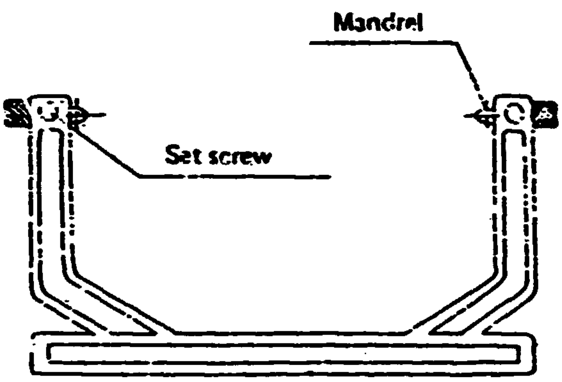


A smooth, regularly shaped orifice is the key to a succe[illegible] nozzle design. Placement of the nozzle is also important. This jet nozzle directs [illegible] to the angle formed by the intersection of the wheel and the workpiece.

RADIUS FORMING ATTACHMENT

The Radius Forming Attachment is composed of a main stand, 3 pieces of swing rods and a diamond tool.

1. Main Stand (Fig,38)



Fig,38

2. Swing rod and diamond tool (Fig.39)

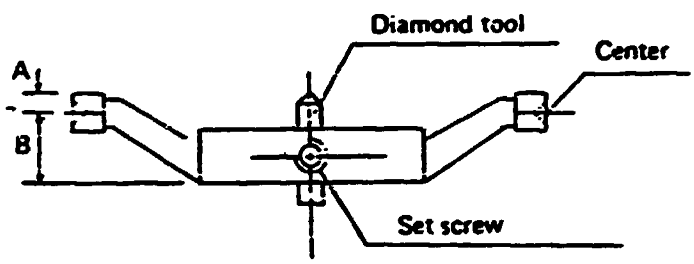


Fig.39

A name plate is attached to the swing rod with A and B dimension:

A: Radius of the rod

B: Center height from the bottom side

3. To determine the concave and convex R:

3.1 X = Block gage thickness

3.2 To determine the convex R: Put the swing rod on a plane disk, Put a block gauge of proper thickness under the diamond tool. Then R = X - A (see Fig. 40)

3.3 To determine the small concave R: See Fig. 41, R = A - X

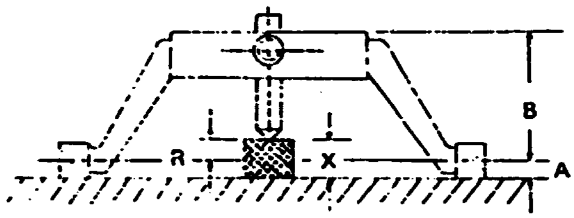


Fig. 40

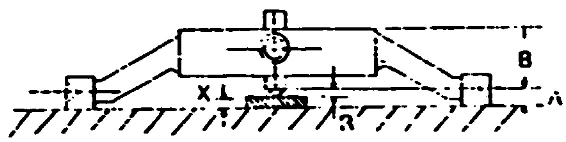


Fig. 41

3.4 To determine the big concave R: R = B + X. See Fig. 42, 43.

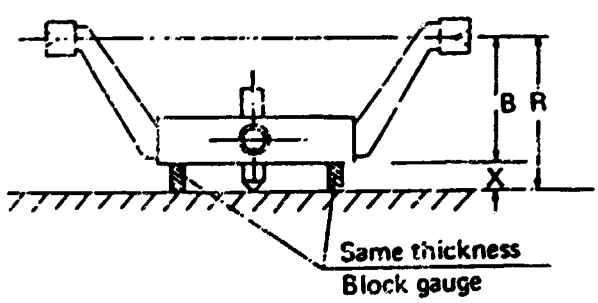


Fig. 42

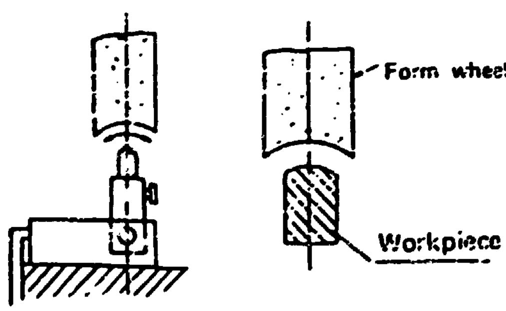


Fig. 43

3.5 Note:

3.5.1 The periphery and side of the grinding wheel shall be well-dressed.

3.5.2 The Radius Forming Attachment shall be parallel to the grinding wheel.

4. Operation of the Radius Forming attachment:

4.1 Find the center of the grinding wheel. Then fix the work table. (Fig.44)

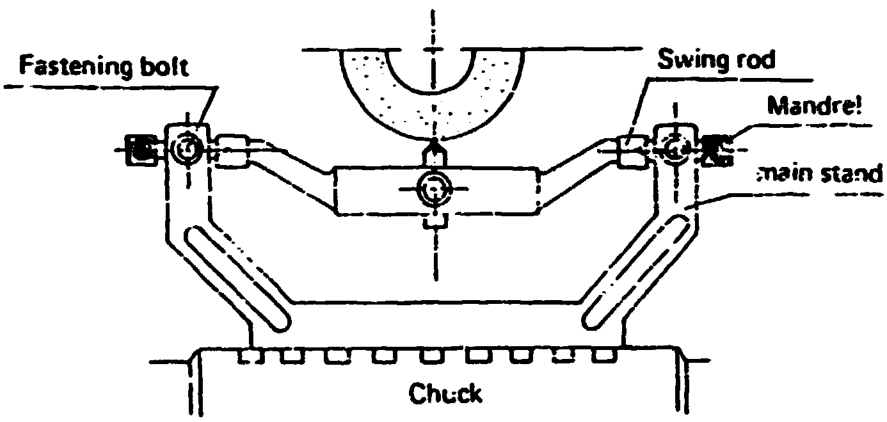
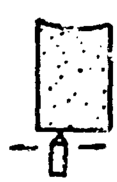


Fig.44

4.2 Turn the fownfeed handwheel at 1/3 on the width of the wheel so that the wheel cuts into 0.02mm of the Diamond tool. Now turn the cross-feed handwheel to dress the grinding wheel, and turn the calibration reading on the downfeed handwheel back to zero.



Getting the best out of your single-point diamond dressers

■ *Diamonds* are sensitive to impact, shock, and vibration, all of which should be avoided in practice. Both the grinding machine and the wheel should be vibration-free and the diamond toolholder should be rigidly mounted with short overhang.

When using a single-point diamond tool, the holder should always be inclined at a radial tangent to the wheel of 10-15°, pointing in the direction of rotation to obtain a dragging effect. The same result can be obtained by adjusting the diamond tool in a similar manner in relation to the crossfeed of the tool, with best tool performance gained if both angles are applied simultaneously.

Positioning the diamond in this manner maintains its sharpness—and there is a further advantage if the diamond is only applied in a wear-resistant direction not coincident with the directions of the crystal axes.

Try to maintain a pyramid point

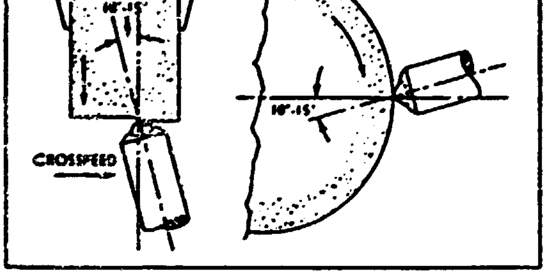
If the diamond point is kept too long in the same position, an excessive flat will be formed on the point which will result in a too-smooth dressing that will burn the workpiece and generate excessive pressures which will overheat the diamond, causing it to prematurely breakdown even in the presence of ample coolant. As soon as the flat on a diamond reaches about .040 sq. in., the tool should be turned 20-40° on its axis and, if subsequent turns follow the correct sequence, a pyramid will be formed, ensuring a sharp point at all times.

In operation, the diamond should be carefully brought into contact with the wheel—and always at its highest point (don't forget that the leading edges of the wheel wear down more than does the center of the wheel); a sudden undue pressure on the diamond structure can result in serious fracture. Particular care should be taken with a new grinding wheel which is certain to be running out of truth (even if it has been pre-dressed with a non-diamond tool).

Truing and dressing with a low wheel speed saves wear on the diamond, but if wheel speed cannot be reduced a peripheral speed of 5000—6900 sfpm will produce satisfactory results. On no account should the wheel be stopped before withdrawal of the diamond.

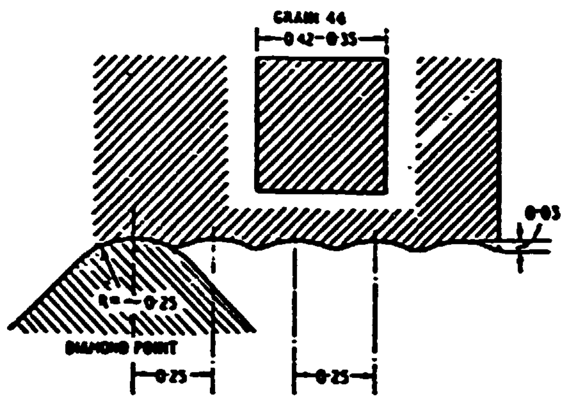
Too deep a cut will cause overheating of the diamond, therefore the life of the diamond will be longer if several light cuts are taken rather than a single deep cut. The average depth of cut for dressing and truing operations should be between .00079" and .0011" per pass and for very fine wheels it is better to restrict the depth of cut to between .00019" and .00039".

Crossfeed greatly affects the wheel surface. Too fast a crossfeed not produces a screw thread and a coarser wheel surface but also the effective wheel width is reduced with the result that the specific grinding pressure will be increased, wearing the wheel more rapidly and preventing its use for accurate work. With a slower crossfeed a finer cutting wheel surface is obtained, but it should be borne in mind that too slow a crossfeed will probably blunt the grains of wheel abrasive. Nevertheless, a reduced crossfeed can be taken if a fine surface finish of the workpiece has to be obtained with a

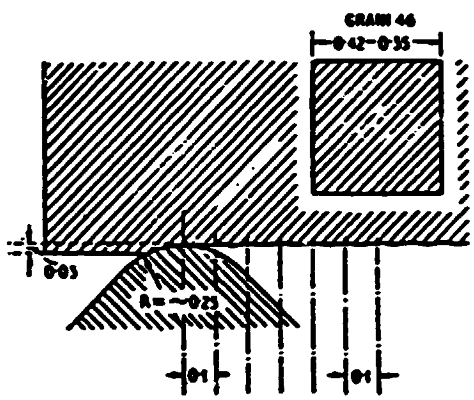


1—Wear of the diamond tool is considerably reduced by angling the dresser in the direction of wheel rotation and against the crossfeed.

SINGLE-POINT DRESSERS continued



2—Correct crossfeed, if compared with the grain size it is clear that each grain is cut at least once but not more than twice.



3—Crossfeed here is too small . . . each grain is being cut four times.

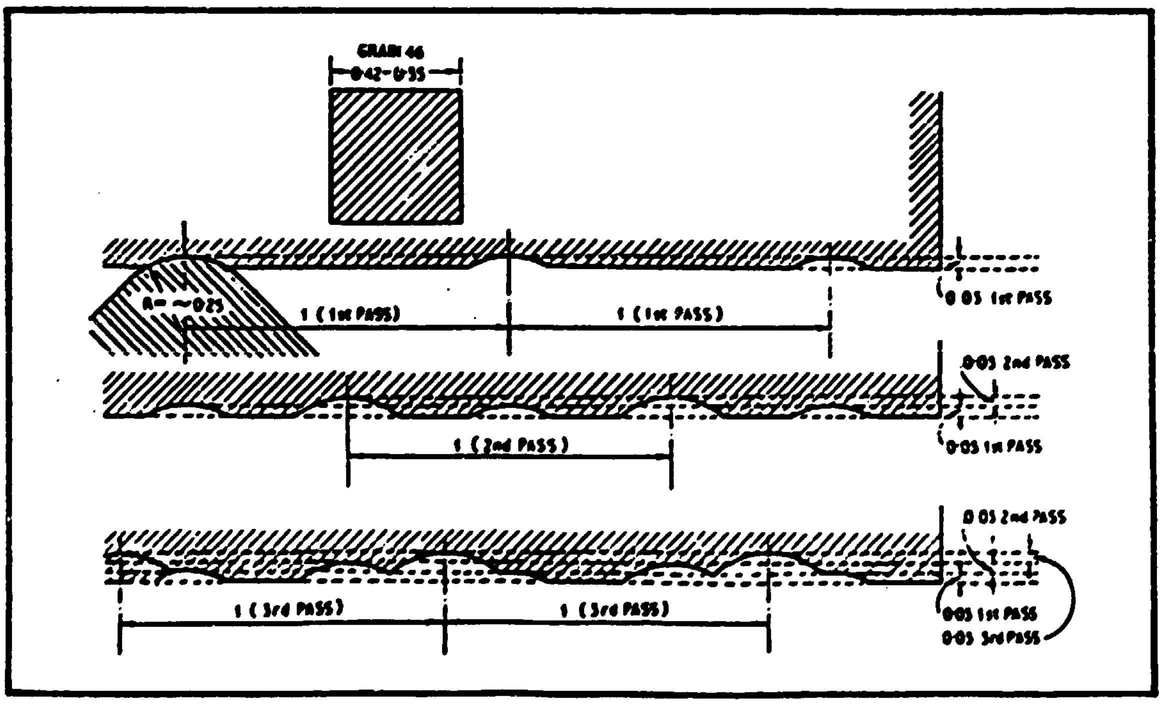
grinding wheel of too coarse a grain. In order to get the individual grains as sharp as possible and give the wheel its maximum efficiency, each grain of the wheel surface should not be attacked by the diamond point more than twice. As a rule, the maximum crossfeed per wheel revolution should be slightly less than the grain-size.[1] Table 1 gives the crossfeed for several grainsizes.

As an example, suppose one wanted to calculate the number of seconds for turning a grinding wheel about 10" (250 mm) wide (the diameter of the wheel does not matter) rotating at 1200 rpm. As shown in Table 1, for grain 46, for instance, a crossfeed of .008 ipr to .014 ipr is recommended. So, the width of 10" should be trued in 710—1250 revolutions. The time for a single pass is from 35—62 seconds, Table 2.

Protect the point from heat

Good cooling is of utmost importance for economical diamond life. A copius flow of coolant should be directed on the diamond itself and not just on the wheel surface. A wet wheel does not cool the diamond. Because intermittent coolant on the diamond will produce violent changes in temperature and damage the diamond, the coolant should be flowing before the diamond touches the wheel. If coolant cannot be used or applied in a copius flow it is less harmful for the diamond to dress the wheel entirely dry, provided the

4—Below: Crossfeed that is too large, with at least two grains being jumped at each pass and cut on subsequent passes, resulting in a bad wheel surface.



depth of cut is kept to a minimum. When dressing dry there should be a pause between each pass to allow the diamond to cool naturally.

Another important aspect of the use of diamond dressers is to avoid over using the tool between resets. The diamond should not be allowed to wear into the setting material because, apart from the risk of losing the diamond due to lack of holding power, it is possible to wear away the next valuable dressing point. The diamond should be sent to the supplier for resetting as soon as it has become worn to near the setting metal.

In addition to the importance of using a diamond tool correctly, the size of the diamond itself is also important. It should never be too small. The choice of diamond size is, in the first place, related to the size of the grinding wheel and then to its grainsize, its hardness and the abrasive material as well as the peripheral speed of the wheel.

However efficient the cooling may be, a certain amount of heat developed is proportional to the dis- heat has an influence on the wear of the diamond. The amount of heat developed is proportioned to the distance covered by the diamond on the wheel surface, i.e., to the product of wheel diameter and wheel width.

The heat-transfer from the diamond to the setting-metal is so gradual as to lead to an increase in temperature of the diamond itself. A bigger diamond can accumulate more heat than a smaller one and, owing to its greater surface and its greater contact with the setting-metal, it also has a better heat transfer capability. So, in principle, a bigger diamond works cooler than a smaller one.

In Table 3 the relationships between diamond size and wheel size are selected in such a way that the product of diamond volume and diamond surface is proportional to the product of wheel diameter and wheel width.

Table 3 relates to normal grinding wheels (a) of aluminum oxide; (b) with a hardness of Grade M and softer; (c) with a grainsize 46 and finer; and (d) running with a peripheral speed of 5000—6000 sfpm.

For each of the following cases it is better to choose the diamond size one number greater:

(a) for silicon-carbide wheels
(a) for silicon-carbide wheels
(b) for wheels harder than Grade M
(c) for wheels with a coarser grain than 46.

To determine the diamond size for a wheel running at a higher speed than 5000—6000 sfpm, the product of the wheel dimensions should be multiplied by the same factor. Thus, for a wheel running at 12,000 sfpm (twice as fast) a diamond should be used as indicated for a wheel twice the size. • • •

[1]The author is grateful to H. B. Veldman Ing., at Eindhoven, who first drew his attention to this relationship between crossfeed and grainsize, the correctness of which was confirmed by several trials on grinding machines.

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TABLE 1

WHEEL GRAIN	RECOMMENDED CROSSFEED (inches per revolution)
30	.0138 - .0236
36	.0118 - .0152
46	.0079 - .0138
54	.0058 - .0118
60	.0059 - .0089
80	.0035 - .0067
120	.0024 - .0039
180	.0016 - .0028
220	.0010 - .0015
280	.0008 - .0011
320	.0006 - .0008

TABLE 2

RECOMMENDED TRUING AND DRESSING TIME (IN SECONDS) FOR SINGLE-POINT DIAMOND TOOLS PER 100 MM (4") WHEEL WIDTH

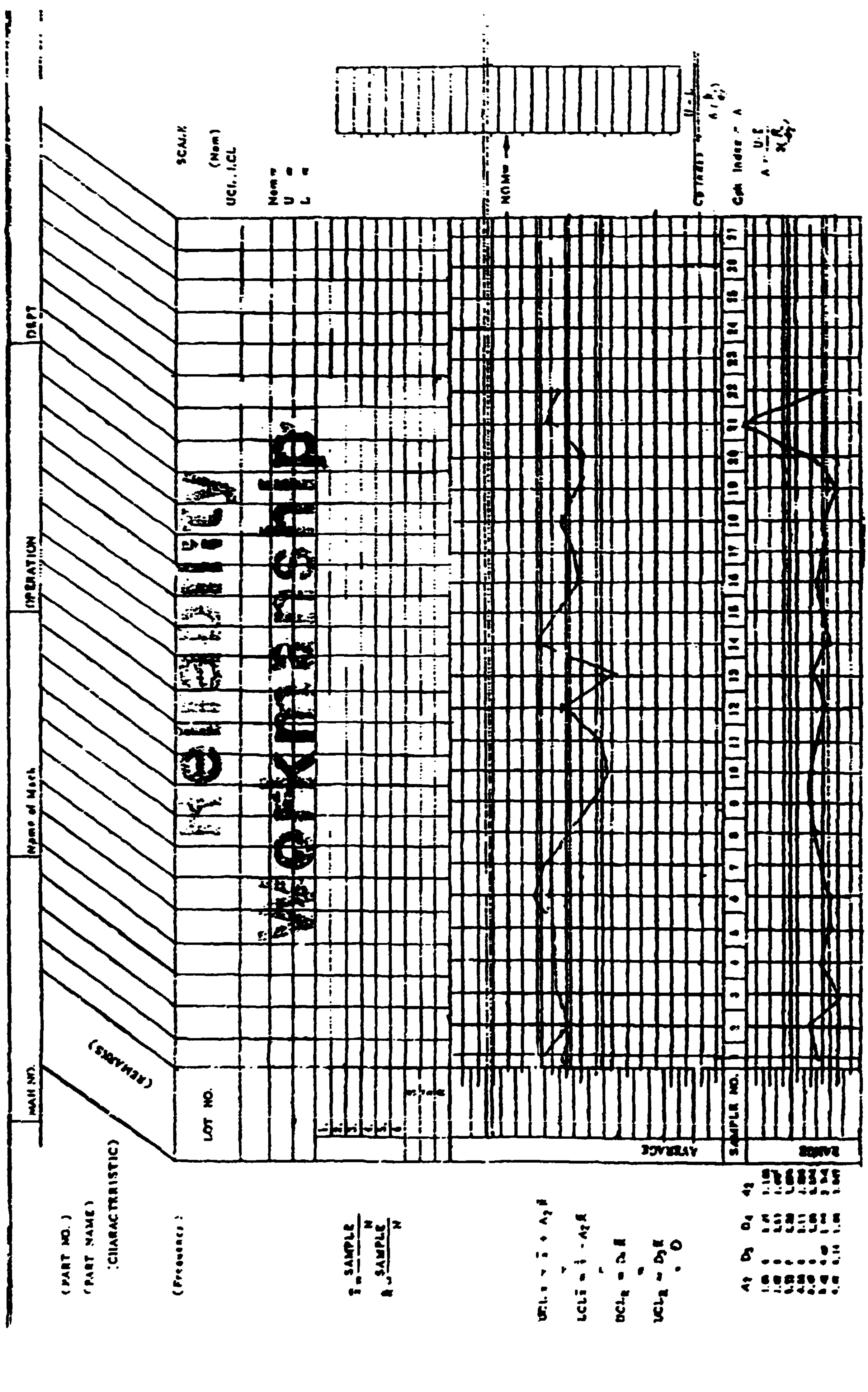
RPM	GRAIN 30	GRAIN 36	GRAIN 46	GRAIN 54	GRAIN 60	GRAIN 80	GRAIN 120
	seconds	seconds	seconds	seconds	seconds	seconds	seconds
500	20 -34	24 -40	34 -60	42 -70	42-80	70 -120	120-120
750	12 -23	16 -26	23 -40	26 -47	32-53	47 -85	80-133
1000	10 -17	12 -25	17 -30	20 -35	24-40	35 -60	60-100
1250	8 -14	10 -16	14 -24	16 -29	19-32	28 -48	48-80
1500	6½-11½	8 -13	11½-20	13 -23½	16-27	23½-40	40-66
1750	5½-10	7 -11½	10 17	11½-20	14-23	26 -35	35-57
2000	5 - 8½	6 -10	6½-15	10 -17	12-20	17 -30	30-50
2250	4½- 7½	5½- 3	7½-13	9 -15½	11-18	16 -27	27-44
2500	4 - 7	5 - 8	7 -12	8 -14	10-16	14 -24	24-40
2750	3½- 6	4 - 7	6 -11	7 -13	9-14	13 -22	22-36

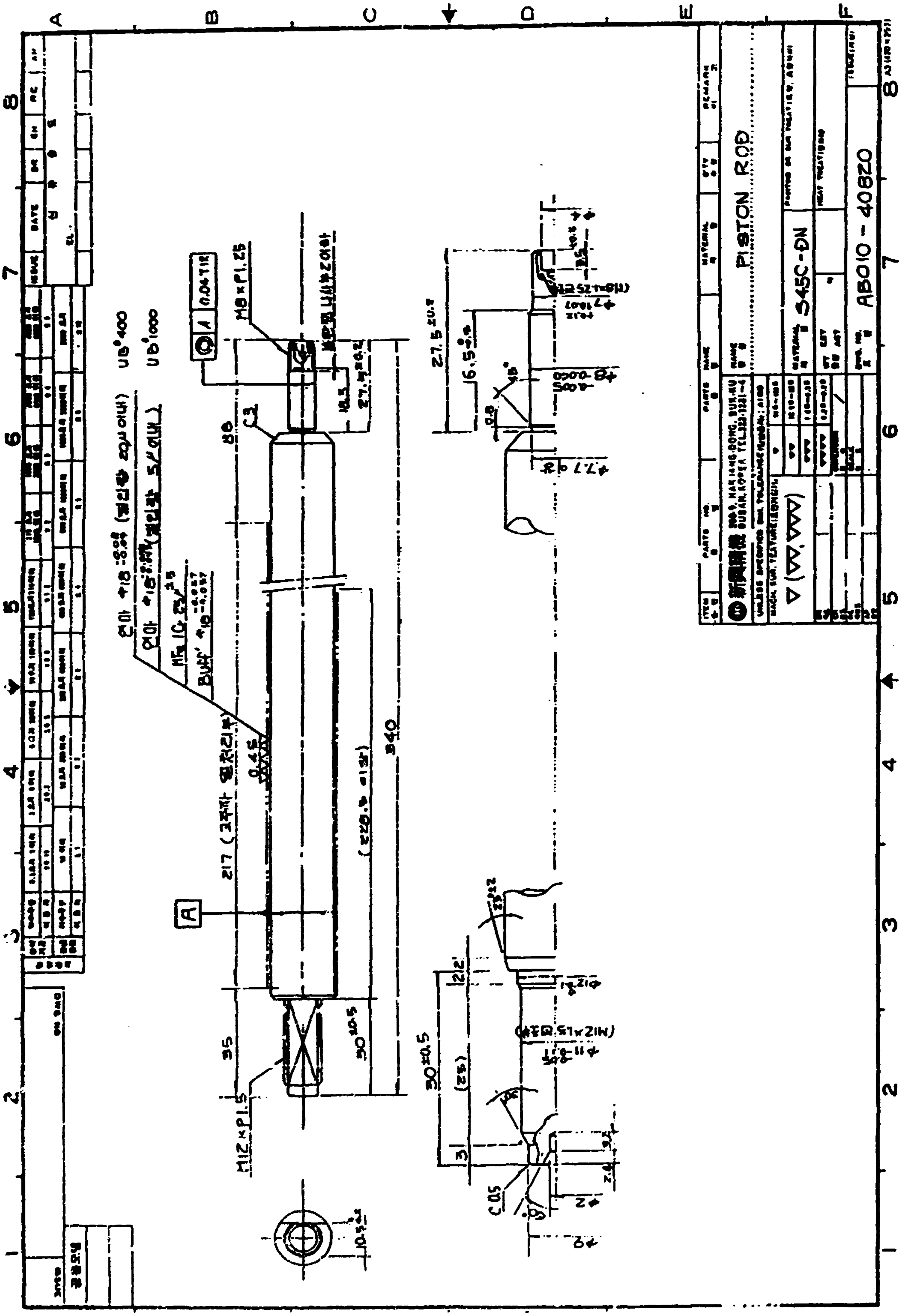
TABLE 3

RECOMMENDED DIAMOND SIZES

DIAMOND SIZE (in carats)	FOR GRINDING WHEELS WITH A PRODUCT OF DIAMETER X WIDTH (square inches)
.25	3.100 or smaller
.35	5.900 "
.50	10.550 "
.60	14.250 "
.75	20.600 "
1.00	33.350 "
1.25	45.000 "
1.50	65.000 "
1.75	85.250 "
2.00	105.500 "
2.50	155.000 "
3.00	207.000 "
4.00	342.000 "

(The Right Way)




PISTON ROD
S45C-DN
AB010-40820
M12×P1.5