RI 8979

Bureau of Mines Report of Investigations/1985

Computer Program To Relate Dust Generation to Drum-Type Coal Mining Machines

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UNITED STATES DEPARTMENT OF THE INTERIOR

BUREAU OF MINES 75TH ANNIVERSARY 1910 1985

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UNITED STATES DEPARTMENT OF THE INTERIOR
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BUREAU OF MINES
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Library of Congress Cataloging in Publication Data:

Roepke, Wallace W

Computer program to relate dust generation to drum-type coal mining machines.

(Report of investigations ; 8979)

Supt. of Docs. no.: I 28.23:8979.

1. Coal mines and mining—Dust control—Computer programs. 2. Coal-mining machinery—Computer programs. I. Hanson, Bruce D. II. Schmidt, Robert L. III. Title. IV. Series: Report of investigations (United States. Bureau of Mines) ; 8979.

TN23.U43 [TN813] 622s [622'.8] 85-600187

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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

cfm	cubic foot per minute (airflow)
ft	foot
ft/min	foot per minute
ft^3/min	cubic foot per minute (solids)
in	inch
in^3	cubic inch
lb	pound
lb/ft^3	pound per cubic foot
Mcfm	thousand cubic feet per minute
mg	milligram
mg/m^3	milligram per cubic meter
mg/min	milligram per minute
mg/st	milligram per short ton
min	minute
μm^3	cubic micrometer
μm^3/ft	cubic micrometer per foot
pct	percent
psi	pound per square inch
rpm	revolution per minute
st/min	short ton per minute
st per shift	short ton per shift

COMPUTER PROGRAM TO RELATE DUST GENERATION TO DRUM-TYPE COAL MINING MACHINES

By Wallace W. Roepke,[1] Bruce D. Hanson,[2] and Robert L. Schmidt[1]

ABSTRACT

The Bureau of Mines has developed an interactive computer program that enables mine operators and others to identify the effect of cutting system changes on relative dustiness at the face. The program, which simultaneously evaluates machine parameters, coal seam parameters, and operator-controllable parameters, was developed for use on any microcomputer using BASIC programming language. The program allows the user to change one or more of the cutting system parameters at a time to see how these changes affect relative dustiness. A complete program listing and flowchart are included along with operating instructions and sample outputs. An example showing how to use the program is also included.

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INTRODUCTION

Since the enactment of the Federal Coal Mine Health and Safety Act of 1969, the Bureau of Mines has conducted an intensive research program on the control and abatement of respirable coal dust. This research has been channeled into three separate but interrelated approaches: (1) primary control, wherein the coal is fragmented so that either generation of respirable dust is reduced or the dust is not entrained in the airstream, (2) secondary suppression, wherein respirable dust, already entrained, is "knocked down" or diverted with water sprays, dust collectors, or changes in ventilating patterns, and (3) respirable dust instrumentation development, which is essential to the conduct of the other two approaches. This paper deals only with the first approach, i.e., with reducing dust generation during cutting by adjusting cutting system parameters.

Bureau research on reduction of primary dust generation during coal cutting has been conducted over the past 15 years in small-scale laboratory tests, intermediate-sized prototype tests, and full-scale in-mine demonstrations. The main objective of this work has been to determine the effect of controllable machine parameters on respirable dust generation. These controllable parameters include such things as bit geometry, bit mounting configuration, and operator techniques.

The body of data collected during this research provides a broad base of knowledge on coal cutting phenomena. The results are available to the industry in a multitude of Bureau publications. There is so much information in so many places that anyone interested in reducing respirable dust generation in a specific coal mining operation may have difficulty in finding all the available data and extracting the specific information needed. The advent of the microcomputer and its universal availability provide a means of alleviating this problem.

This publication presents a computer program which is a synthesis of research results about the effects of various cutting system parameters on the generation of respirable coal dust. It is the first attempt to provide a means to consider the effects of several parameters simultaneously. It will enable an individual to play "what if" with those cutting system parameters that can be controlled. The program deals in relative rather than absolute values, since the user only needs to know whether the changes will increase or decrease dust generation.

This publication is the first step in a long-term effort to structure available data on machine parameter effects into a mathematical cutting system model (CSM). The CSM input will be measurable or controllable machine, site, and coal parameters, and the output will be the dust generation and energy requirements of the complete cutting system. Until this complete model is a reality, the RElative Dustiness Indicator (REDI) program based on empirical data will be useful to the industry.

ACKNOWLEDGMENTS

The data used to develop this first cutting system model have been acquired over many years by several people at the Bureau's Twin Cities Research Center, each of whom has contributed significantly to the program effort. Initial efforts were started by Kelly Strebig, supervisory physical scientist, and William Zeller, physical scientist, in 1970. Since 1973 Ted Myren, mining engineering technician, has been actively involved with every activity; without his skillful and willing assistance over the years, the work would not have been possible. More recently field data acquisition with the In-Seam Tester has received the active support and guidance of Laxman Sundae, mining engineer. The continuing

efforts of Carl Wingquist, physicist, on instrumentation and Richard C. Olson, mechanical engineer, on test systems design to support the research efforts have also been essential to the results.

REDI PROGRAM DESCRIPTION

This program has been developed to provide operators and machine designers with a mechanism for determining the effects of cutting system changes on dust generation due to cutting action of the drum.

This program is meant to be generic rather than site specific. Therefore, no site-specific variable coal dustiness index is incorporated in this model. The dust factor used is an average value which will increase or decrease as the user inputs changes to the program in response to prompting questions asked by the program. This will provide the user with a relative change in dust generated. Determination of the actual dust volume change would require an operator to take dust samples at the actual mine site.

The program is simple and easy to use. It is written in BASIC for an Apple IIe microcomputer[3] and requires approximately 7k of memory. A listing of the program is given in appendix A. A detailed explanation is given in appendix B. The BASIC functions used in the program should be fairly universal with the exception of the HTAB command. The output is formatted for 80 columns. Once REDI is loaded, prompts will appear where necessary to guide the operator on the input needed. While a printer is not a necessity, it is useful since the output more than fills the screen and will, therefore, scroll off the top.

The input variables are listed in table 1. The machine dimensions and swell factor will determine the volume of cut coal that can be held between the drum and face without further crushing. Swell factor is defined as the increase in volume when a given mass of solid coal is fragmented. The program incorporates the number of vane starts and the wrap angle since the volume of the vane(s) must be known to obtain free volume available for fragmented coal. The vane angle component obtained by the program is the information needed to properly design for coal transfer to the panline. Rapid transport to the panline will prevent additional dust generation by secondary fragmentation.

When the program asks the user if optimum bits are desired, a "Y" answer causes the computer to calculate the number of face bits by using the space-to-depth ratio and advance rate. The number of bits

[3]Reference to specific products does not imply endorsement by the Bureau of Mines. For use with other microcomputers, see section on "Program Conversion."

TABLE 1. - Input variables

Variable Type	Variables
Machine dimensions...........	Drum diameter, top vane diameter, inner drum diameter, vane height, vane thickness, vane width, web width, drum vane wrap angle, number of starts, shearer horsepower, drum revolutions per minute.
Coal properties..............	Compressive strength, grindability index, swell factor, 2 dust parameters.
Operator controlled..........	Bits per vane, number of gage bits, number of gage lines, airflow, production time per shift.

can also be set by the user to any number desired. Gage bits are still considered as an independent variable since insufficient data are available yet to properly design end rings. Primary dust (dust generated from cutting coal) is determined from the number of bits and the average depth of cut. The calculation is based on the total lineal cutting done by the bits. The dust generated per foot of cut is a function of depth of cut. The coefficients used (two dust parameters for slope and intercept on dust versus depth) were derived from analysis of cutting tests done by the Bureau. An assumption is made that the secondary dust generated from recirculation, grinding, and falling coal is directly proportional to the product of the Hardgrove grindability index and the amount of primary dust generated. Although exact correlation has not been made, laboratory research and field tests support this assumption adequately for purposes of this relative dustiness program. Once the dust generation rate of the cutting system has been established, a relative shift average dust concentration is calculated based on the airflow and production time per shift.

While the program was developed to provide the user with a tool for determining relative changes in dust concentration due to changes in drum parameters or operating conditions, it may be possible to use the program to obtain site-specific dust concentrations. To do this, the user can compare the program results for a set of conditions for which actual dust concentration values are available. If the first and second dust parameters are then multiplied by the ratio of actual dust level and the program-computed dust level, the program will produce a dust level equal to the actual value. There is no assurance that modifying the dust parameters to the actual dust levels for a given set of conditions will give program results and actual dust levels showing exact correlation for changes in operating conditions, since the slope and intercept may not be correct over the full range of conditions. On a relative basis and order of magnitude basis, however, the program should then be representative of actual in situ conditions.

PROGRAM USAGE

The flowchart for this program is shown in figure 1. The complete program listing is contained in appendix A. Appendix B contains a complete functional description and list of variables. Data input is accomplished either by use of DATA statements (lines 520 and 530) or by entering the data from the keyboard in response to program prompts (lines 550 to 590). When using the DATA statements method, the order of the input variables is the same as that of the variable names contained in the array NAM$ (lines 270 to 470). It will be to the user's advantage to use the DATA statements method (lines 520 and 530) of inserting machine parameters and seam conditions for his or her own operation and then SAVE(ing) the revised program for later reuse. If this is not done, each time the computer is turned off the site-specific changes inserted will be lost. After the data have been entered, they will be listed and the user will be given the opportunity to make changes or corrections (fig. 2). If there are changes, the entire data list will be printed again so change(s) may be made in response to prompts shown in figure 3. After necessary changes have been made, or if no changes are necessary, the user next has the option of having the program calculate the optimum bit spacing. For compressive coal strength less than 4,000 psi, bit spacing will be two times the maximum depth of cut. For a compressive strength greater than 4,000 psi, bit spacing will be 4/3 times the maximum depth of cut. The program then prints a table containing bit information, maximum cutting force available per bit, production information, and dust levels (fig. 4). The calculations are always maximums based on full utilization of the free volume of the drum. The user does not have the option of increasing the original maximum volume shown. If the user attempts to increase the maximum, the program will automatically print

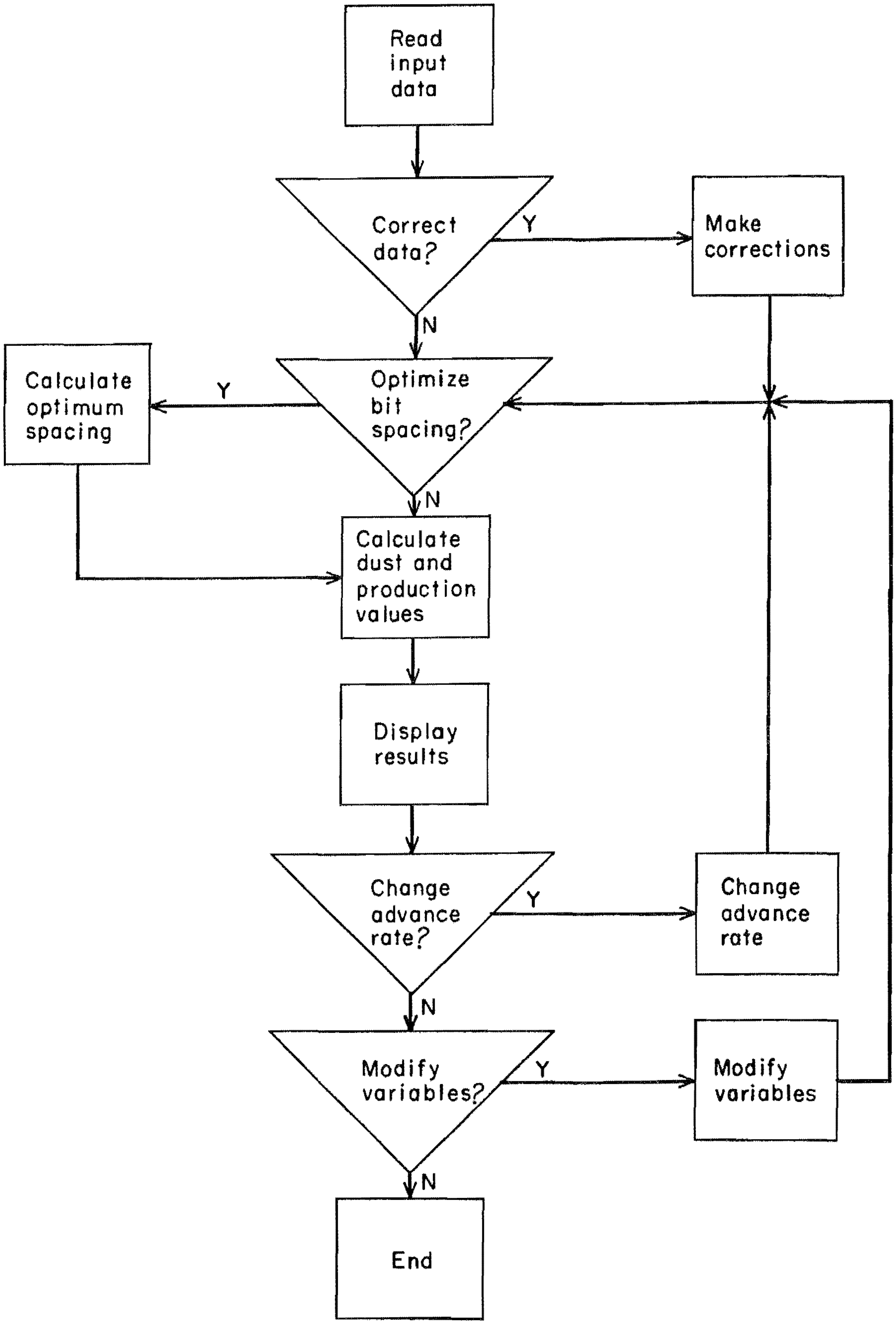

FIGURE 1. - Flowchart.

```
]RUN

                    RELATIVE DUSTINESS INDICATOR

            by Wallace W. Roepke and Bruce D. Hanson
          US Department of the Interior, Bureau of Mines

   For technical assistance contact the authors at the Twin Cities
   Research Center, 5629 Minnehaha Avenue So., Minneapolis, MN 55417
              or phone(612) 725-3466 or 725-3232

  THIS PROGRAM CALCULATES RELATIVE RESPIRABLE DUST GENERATED BY A ROTARY DRUM
 BASED ON THE DRUM DIMENSIONS, COAL PARAMETERS AND OPERATING CONDITIONS OF THE
 MINER. SECONDARY DUST, THAT IS, DUST GENERATED BY THE GRINDING ACTION OF THE
 DRUM AND FALLING COAL, IS INCLUDED IN THE CALCULATIONS. THE EFFECTS OF
 SUPPRESSION AND/OR COLLECTION SYSTEMS ARE NOT INCORPORATED. THE USER CAN
 MODIFY ALL OF THE DRUM DIMENSIONS, COAL PARAMETERS AND OPERATING CONDITIONS
 EITHER COLLECTIVELY OR INDIVIDUALLY TO DETERMINE THE EFFECT ON DUST GENERATION.

 .....HIT ANY KEY TO CONTINUE.....


 DRUM DIAMETER (IN)              51      INNER DRUM DIAMETER (IN)       30.625
 TOP VANE DIAMETER (IN)          45      DRUM VANE WRAP (DEG)          150
 VANE WIDTH (IN)                 27.5    WEB WIDTH (IN)                 30
 VANE LENGTH (IN)                65.01   VANE ANGLE (DEG)               64.97
 VANE THICKNESS (IN)              3      VANE HEIGHT (IN)                6
 NUMBER OF STARTS                 3      DRUM REVOLUTIONS (RPM)         41
 SHEARER H.P.                   250      SWELL FACTOR                    1.4
 COMPRESSIVE STRENGTH (PSI)    3400      GRINDABILITY INDEX            100
 FIRST DUST PARAMETER      10000000      SECOND DUST PARAMETER     5000000
 AIRFLOW (CFM)                 5000      PRODUCTION TIME PER SHIFT (%) 20

             PLEASE CHECK THESE VALUES, DO YOU
             WISH TO MAKE ANY CHANGES (Y/N) ? Y
```

FIGURE 2. - Program output showing listing of input variables and data correction prompts.

THE FREE VOLUME OF THE DRUM HAS BEEN EXCEEDED. EXCESSIVE RESPIRABLE DUST IS BEING CREATED BY RECIRCULATION AND CRUSHING OF THE CUT COAL.

The assumption is made in the program that coal beyond the maximum free volume always produces respirable dust in excess of the legal limit.

The user has the option of modifying the maximums by reducing the advance rate to match a particular situation. When this option is selected, the user inputs the new advance in either feet per minute, short tons per minute, or cubic feet per minute. Once the new advance rate is entered, the program asks if the optimum bit spacing is to be calculated for the reduced advance rate. The program output will proceed as described in figure 5. It should be noted that if the user subsequently modifies any of the parameters, the program will revert to using maximum free volume in the calculations. If the user does not use the reduced advance option, the program prompt asks if there are any changes in drum dimensions, bit parameters, or operating conditions. If the user responds in the affirmative, the program will go back to the data modification procedure (fig. 3). A "NO" (N) response terminates the program. Note in

```
1 - DRUM DIAMETER (IN)                 51
2 - TOP VANE DIAMETER (IN)             45
3 - INNER DRUM DIAMETER (IN)           30.625
4 - DRUM REVOLUTIONS (RPM)             41
5 - VANE WIDTH (IN)                    27.5
6 - WEB WIDTH (IN)                      30
7 - DRUM VANE WRAP (DEG)               150
8 - VANE THICKNESS (IN)                3
9 - VANE HEIGHT (IN)                   6
10 - NUMBER OF STARTS                  3
11 - BITS PER VANE                     6
12 - NUMBER OF GAGE BITS               24
13 - NUMBER OF GAGE LINES              4
14 - SHEARER H.P.                      250
15 - COMPRESSIVE STRENGTH (PSI)        3400
16 - GRINDABILITY INDEX                100
17 - SWELL FACTOR                      1.4
18 - FIRST DUST PARAMETER              10000000
19 - SECOND DUST PARAMETER             5000000
20 - PRODUCTION TIME PER SHIFT (%)     20
21 - AIRFLOW (CFM)                     5000

ENTER THE NUMBER OF THE VARIABLE YOU WISH
TO CHANGE, USE ZERO(0) TO TERMINATE - 21
ENTER NEW AIRFLOW (CFM) - 7500


ENTER THE NUMBER OF THE VARIABLE YOU WISH
TO CHANGE, USE ZERO(0) TO TERMINATE - 0
```

FIGURE 3. - Program output showing data modification procedure.

figure 5 that the dust increased even though the production was reduced by one-third from 12 st/min to 8 st/min. This occurs because the depth of cut was decreased, causing two more bits per vane to be inserted when optimum bit spacing was used.

An example of program use is summarized in table 2. The program printouts for this example are shown in appendix C.

For the sake of brevity, only the portion of the printout necessary for the reader to follow the example is included in appendix C. In this particular example, six operator-controlled variables were changed to reduce the dust level.

The last two lines of table 2 show how the program can be used to examine means of increasing production levels and determine the effect on relative dust levels. The data incorporated into the program are for a specific shearer system. All of the examples presented in the text use the program as written so that readers may follow it easily. It is anticipated that each user will insert specific system conditions in the manner described above.

```
DO YOU WISH TO RECALCULATE OPTIMUM BITS
PER VANE (CURRENT VALUE IS 6) (Y/N) ? Y
```

```
MAX. CUT DEPTH, VANE BIT (IN)   3.03   MAX. CUT DEPTH, GAGE BIT (IN)    .5
VANE BIT SPACING (IN)           5.5    NUMBER OF GAGE LINES             4
BITS PER VANE                   4      NUMBER OF GAGE BITS PER LINE     6
AVAIL. CUTTING FORCE (LB)    2511.77

ADVANCE (FT/MIN)               31.04   CUBIC FEET PER MINUTE        302.31
TONS PER SHIFT               1160.87   TONS PER MINUTE               12.09

DUST (MG) PER MINUTE         3937.23   DUST (MG) PER TON            325.59
VANE CONTRIBUTION (%)          47.91   GAGE CONTRIBUTION (%)         52.09

            ****************************************
            * DUST CONCENTRATION (MG/M^3)     3.71 *
            ****************************************
```

FIGURE 4. - Program output showing dust value for optimum bit spacing option with maximum production.

```
ANY CHANGE IN ADVANCE(FT/MIN), TONS PER MINUTE,
OR CUBIC FEET PER MINUTE (Y/N) ? Y

ENTER NEW VALUE IF YOU WISH TO CHANGE ADVANCE,
OTHERWISE ENTER ZERO (0) - 0

ENTER NEW VALUE IF YOU WISH TO CHANGE TONS PER MINUTE,
OTHERWISE ENTER ZERO (0) - 8

DO YOU WISH TO RECALCULATE OPTIMUM BITS
PER VANE (CURRENT VALUE IS 4) (Y/N) ? Y




MAX. CUT DEPTH, VANE BIT (IN)   2       MAX. CUT DEPTH, GAGE BIT (IN)   .33
VANE BIT SPACING (IN)          3.93     NUMBER OF GAGE LINES             4
BITS PER VANE                  6        NUMBER OF GAGE BITS PER LINE     6
AVAIL. CUTTING FORCE (LB)   1674.51

ADVANCE (FT/MIN)              20.53     CUBIC FEET PER MINUTE          200
TONS PER SHIFT               768        TONS PER MINUTE                  8

DUST (MG) PER MINUTE        4239.31     DUST (MG) PER TON           529.91
VANE CONTRIBUTION (%)         54.38     GAGE CONTRIBUTION (%)        45.62

                ****************************************
                * DUST CONCENTRATION (MG/M^3)      3.99 *
                ****************************************
```

FIGURE 5. - Program output showing effect of changing advance rate.

TABLE 2. - Program usage example: Operator-controlled variables

Number of gage--		Number of vane--		Speed, rpm	Advance rate, st/min	Airflow, Mcfm	Time cutting, pct	Production, st per shift	Dust level, mg/m^3
Bits	Lines	Bits	Vanes						
24	4	30	3	41	12.09	5	40	2,321	19.12
24	4	30	3	41	8	5	40	1,536	16.32
24	4	30	3	41	8	8	40	1,536	10.2
24	4	18	3	41	8	8	40	1,536	7.49
15	3	18	3	41	8	8	40	1,536	6.26
15	3	18	3	41	8	8	20	768	3.13
15	3	18	3	41	8	10	20	768	2.5
15	3	15	3	41	8	10	20	768	2.23
15	3	15	3	35	8	10	20	768	2.01
12	3	15	3	35	8	10	20	768	1.88
12	3	15	3	35	9	10	20	864	1.97
12	3	12	3	35	10.32	10	20	991	1.81

PROGRAM CONVERSION

To convert the Apple IIe program for use with another microcomputer, the output statements must be modified. The Apple IIe version assumes a screen 80 columns wide with 24 vertical lines. Conversion to a 40-column screen is accomplished by abbreviating the text portion of the output. If the text scrolls off the screen, elimination of print statements that print blank lines will close the text. If the data modification section (fig. 2) scrolls off the screen, printing the data list in two columns should alleviate the problem.

Using the HTAB function is necessary with the Apple IIe because the TAB function acts as a SPC (space) function when the IIe is in the 80-column mode. The HTAB statements must be deleted or replaced with an equivalent function, such as LOCATE (IBM PC BASIC.) Deleting the HTAB statements will have no effect on the output except an occasional shifting of the left column.

Modification of the subroutine, starting at line 2180 and lines 1530-1580 in the main program, will be necessary if the optional hard copy feature is to be retained. The BASIC manual for the particular system being used should be consulted.

The GET A$ statement (line 230) is used to stop the program to allow the user to read the preamble. The GET function should be replaced with an equivalent function. An alternative is to use an INPUT A$, in which case the program can only be continued by hitting the RETURN key.

SUMMARY

An interactive computer program written in BASIC has been developed to allow operators and others to determine relative dustiness at the face. The program lets the user make one or more changes in the cutting system to determine the effect of these changes without the time or expense of making the changes on the equipment at the face.

The program is a precursor to a more sophisticated cutting system model. The complete cutting system model will more rigorously calculate average and peak forces and will incorporate engineering factors such as torque, thrust, and motor size requirements.

APPENDIX A.--PROGRAM LISTING

```
10  DIM NAM$(21),IV(21)
20  PR# 3
30  PRINT
40  PRINT
50  PRINT  TAB( 26);"RELATIVE DUSTINESS INDICATOR"
60  PRINT
70  PRINT  TAB( 20);"by Wallace W. Roepke and Bruce D. Hanson"
80  PRINT  TAB( 17);"US Department of the Interior, Bureau of Mines"
90  PRINT
100  PRINT "     For technical assistance contact the authors at the Twin
      Cities"
110  PRINT "     Research Center, 5629 Minnehaha Avenue So., Minneapolis,
      MN 55417"
120  PRINT  TAB( 20);"or phone(612) 725-3466 or 725-3232"
130  PRINT
140  PRINT "  THIS PROGRAM CALCULATES RELATIVE RESPIRABLE DUST GENERATED
     BY A ROTARY DRUM"
150  PRINT "BASED ON THE DRUM DIMENSIONS, COAL PARAMETERS AND OPERATING C
     ONDITIONS OF THE"
160  PRINT "MINER. SECONDARY DUST, THAT IS, DUST GENERATED BY THE GRINDIN
     G ACTION OF THE"
170  PRINT "DRUM AND FALLING COAL, IS INCLUDED IN THE CALCULATIONS. THE E
     FFECTS OF"
180  PRINT "SUPPRESSION AND/OR COLLECTION SYSTEMS ARE NOT INCORPORATED. T
     HE USER CAN"
190  PRINT "MODIFY ALL OF THE DRUM DIMENSIONS, COAL PARAMETERS AND OPERAT
     ING CONDITIONS"
200  PRINT "EITHER COLLECTIVELY OR INDIVIDUALLY TO DETERMINE THE EFFECT O
     N DUST GENERATION."
210  PRINT
220  PRINT ".....HIT ANY KEY TO CONTINUE....."
230  GET A$
240 C1 =  LOG (10)
250  DEF  FN RO(X) =  INT (100 * X + .5) / 100
260  DEF  FN OP(Y) =  INT ( LOG (Y) / C1)
270 NAM$(1) = "DRUM DIAMETER (IN)"
280 NAM$(2) = "TOP VANE DIAMETER (IN)"
290 NAM$(3) = "INNER DRUM DIAMETER (IN)"
300 NAM$(4) = "DRUM REVOLUTIONS (RPM)"
310 NAM$(5) = "VANE WIDTH (IN)"
320 NAM$(6) = "WEB WIDTH (IN)"
330 NAM$(7) = "DRUM VANE WRAP (DEG)"
340 NAM$(8) = "VANE THICKNESS (IN)"
350 NAM$(9) = "VANE HEIGHT (IN)"
360 NAM$(10) = "NUMBER OF STARTS"
370 NAM$(11) = "BITS PER VANE "
380 NAM$(12) = "NUMBER OF GAGE BITS"
390 NAM$(13) = "NUMBER OF GAGE LINES"
400 NAM$(14) = "SHEARER H.P."
410 NAM$(15) = "COMPRESSIVE STRENGTH (PSI)"
420 NAM$(16) = "GRINDABILITY INDEX"
430 NAM$(17) = "SWELL FACTOR"
440 NAM$(18) = "FIRST DUST PARAMETER"
450 NAM$(19) = "SECOND DUST PARAMETER"
460 NAM$(20) = "PRODUCTION TIME PER SHIFT (%)"
470 NAM$(21) = "AIRFLOW (CFM)"
```

```
480 PI = 3.1415926
490  FOR I = 1 TO 21
500  READ IV(I)
510  NEXT I
520  DATA       51,45,30.625,41,27.5,30,150,3,6,3,6,24,4,250,3400,100
530  DATA      1.4,1E7,5E6,20,5000
540  GOTO 600
550  FOR I = 1 TO 19 STEP 3
560  PRINT
570  PRINT "ENTER ";NAM$(I);", ";NAM$(I + 1);" AND ";NAM$(I + 2);
580  INPUT " - ";IV(I),IV(I + 1),IV(I + 2)
590  NEXT I
600  PRINT
610  PRINT
620 FL = 0
630 VL = (((PI * IV(2)) * (IV(7) / 360)) ^ 2 + (IV(5)) ^ 2) ^ (1 / 2)
640 AN =  ATN ((PI * IV(2) * (IV(7) / 360)) / IV(5)) * (180 / PI)
650 X = 13 -  FN OP(IV(1))
660  PRINT "DRUM DIAMETER (IN)"; SPC( X);IV(1);
670 X = 7 -  FN OP(IV(3))
680  HTAB 36
690  PRINT "   INNER DRUM DIAMETER (IN)"; SPC( X);IV(3)
700 X = 9 -  FN OP(IV(2))
710  PRINT "TOP VANE DIAMETER (IN)"; SPC( X);IV(2);
720 X = 11 -  FN OP(IV(7))
730  HTAB 36
740  PRINT "   DRUM VANE WRAP (DEG)"; SPC( X);IV(7)
750 X = 16 -  FN OP(IV(5))
760  PRINT "VANE WIDTH (IN)"; SPC( X);IV(5);
770  HTAB 36
780 X = 17 -  FN OP(IV(6))
790  PRINT "   WEB WIDTH (IN)"; SPC( X);IV(6)
800 X = 15 -  FN OP(VL)
810  PRINT "VANE LENGTH (IN)"; SPC( X); FN RO(VL);
820  HTAB 36
830 X = 15 -  FN OP(AN)
840  PRINT "   VANE ANGLE (DEG)"; SPC( X); FN RO(AN)
850 X = 12 -  FN OP(IV(8))
860  PRINT "VANE THICKNESS (IN)"; SPC( X);IV(8);
870  HTAB 36
880 X = 15 -  FN OP(IV(9))
890  PRINT "   VANE HEIGHT (IN)"; SPC( X);IV(9)
900 X = 15 -  FN OP(IV(10))
910  PRINT "NUMBER OF STARTS"; SPC( X);IV(10);
920  HTAB 36
930 X = 9 -  FN OP(IV(4))
940  PRINT "   DRUM REVOLUTIONS (RPM)"; SPC( X);IV(4)
950 X = 19 -  FN OP(IV(14))
960  PRINT "SHEARER H.P."; SPC( X);IV(14);
970  HTAB 36
980 X = 19 -  FN OP(IV(17))
990  PRINT "   SWELL FACTOR"; SPC( X);IV(17)
1000 X = 5 -  FN OP(IV(15))
1010  PRINT "COMPRESSIVE STRENGTH (PSI)"; SPC( X);IV(15);
1020  HTAB 36
```

```
1030 X = 13 -  FN OP(IV(16))
1040  PRINT "   GRINDABILITY INDEX"; SPC( X);IV(16)
1050 X = 10 -  FN OP(IV(18))
1060  PRINT "FIRST DUST PARAMETER"; SPC( X);IV(18);
1070  HTAB 36
1080 X = 10 -  FN OP(IV(19))
1090  PRINT "   SECOND DUST PARAMETER"; SPC( X);IV(19)
1100 X = 18 -  FN OP(IV(21))
1110  PRINT "AIRFLOW (CFM)"; SPC( X);IV(21);
1120  HTAB 36
1130 X = 2 -  FN OP(IV(20))
1140  PRINT "   PRODUCTION TIME PER SHIFT (%)"; SPC( X);IV(20)
1150  PRINT
1160  PRINT  TAB( 18)"PLEASE CHECK THESE VALUES, DO YOU"
1170  PRINT  TAB( 18)"WISH TO MAKE ANY CHANGES ";
1180  INPUT "(Y/N) ? ";A$
1190  IF A$ = "Y" THEN  GOSUB 2030
1200 VO = (PI * (IV(1) / 2) ^ 2 - PI * (IV(3) / 2) ^ 2) * IV(6)
1210 VO = VO - VL * IV(9) * IV(8) * IV(10)
1220 CM = VO / IV(17) / 3456 * IV(4)
1230 CF = CM
1240  GOSUB 1940
1250 TP = (CF * 80) / 2000
1260 AD = (CF / (IV(1) / 12)) / (IV(5) / 12)
1270 DC = AD * 12 / IV(10) / IV(4)
1280 PS = TP * 4.8 * IV(20)
1290 GD = DC / (IV(12) / IV(13))
1300  IF IV(11) > 0 THEN 1360
1310 SF = 2
1320  IF IV(15) > 4000 THEN SF = 4 / 3
1330 OS = DC * SF
1340 F = IV(5) / OS - .5
1350 IV(11) =  INT (F)
1360 BI = IV(10) * IV(11) + IV(12)
1370 OS = IV(5) / (IV(11) + 1)
1380 PO = IV(12) / IV(13)
1390 T = (IV(14) * 33000) / (2 * PI * IV(4))
1400 TD = IV(1) / 2
1410 FC = (12 * T) / TD
1420 FC = FC / (IV(11) * IV(10) * .5)
1430 DV = (BI - IV(12)) * (IV(18) + .8 * IV(19) * DC) * IV(16) / 10
1440 DG = IV(12) * (IV(18) + .8 * IV(19) * GD) * IV(16) / 10
1450 DU = DV + DG
1460 VC = 100 * DV / DU
1470 GC = 100 - VC
1480 DU = DU * PI * IV(1) / 12
1490 DM = DU * IV(4) / 7.7E8
1500 DT = DM / TP
1510 DS = 35.3145 * DM / IV(21)
1520 DS = DS * IV(20) / 100
1530 Y = 3
```

```
1540  GOSUB 2180
1550  PRINT : PRINT  TAB( 18)"DO YOU WISH A HARD COPY OF THE ABOVE RESULT
     S";: INPUT " (Y/N) ? ";A$
1560  IF A$ = "N" THEN 1590
1570 Y = 1: GOSUB 2180
1580 Y = 3: GOSUB 2180
1590  PRINT
1600  PRINT  TAB( 18);"ANY CHANGE IN ADVANCE(FT/MIN), TONS PER MINUTE,"
1610  PRINT  TAB( 18)"OR CUBIC FEET PER MINUTE";
1620  INPUT " (Y/N) ? ";A$
1630  IF A$ = "N" THEN 1670
1640  GOSUB 1760
1650  PRINT
1660  GOTO 1250
1670  PRINT
1680  PRINT  TAB( 18)"ANY CHANGE IN DRUM DIMENSIONS, BIT PARAMETERS,"
1690  PRINT  TAB( 18)"OR OPERATING CONDITIONS";
1700  INPUT " (Y/N) ? ";A$
1710  PRINT
1720  IF A$ <  > "Y" THEN 1750
1730  GOSUB 2030
1740  GOTO 600
1750  END
1760  PRINT
1770  PRINT  TAB( 18)"ENTER NEW VALUE IF YOU WISH TO CHANGE ADVANCE, "
1780  PRINT  TAB( 18)"OTHERWISE ENTER ZERO";
1790  INPUT " (0) - ";AD
1800  IF AD = 0 THEN 1830
1810 CF = IV(1) / 12 * IV(5) / 12 * AD
1820  GOTO 1940
1830  PRINT
1840  PRINT  TAB( 18)"ENTER NEW VALUE IF YOU WISH TO CHANGE TONS PER MINU
     TE,"
1850  PRINT  TAB( 18)"OTHERWISE ENTER ZERO";
1860  INPUT " (0) - ";TP
1870  IF TP = 0 THEN 1900
1880 CF = (TP * 2000) / 80
1890  GOTO 1940
1900  PRINT
1910  PRINT  TAB( 18)"ENTER NEW CUBIC FEET PER ";
1920  INPUT "MINUTE - ";CF
1930  IF CF = 0 THEN 1940
1940  PRINT
1950  PRINT  TAB( 18)"DO YOU WISH TO RECALCULATE OPTIMUM BITS"
1960  PRINT  TAB( 18)"PER VANE (CURRENT VALUE IS ";IV(11);")";
1970  INPUT " (Y/N) ? ";A$
1980  IF A$ = "Y" THEN IV(11) = 0
1990 FL = 0
2000  IF CF > CM THEN FL = 1
2010  PRINT
2020  RETURN
2030  PRINT
2040  PRINT
```

```
2050  FOR I = 1 TO 21
2060 X = 35 -  LEN (NAM$(I)) -  INT (I / 10)
2070  PRINT  TAB( 18)I;" - ";NAM$(I); TAB( X);IV(I)
2080  NEXT I
2090  PRINT
2100  PRINT  TAB( 18)"ENTER THE NUMBER OF THE VARIABLE YOU WISH "
2110  PRINT  TAB( 18)"TO CHANGE, USE ZERO(0) TO TERMINATE ";
2120  INPUT "- ";J
2130  IF J = 0 THEN  RETURN
2140  PRINT  TAB( 18)"ENTER NEW ";NAM$(J);
2150  INPUT " - ";IV(J)
2160  GOTO 2090
2170  RETURN
2180  PR# Y
2190  FOR I = 1 TO 6
2200  PRINT
2210  NEXT I
2220 X = 2 -  FN OP(DC)
2230  PRINT "MAX. CUT DEPTH, VANE BIT (IN)"; SPC( X); FN RO(DC);
2240 X = 2 -  FN OP(GD)
2250  HTAB 36
2260  PRINT "   MAX. CUT DEPTH, GAGE BIT (IN)"; SPC( X); FN RO(GD)
2270 X = 10 -  FN OP(OS)
2280  PRINT "VANE BIT SPACING (IN)"; SPC( X); FN RO(OS);
2290  HTAB 36
2300 X = 11 -  FN OP(IV(13))
2310  PRINT "   NUMBER OF GAGE LINES"; SPC( X);IV(13)
2320 X = 18 -  FN OP(IV(11))
2330  PRINT "BITS PER VANE"; SPC( X);IV(11);
2340  HTAB 36
2350 X = 3 -  FN OP(PO)
2360  PRINT "   NUMBER OF GAGE BITS PER LINE"; SPC( X);PO
2370 X = 6 -  FN OP(FC)
2380  PRINT "AVAIL. CUTTING FORCE (LB)"; SPC( X); FN RO(FC)
2390  PRINT
2400 X = 15 -  FN OP(AD)
2410  PRINT "ADVANCE (FT/MIN)"; SPC( X); FN RO(AD);
2420 X = 10 -  FN OP(CF)
2430  HTAB 36
2440  PRINT "   CUBIC FEET PER MINUTE"; SPC( X); FN RO(CF)
2450 X = 17 -  FN OP(PS)
2460  PRINT "TONS PER SHIFT"; SPC( X); FN RO(PS);
2470  HTAB 36
2480 X = 16 -  FN OP(TP)
2490  PRINT "   TONS PER MINUTE"; SPC( X); FN RO(TP)
2500  PRINT
2510 X = 11 -  FN OP(DM)
2520  PRINT "DUST (MG) PER MINUTE"; SPC( X); FN RO(DM);
2530  HTAB 36
2540 X = 14 -  FN OP(DT)
2550  PRINT "   DUST (MG) PER TON"; SPC( X); FN RO(DT)
2560 X = 10 -  FN OP(VC)
```

```
2570  PRINT "VANE CONTRIBUTION (%)"; SPC( X); FN RO(VC);
2580 X = 10 -  FN OP(GC)
2590  HTAB 36
2600  PRINT "   GAGE CONTRIBUTION (%)"; SPC( X); FN RO(GC)
2610  PRINT
2620  PRINT  TAB( 18);"*****************************************"
2630 X = 6 -  FN OP(DS)
2640  IF FL > 0 THEN 2680
2650  PRINT  TAB( 18);"* DUST CONCENTRATION (MG/M^3)"; SPC( X); FN RO(DS)
     ;" *"
2660  PRINT  TAB( 18);"*****************************************"
2670  IF FL = 0 THEN 2730
2680  PRINT  TAB( 18);"* THE FREE VOLUME OF THE DRUM HAS BEEN  *"
2690  PRINT  TAB( 18);"* EXCEEDED, EXCESSIVE RESPIRABLE DUST   *"
2700  PRINT  TAB( 18);"* IS BEING CREATED BY RECIRCULATION AND *"
2710  PRINT  TAB( 18);"* CRUSHING OF THE CUT COAL              *"
2720  PRINT  TAB( 18);"*****************************************"
2730  PRINT
2740  RETURN
```

APPENDIX B.--VARIABLE, FUNCTION, AND PROGRAM DESCRIPTIONS

Variable	Variable Description
AD	Advance rate, ft/min
AN	Vane angle, degree
BI	Total number of bits, vane plus gage
CF	Production rate, ft^3/min of in situ coal
CM	Same as CF
DC	Depth of cut for vane bits, in
DG	Dust from gage bits, μm^3/ft
DM	Total dust rate, mg/min
DS	Total dust concentration, mg/m^3
DT	Total dust rate, mg/st coal
DU	Dust per revolution, μm^3
DV	Dust from vane bits, μm^3/ft
FC	Available force per vane bit, lb
FL	Flag, set to 1 if free volume of drum is exceeded
GC	Contribution of gage bits to bit dust make, pct
GD	Depth of cut for gage bits, in
OS	Bit spacing, in
PO	Number of bits per gage line
SF	Spacing factor
TD	Drum radius, in
TP	Production rate, st/min
VC	Contribution of vane bits to dust make, pct
VL	Vane length, in
VO	Internal free volume drum, in^3

Function Description

Two functions are used in the program for output purposes. Function RO(X) rounds off to two places to the right of the decimal. Function OP(X) returns the number of digits to the left of the decimal.

Program Description

Line Numbers	Description
10-470........................	Prints output heading, sets values for NAM$, PI and defines two functions RO and OP, which are used for output purposes.
490-530........................	Reads input data using DATA statements
550-590........................	Reads input data from screen
620...........................	Zeros flag for drum volume being exceeded
630...........................	Computes vane length (VL) from the formula $VL^2 = (\pi \times TVD \times WA/360)^2 + VW^2$, where TVD = top vane diameter, WA = wrap angle, VW = vane width
640...........................	Computes vane angle (VA) from the formula $VA = \arctan (\pi \times TVD \times WA/360*VW)$ where TVD = top vane diameter, WA = wrap angle, VW = vane width
650-1190......................	Prints listing of input variables
1200-1420.....................	Computes operating parameters of drum
1200-1210.....................	Computes free volume of the drum, which is equal to outer drum volume minus the inner drum diameter volume minus the volume of the vanes
1220..........................	Computes maximum cubic feet (in situ) per minute. The constant 3456 is 1728 (cubic inches in a cubic foot) times 2 (only 1/2 the drum is cutting coal).
1230-1420.....................	Computes operating parameters for the drum. A coal density of 80 lb/ft^3 is used in line 1250. The available force per bit calculation in line 1420 assumes only half the bits are in the coal at any instant of time.
1430-1520.....................	Computes dust values. Primary dust is assumed to have a linear relationship with depth of cut. The factor of 0.8 in line 1440 is the ratio of average depth of cut to maximum depth of cut. Also in line 1440, the total dust is found by multiplying the primary dust by the grindability index and dividing by 10. In line 1440, the constant 7.7×10^8 converts cubic micrometers to milligrams. In 1510, the constant 35.3145 converts cubic feet per minute to cubic meters per minute.
1530-1580.....................	Prints operating parameters and dust values
1590-1750.....................	Checks if user wishes to change advance rate or drum variables
1760-2020.....................	Subroutine for changing advance rate
2030-2170.....................	Subroutine for changing drum variables
2180-2740.....................	Subroutine for printing operating parameters and dust values

APPENDIX C.--EXAMPLE OF OUTPUT

```
]RUN

                    RELATIVE DUSTINESS INDICATOR

              by Wallace W. Roepke and Bruce D. Hanson
           US Department of the Interior, Bureau of Mines

     For technical assistance contact the authors at the Twin Cities
     Research Center, 5629 Minnehaha Avenue So., Minneapolis, MN 55417
                  or phone(612) 725-3466 or 725-3232

  THIS PROGRAM CALCULATES RELATIVE RESPIRABLE DUST GENERATED BY A ROTARY DRUM
BASED ON THE DRUM DIMENSIONS, COAL PARAMETERS AND OPERATING CONDITIONS OF THE
MINER. SECONDARY DUST, THAT IS, DUST GENERATED BY THE GRINDING ACTION OF THE
DRUM AND FALLING COAL, IS INCLUDED IN THE CALCULATIONS. THE EFFECTS OF
SUPPRESSION AND/OR COLLECTION SYSTEMS ARE NOT INCORPORATED. THE USER CAN
MODIFY ALL OF THE DRUM DIMENSIONS, COAL PARAMETERS AND OPERATING CONDITIONS
EITHER COLLECTIVELY OR INDIVIDUALLY TO DETERMINE THE EFFECT ON DUST GENERATION.

.....HIT ANY KEY TO CONTINUE.....


DRUM DIAMETER (IN)              51      INNER DRUM DIAMETER (IN)       30.625
TOP VANE DIAMETER (IN)          45      DRUM VANE WRAP (DEG)          150
VANE WIDTH (IN)                 27.5    WEB WIDTH (IN)                 30
VANE LENGTH (IN)                65.01   VANE ANGLE (DEG)               64.97
VANE THICKNESS (IN)              3      VANE HEIGHT (IN)                6
NUMBER OF STARTS                 3      DRUM REVOLUTIONS (RPM)         41
SHEARER H.P.                   250      SWELL FACTOR                    1.4
COMPRESSIVE STRENGTH (PSI)  3400        GRINDABILITY INDEX            100
FIRST DUST PARAMETER    10000000        SECOND DUST PARAMETER     5000000
AIRFLOW (CFM)                5000       PRODUCTION TIME PER SHIFT (%) 20

               PLEASE CHECK THESE VALUES, DO YOU
               WISH TO MAKE ANY CHANGES (Y/N) ? Y
```

```
1 - DRUM DIAMETER (IN)                      51
2 - TOP VANE DIAMETER (IN)                  45
3 - INNER DRUM DIAMETER (IN)                30.625
4 - DRUM REVOLUTIONS (RPM)                  41
5 - VANE WIDTH (IN)                         27.5
6 - WEB WIDTH (IN)                          30
7 - DRUM VANE WRAP (DEG)                    150
8 - VANE THICKNESS (IN)                     3
9 - VANE HEIGHT (IN)                          6
10 - NUMBER OF STARTS                       3
11 - BITS PER VANE                          6
12 - NUMBER OF GAGE BITS                    24
13 - NUMBER OF GAGE LINES                   4
14 - SHEARER H.P.                           250
15 - COMPRESSIVE STRENGTH (PSI)             3400
16 - GRINDABILITY INDEX                     100
17 - SWELL FACTOR                           1.4
18 - FIRST DUST PARAMETER                   10000000
19 - SECOND DUST PARAMETER                  5000000
20 - PRODUCTION TIME PER SHIFT (%)        20
21 - AIRFLOW (CFM)                        5000

ENTER THE NUMBER OF THE VARIABLE YOU WISH
TO CHANGE, USE ZERO(0) TO TERMINATE - 11
ENTER NEW BITS PER VANE  - 10

ENTER THE NUMBER OF THE VARIABLE YOU WISH
TO CHANGE, USE ZERO(0) TO TERMINATE - 20
ENTER NEW PRODUCTION TIME PER SHIFT (%) - 40

ENTER THE NUMBER OF THE VARIABLE YOU WISH
TO CHANGE, USE ZERO(0) TO TERMINATE - 0

DO YOU WISH TO RECALCULATE OPTIMUM BITS
PER VANE (CURRENT VALUE IS 10) (Y/N) ? N
```

```
MAX. CUT DEPTH, VANE BIT (IN)  3.03   MAX. CUT DEPTH, GAGE BIT (IN)   .5
VANE BIT SPACING (IN)           2.5   NUMBER OF GAGE LINES            4
BITS PER VANE                  10     NUMBER OF GAGE BITS PER LINE    6
AVAIL. CUTTING FORCE (LB)    1004.71

ADVANCE (FT/MIN)               31.04  CUBIC FEET PER MINUTE        302.31
TONS PER SHIFT               2321.75  TONS PER MINUTE               12.09

DUST (MG) PER MINUTE         6767     DUST (MG) PER TON            559.61
VANE CONTRIBUTION (%)          69.7   GAGE CONTRIBUTION (%)         30.3

                 ****************************************
                 * DUST CONCENTRATION (MG/M^3)     19.12 *
                 ****************************************

                 ANY CHANGE IN ADVANCE(FT/MIN), TONS PER MINUTE,
                 OR CUBIC FEET PER MINUTE (Y/N) ? Y

                 ENTER NEW VALUE IF YOU WISH TO CHANGE ADVANCE,
                 OTHERWISE ENTER ZERO (0) - 0

                 ENTER NEW VALUE IF YOU WISH TO CHANGE TONS PER MINUTE,
                 OTHERWISE ENTER ZERO (0) - 8

                 DO YOU WISH TO RECALCULATE OPTIMUM BITS
                 PER VANE (CURRENT VALUE IS 10) (Y/N) ? N
```

```
MAX. CUT DEPTH, VANE BIT (IN)  2      MAX. CUT DEPTH, GAGE BIT (IN)   .33
VANE BIT SPACING (IN)           2.5   NUMBER OF GAGE LINES            4
BITS PER VANE                  10     NUMBER OF GAGE BITS PER LINE    6
AVAIL. CUTTING FORCE (LB)    1004.71

ADVANCE (FT/MIN)               20.53  CUBIC FEET PER MINUTE        200
TONS PER SHIFT               1536     TONS PER MINUTE                8

DUST (MG) PER MINUTE         5776.1   DUST (MG) PER TON            722.01
VANE CONTRIBUTION (%)          66.51  GAGE CONTRIBUTION (%)         33.49

                 ****************************************
                 * DUST CONCENTRATION (MG/M^3)     16.32 *
                 ****************************************

                 ANY CHANGE IN ADVANCE(FT/MIN), TONS PER MINUTE,
                 OR CUBIC FEET PER MINUTE (Y/N) ? N

                 ANY CHANGE IN DRUM DIMENSIONS, BIT PARAMETERS,
                 OR OPERATING CONDITIONS (Y/N) ? Y
```

1 - DRUM DIAMETER (IN)		51
2 - TOP VANE DIAMETER (IN)		45
3 - INNER DRUM DIAMETER (IN)		30.625
4 - DRUM REVOLUTIONS (RPM)		41
5 - VANE WIDTH (IN)		27.5
6 - WEB WIDTH (IN)		30
7 - DRUM VANE WRAP (DEG)		150
8 - VANE THICKNESS (IN)		3
9 - VANE HEIGHT (IN)		6
10 - NUMBER OF STARTS		3
11 - BITS PER VANE		10
12 - NUMBER OF GAGE BITS		24
13 - NUMBER OF GAGE LINES		4
14 - SHEARER H.P.		250
15 - COMPRESSIVE STRENGTH (PSI)		3400
16 - GRINDABILITY INDEX		100
17 - SWELL FACTOR		1.4
18 - FIRST DUST PARAMETER		10000000
19 - SECOND DUST PARAMETER		5000000
20 - PRODUCTION TIME PER SHIFT (%)	40	
21 - AIRFLOW (CFM)	5000	

ENTER THE NUMBER OF THE VARIABLE YOU WISH
TO CHANGE, USE ZERO(0) TO TERMINATE - 21
ENTER NEW AIRFLOW (CFM) - 8000

ENTER THE NUMBER OF THE VARIABLE YOU WISH
TO CHANGE, USE ZERO(0) TO TERMINATE - 0

DRUM DIAMETER (IN)	51	INNER DRUM DIAMETER (IN)	30.625
TOP VANE DIAMETER (IN)	45	DRUM VANE WRAP (DEG)	150
VANE WIDTH (IN)	27.5	WEB WIDTH (IN)	30
VANE LENGTH (IN)	65.01	VANE ANGLE (DEG)	64.97
VANE THICKNESS (IN)	3	VANE HEIGHT (IN)	6
NUMBER OF STARTS	3	DRUM REVOLUTIONS (RPM)	41
SHEARER H.P.	250	SWELL FACTOR	1.4
COMPRESSIVE STRENGTH (PSI)	3400	GRINDABILITY INDEX	100
FIRST DUST PARAMETER	10000000	SECOND DUST PARAMETER	5000000
AIRFLOW (CFM)	8000	PRODUCTION TIME PER SHIFT (%)	40

PLEASE CHECK THESE VALUES, DO YOU
WISH TO MAKE ANY CHANGES (Y/N) ? N

DO YOU WISH TO RECALCULATE OPTIMUM BITS
PER VANE (CURRENT VALUE IS 10) (Y/N) ? N

```
MAX. CUT DEPTH, VANE BIT (IN)  2       MAX. CUT DEPTH, GAGE BIT (IN)    .33
VANE BIT SPACING (IN)           2.5    NUMBER OF GAGE LINES              4
BITS PER VANE                  10      NUMBER OF GAGE BITS PER LINE     6
AVAIL. CUTTING FORCE (LB)   1004.71

ADVANCE (FT/MIN)              20.53    CUBIC FEET PER MINUTE         200
TONS PER SHIFT              1536       TONS PER MINUTE                 8

DUST (MG) PER MINUTE        5776.1     DUST (MG) PER TON             722.01
VANE CONTRIBUTION (%)         66.51    GAGE CONTRIBUTION (%)          33.49

                  ****************************************
                  * DUST CONCENTRATION (MG/M^3)     10.2 *
                  ****************************************

                  ANY CHANGE IN ADVANCE(FT/MIN), TONS PER MINUTE,
                  OR CUBIC FEET PER MINUTE (Y/N) ? N

                  ANY CHANGE IN DRUM DIMENSIONS, BIT PARAMETERS,
                  OR OPERATING CONDITIONS (Y/N) ? Y


                  1 - DRUM DIAMETER (IN)                51
                  2 - TOP VANE DIAMETER (IN)            45
                  3 - INNER DRUM DIAMETER (IN)          30.625
                  4 - DRUM REVOLUTIONS (RPM)            41
                  5 - VANE WIDTH (IN)                   27.5
                  6 - WEB WIDTH (IN)                    30
                  7 - DRUM VANE WRAP (DEG)              150
                  8 - VANE THICKNESS (IN)               3
                  9 - VANE HEIGHT (IN)                  6
                  10 - NUMBER OF STARTS                 3
                  11 - BITS PER VANE                    10
                  12 - NUMBER OF GAGE BITS              24
                  13 - NUMBER OF GAGE LINES             4
                  14 - SHEARER H.P.                     250
                  15 - COMPRESSIVE STRENGTH (PSI)       3400
                  16 - GRINDABILITY INDEX               100
                  17 - SWELL FACTOR                     1.4
                  18 - FIRST DUST PARAMETER             10000000
                  19 - SECOND DUST PARAMETER            5000000
                  20 - PRODUCTION TIME PER SHIFT (%)   40
                  21 - AIRFLOW (CFM)                   8000

                  ENTER THE NUMBER OF THE VARIABLE YOU WISH
                  TO CHANGE, USE ZERO(0) TO TERMINATE - 11
                  ENTER NEW BITS PER VANE  - 6

                  ENTER THE NUMBER OF THE VARIABLE YOU WISH
                  TO CHANGE, USE ZERO(0) TO TERMINATE - 0
```

```
MAX. CUT DEPTH, VANE BIT (IN)  2       MAX. CUT DEPTH, GAGE BIT (IN)   .33
VANE BIT SPACING (IN)          3.93    NUMBER OF GAGE LINES             4
BITS PER VANE                  6       NUMBER OF GAGE BITS PER LINE     6
AVAIL. CUTTING FORCE (LB)   1674.51

ADVANCE (FT/MIN)              20.53    CUBIC FEET PER MINUTE          200
TONS PER SHIFT              1536       TONS PER MINUTE                  8

DUST (MG) PER MINUTE        4239.31    DUST (MG) PER TON           529.91
VANE CONTRIBUTION (%)         54.38    GAGE CONTRIBUTION (%)        45.62

                  *****************************************
                  * DUST CONCENTRATION (MG/M^3)      7.49 *
                  *****************************************

                  ANY CHANGE IN ADVANCE(FT/MIN), TONS PER MINUTE,
                  OR CUBIC FEET PER MINUTE (Y/N) ? N

                  ANY CHANGE IN DRUM DIMENSIONS, BIT PARAMETERS,
                  OR OPERATING CONDITIONS (Y/N) ? Y


                  1 - DRUM DIAMETER (IN)                51
                  2 - TOP VANE DIAMETER (IN)            45
                  3 - INNER DRUM DIAMETER (IN)          30.625
                  4 - DRUM REVOLUTIONS (RPM)            41
                  5 - VANE WIDTH (IN)                   27.5
                  6 - WEB WIDTH (IN)                    30
                  7 - DRUM VANE WRAP (DEG)              150
                  8 - VANE THICKNESS (IN)               3
                  9 - VANE HEIGHT (IN)                  6
                  10 - NUMBER OF STARTS                 3
                  11 - BITS PER VANE                    6
                  12 - NUMBER OF GAGE BITS              24
                  13 - NUMBER OF GAGE LINES             4
                  14 - SHEARER H.P.                     250
                  15 - COMPRESSIVE STRENGTH (PSI)       3400
                  16 - GRINDABILITY INDEX               100
                  17 - SWELL FACTOR                     1.4
                  18 - FIRST DUST PARAMETER             10000000
                  19 - SECOND DUST PARAMETER            5000000
                  20 - PRODUCTION TIME PER SHIFT (%)   40
                  21 - AIRFLOW (CFM)                   8000

                  ENTER THE NUMBER OF THE VARIABLE YOU WISH
                  TO CHANGE, USE ZERO(0) TO TERMINATE - 12
                  ENTER NEW NUMBER OF GAGE BITS - 15

                  ENTER THE NUMBER OF THE VARIABLE YOU WISH
                  TO CHANGE, USE ZERO(0) TO TERMINATE - 13
                  ENTER NEW NUMBER OF GAGE LINES - 3

                  ENTER THE NUMBER OF THE VARIABLE YOU WISH
                  TO CHANGE, USE ZERO(0) TO TERMINATE - 0
```

```
MAX. CUT DEPTH, VANE BIT (IN)  2       MAX. CUT DEPTH, GAGE BIT (IN)   .4
VANE BIT SPACING (IN)          3.93    NUMBER OF GAGE LINES            3
BITS PER VANE                  6       NUMBER OF GAGE BITS PER LINE    5
AVAIL. CUTTING FORCE (LB)   1674.51

ADVANCE (FT/MIN)              20.53    CUBIC FEET PER MINUTE         200
TONS PER SHIFT              1536       TONS PER MINUTE                 8

DUST (MG) PER MINUTE        3542.5     DUST (MG) PER TON             442.81
VANE CONTRIBUTION (%)         65.07    GAGE CONTRIBUTION (%)          34.93

                ****************************************
                * DUST CONCENTRATION (MG/M^3)      6.26 *
                ****************************************

                ANY CHANGE IN ADVANCE(FT/MIN), TONS PER MINUTE,
                OR CUBIC FEET PER MINUTE (Y/N) ? N

                ANY CHANGE IN DRUM DIMENSIONS, BIT PARAMETERS,
                OR OPERATING CONDITIONS (Y/N) ? Y


                1 - DRUM DIAMETER (IN)                 51
                2 - TOP VANE DIAMETER (IN)             45
                3 - INNER DRUM DIAMETER (IN)           30.625
                4 - DRUM REVOLUTIONS (RPM)             41
                5 - VANE WIDTH (IN)                    27.5
                6 - WEB WIDTH (IN)                     30
                7 - DRUM VANE WRAP (DEG)               150
                8 - VANE THICKNESS (IN)                3
                9 - VANE HEIGHT (IN)                   6
                10 - NUMBER OF STARTS                  3
                11 - BITS PER VANE                     6
                12 - NUMBER OF GAGE BITS               15
                13 - NUMBER OF GAGE LINES              3
                14 - SHEARER H.P.                      250
                15 - COMPRESSIVE STRENGTH (PSI)        3400
                16 - GRINDABILITY INDEX                100
                17 - SWELL FACTOR                      1.4
                18 - FIRST DUST PARAMETER              10000000
                19 - SECOND DUST PARAMETER             5000000
                20 - PRODUCTION TIME PER SHIFT (%)   40
                21 - AIRFLOW (CFM)                   8000

                ENTER THE NUMBER OF THE VARIABLE YOU WISH
                TO CHANGE, USE ZERO(0) TO TERMINATE - 20
                ENTER NEW PRODUCTION TIME PER SHIFT (%) - 20

                ENTER THE NUMBER OF THE VARIABLE YOU WISH
                TO CHANGE, USE ZERO(0) TO TERMINATE - 0
```

```
MAX. CUT DEPTH, VANE BIT (IN)  2       MAX. CUT DEPTH, GAGE BIT (IN)    .4
VANE BIT SPACING (IN)          3.93    NUMBER OF GAGE LINES              3
BITS PER VANE                  6       NUMBER OF GAGE BITS PER LINE      5
AVAIL. CUTTING FORCE (LB)   1674.51

ADVANCE (FT/MIN)              20.53    CUBIC FEET PER MINUTE           200
TONS PER SHIFT               768       TONS PER MINUTE                   8

DUST (MG) PER MINUTE        3542.5     DUST (MG) PER TON            442.81
VANE CONTRIBUTION (%)         65.07    GAGE CONTRIBUTION (%)         34.93

                 *****************************************
                 * DUST CONCENTRATION (MG/M^3)       3.13 *
                 *****************************************

                 ANY CHANGE IN ADVANCE(FT/MIN), TONS PER MINUTE,
                 OR CUBIC FEET PER MINUTE (Y/N) ? N

                 ANY CHANGE IN DRUM DIMENSIONS, BIT PARAMETERS,
                 OR OPERATING CONDITIONS (Y/N) ? Y


                 1 - DRUM DIAMETER (IN)                51
                 2 - TOP VANE DIAMETER (IN)            45
                 3 - INNER DRUM DIAMETER (IN)          30.625
                 4 - DRUM REVOLUTIONS (RPM)            41
                 5 - VANE WIDTH (IN)                   27.5
                 6 - WEB WIDTH (IN)                    30
                 7 - DRUM VANE WRAP (DEG)              150
                 8 - VANE THICKNESS (IN)               3
                 9 - VANE HEIGHT (IN)                  6
                 10 - NUMBER OF STARTS                 3
                 11 - BITS PER VANE                    6
                 12 - NUMBER OF GAGE BITS              15
                 13 - NUMBER OF GAGE LINES             3
                 14 - SHEARER H.P.                     250
                 15 - COMPRESSIVE STRENGTH (PSI)       3400
                 16 - GRINDABILITY INDEX               100
                 17 - SWELL FACTOR                     1.4
                 18 - FIRST DUST PARAMETER             10000000
                 19 - SECOND DUST PARAMETER            5000000
                 20 - PRODUCTION TIME PER SHIFT (%)   20
                 21 - AIRFLOW (CFM)                   8000

                 ENTER THE NUMBER OF THE VARIABLE YOU WISH
                 TO CHANGE, USE ZERO(0) TO TERMINATE - 21
                 ENTER NEW AIRFLOW (CFM) - 10000

                 ENTER THE NUMBER OF THE VARIABLE YOU WISH
                 TO CHANGE, USE ZERO(0) TO TERMINATE - 0
```

```
MAX. CUT DEPTH, VANE BIT (IN)  2      MAX. CUT DEPTH, GAGE BIT (IN)    .4
VANE BIT SPACING (IN)          3.93   NUMBER OF GAGE LINES              3
BITS PER VANE                  6      NUMBER OF GAGE BITS PER LINE      5
AVAIL. CUTTING FORCE (LB)   1674.51

ADVANCE (FT/MIN)              20.53   CUBIC FEET PER MINUTE           200
TONS PER SHIFT               768      TONS PER MINUTE                   8

DUST (MG) PER MINUTE        3542.5    DUST (MG) PER TON            442.81
VANE CONTRIBUTION (%)         65.07   GAGE CONTRIBUTION (%)         34.93

                 *****************************************
                 * DUST CONCENTRATION (MG/M^3)      2.5 *
                 *****************************************

                 ANY CHANGE IN ADVANCE(FT/MIN), TONS PER MINUTE,
                 OR CUBIC FEET PER MINUTE (Y/N) ? N

                 ANY CHANGE IN DRUM DIMENSIONS, BIT PARAMETERS,
                 OR OPERATING CONDITIONS (Y/N) ? Y


                 1 - DRUM DIAMETER (IN)                51
                 2 - TOP VANE DIAMETER (IN)            45
                 3 - INNER DRUM DIAMETER (IN)          30.625
                 4 - DRUM REVOLUTIONS (RPM)            41
                 5 - VANE WIDTH (IN)                   27.5
                 6 - WEB WIDTH (IN)                    30
                 7 - DRUM VANE WRAP (DEG)              150
                 8 - VANE THICKNESS (IN)               3
                 9 - VANE HEIGHT (IN)                  6
                 10 - NUMBER OF STARTS                 3
                 11 - BITS PER VANE                    6
                 12 - NUMBER OF GAGE BITS              15
                 13 - NUMBER OF GAGE LINES             3
                 14 - SHEARER H.P.                     250
                 15 - COMPRESSIVE STRENGTH (PSI)       3400
                 16 - GRINDABILITY INDEX               100
                 17 - SWELL FACTOR                     1.4
                 18 - FIRST DUST PARAMETER             10000000
                 19 - SECOND DUST PARAMETER            5000000
                 20 - PRODUCTION TIME PER SHIFT (%)   20
                 21 - AIRFLOW (CFM)                   10000

                 ENTER THE NUMBER OF THE VARIABLE YOU WISH
                 TO CHANGE, USE ZERO(0) TO TERMINATE - 11
                 ENTER NEW BITS PER VANE  - 5

                 ENTER THE NUMBER OF THE VARIABLE YOU WISH
                 TO CHANGE, USE ZERO(0) TO TERMINATE - 0
```

MAX. CUT DEPTH, VANE BIT (IN)	2	MAX. CUT DEPTH, GAGE BIT (IN)	.4
VANE BIT SPACING (IN)	4.58	NUMBER OF GAGE LINES	3
BITS PER VANE	5	NUMBER OF GAGE BITS PER LINE	5
AVAIL. CUTTING FORCE (LB)	2009.42		
ADVANCE (FT/MIN)	20.53	CUBIC FEET PER MINUTE	200
TONS PER SHIFT	768	TONS PER MINUTE	8
DUST (MG) PER MINUTE	3158.3	DUST (MG) PER TON	394.79
VANE CONTRIBUTION (%)	60.82	GAGE CONTRIBUTION (%)	39.18

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****************************************
* DUST CONCENTRATION (MG/M^3)      2.23 *
****************************************
```

ANY CHANGE IN ADVANCE(FT/MIN), TONS PER MINUTE,
OR CUBIC FEET PER MINUTE (Y/N) ? N

ANY CHANGE IN DRUM DIMENSIONS, BIT PARAMETERS,
OR OPERATING CONDITIONS (Y/N) ? Y

1 - DRUM DIAMETER (IN)	51
2 - TOP VANE DIAMETER (IN)	45
3 - INNER DRUM DIAMETER (IN)	30.625
4 - DRUM REVOLUTIONS (RPM)	41
5 - VANE WIDTH (IN)	27.5
6 - WEB WIDTH (IN)	30
7 - DRUM VANE WRAP (DEG)	150
8 - VANE THICKNESS (IN)	3
9 - VANE HEIGHT (IN)	6
10 - NUMBER OF STARTS	3
11 - BITS PER VANE	5
12 - NUMBER OF GAGE BITS	15
13 - NUMBER OF GAGE LINES	3
14 - SHEARER H.P.	250
15 - COMPRESSIVE STRENGTH (PSI)	3400
16 - GRINDABILITY INDEX	100
17 - SWELL FACTOR	1.4
18 - FIRST DUST PARAMETER	10000000
19 - SECOND DUST PARAMETER	5000000
20 - PRODUCTION TIME PER SHIFT (%)	20
21 - AIRFLOW (CFM)	10000

ENTER THE NUMBER OF THE VARIABLE YOU WISH
TO CHANGE, USE ZERO(0) TO TERMINATE - 4
ENTER NEW DRUM REVOLUTIONS (RPM) - 35

ENTER THE NUMBER OF THE VARIABLE YOU WISH
TO CHANGE, USE ZERO(0) TO TERMINATE - 0

```
MAX. CUT DEPTH, VANE BIT (IN)  2.35   MAX. CUT DEPTH, GAGE BIT (IN)   .47
VANE BIT SPACING (IN)          4.58   NUMBER OF GAGE LINES             3
BITS PER VANE                  5      NUMBER OF GAGE BITS PER LINE     5
AVAIL. CUTTING FORCE (LB)   2353.89

ADVANCE (FT/MIN)              20.53   CUBIC FEET PER MINUTE          200
TONS PER SHIFT               768      TONS PER MINUTE                  8

DUST (MG) PER MINUTE        2846.18   DUST (MG) PER TON           355.77
VANE CONTRIBUTION (%)         62.01   GAGE CONTRIBUTION (%)        37.99

                 ****************************************
                 * DUST CONCENTRATION (MG/M^3)      2.01 *
                 ****************************************

                 ANY CHANGE IN ADVANCE(FT/MIN), TONS PER MINUTE,
                 OR CUBIC FEET PER MINUTE (Y/N) ? N

                 ANY CHANGE IN DRUM DIMENSIONS, BIT PARAMETERS,
                 OR OPERATING CONDITIONS (Y/N) ? Y


                 1 - DRUM DIAMETER (IN)                51
                 2 - TOP VANE DIAMETER (IN)            45
                 3 - INNER DRUM DIAMETER (IN)          30.625
                 4 - DRUM REVOLUTIONS (RPM)            35
                 5 - VANE WIDTH (IN)                   27.5
                 6 - WEB WIDTH (IN)                    30
                 7 - DRUM VANE WRAP (DEG)              150
                 8 - VANE THICKNESS (IN)               3
                 9 - VANE HEIGHT (IN)                  6
                 10 - NUMBER OF STARTS                 3
                 11 - BITS PER VANE                    5
                 12 - NUMBER OF GAGE BITS              15
                 13 - NUMBER OF GAGE LINES             3
                 14 - SHEARER H.P.                     250
                 15 - COMPRESSIVE STRENGTH (PSI)       3400
                 16 - GRINDABILITY INDEX               100
                 17 - SWELL FACTOR                     1.4
                 18 - FIRST DUST PARAMETER             10000000
                 19 - SECOND DUST PARAMETER            5000000
                 20 - PRODUCTION TIME PER SHIFT (%)   20
                 21 - AIRFLOW (CFM)                   10000

                 ENTER THE NUMBER OF THE VARIABLE YOU WISH
                 TO CHANGE, USE ZERO(0) TO TERMINATE - 12
                 ENTER NEW NUMBER OF GAGE BITS - 12

                 ENTER THE NUMBER OF THE VARIABLE YOU WISH
                 TO CHANGE, USE ZERO(0) TO TERMINATE - 0
```

```
MAX. CUT DEPTH, VANE BIT (IN)  2.35   MAX. CUT DEPTH, GAGE BIT (IN)   .59
VANE BIT SPACING (IN)          4.58   NUMBER OF GAGE LINES            3
BITS PER VANE                  5      NUMBER OF GAGE BITS PER LINE    4
AVAIL. CUTTING FORCE (LB)   2353.89

ADVANCE (FT/MIN)              20.53   CUBIC FEET PER MINUTE         200
TONS PER SHIFT               768      TONS PER MINUTE                 8

DUST (MG) PER MINUTE        2664.11   DUST (MG) PER TON             333.01
VANE CONTRIBUTION (%)         66.25   GAGE CONTRIBUTION (%)          33.75

                  *****************************************
                  * DUST CONCENTRATION (MG/M^3)       1.88 *
                  *****************************************

                  ANY CHANGE IN ADVANCE(FT/MIN), TONS PER MINUTE,
                  OR CUBIC FEET PER MINUTE (Y/N) ? Y

                  ENTER NEW VALUE IF YOU WISH TO CHANGE ADVANCE,
                  OTHERWISE ENTER ZERO (0) - 0

                  ENTER NEW VALUE IF YOU WISH TO CHANGE TONS PER MINUTE,
                  OTHERWISE ENTER ZERO (0) - 9

                  DO YOU WISH TO RECALCULATE OPTIMUM BITS
                  PER VANE (CURRENT VALUE IS 5) (Y/N) ? N
```

```
MAX. CUT DEPTH, VANE BIT (IN)  2.64   MAX. CUT DEPTH, GAGE BIT (IN)   .66
VANE BIT SPACING (IN)          4.58   NUMBER OF GAGE LINES            3
BITS PER VANE                  5      NUMBER OF GAGE BITS PER LINE    4
AVAIL. CUTTING FORCE (LB)   2353.89

ADVANCE (FT/MIN)              23.1    CUBIC FEET PER MINUTE         225
TONS PER SHIFT               864      TONS PER MINUTE                 9

DUST (MG) PER MINUTE        2792.3    DUST (MG) PER TON             310.26
VANE CONTRIBUTION (%)         67.03   GAGE CONTRIBUTION (%)          32.97

                  *****************************************
                  * DUST CONCENTRATION (MG/M^3)       1.97 *
                  *****************************************

                  ANY CHANGE IN ADVANCE(FT/MIN), TONS PER MINUTE,
                  OR CUBIC FEET PER MINUTE (Y/N) ? N

                  ANY CHANGE IN DRUM DIMENSIONS, BIT PARAMETERS,
                  OR OPERATING CONDITIONS (Y/N) ? Y
```

```
1 - DRUM DIAMETER (IN)                  51
2 - TOP VANE DIAMETER (IN)              45
3 - INNER DRUM DIAMETER (IN)            30.625
4 - DRUM REVOLUTIONS (RPM)              35
5 - VANE WIDTH (IN)                     27.5
6 - WEB WIDTH (IN)                      30
7 - DRUM VANE WRAP (DEG)                150
8 - VANE THICKNESS (IN)                 3
9 - VANE HEIGHT (IN)                    6
10 - NUMBER OF STARTS                   3
11 - BITS PER VANE                      5
12 - NUMBER OF GAGE BITS                12
13 - NUMBER OF GAGE LINES               3
14 - SHEARER H.P.                       250
15 - COMPRESSIVE STRENGTH (PSI)         3400
16 - GRINDABILITY INDEX                 100
17 - SWELL FACTOR                       1.4
18 - FIRST DUST PARAMETER               10000000
19 - SECOND DUST PARAMETER              5000000
20 - PRODUCTION TIME PER SHIFT (%)    20
21 - AIRFLOW (CFM)                    10000

ENTER THE NUMBER OF THE VARIABLE YOU WISH
TO CHANGE, USE ZERO(0) TO TERMINATE - 11
ENTER NEW BITS PER VANE  - 4

ENTER THE NUMBER OF THE VARIABLE YOU WISH
TO CHANGE, USE ZERO(0) TO TERMINATE - 0

DO YOU WISH TO RECALCULATE OPTIMUM BITS
PER VANE (CURRENT VALUE IS 4) (Y/N) ? N


MAX. CUT DEPTH, VANE BIT (IN)  3.03   MAX. CUT DEPTH, GAGE BIT (IN)    .76
VANE BIT SPACING (IN)          5.5    NUMBER OF GAGE LINES              3
BITS PER VANE                  4      NUMBER OF GAGE BITS PER LINE      4
AVAIL. CUTTING FORCE (LB)   2942.36

ADVANCE (FT/MIN)              26.5    CUBIC FEET PER MINUTE        258.07
TONS PER SHIFT              990.99    TONS PER MINUTE               10.32

DUST (MG) PER MINUTE       2559.26    DUST (MG) PER TON            247.92
VANE CONTRIBUTION (%)        62.93    GAGE CONTRIBUTION (%)         37.07

*****************************************
* DUST CONCENTRATION (MG/M^3)      1.81 *
*****************************************

ANY CHANGE IN ADVANCE(FT/MIN), TONS PER MINUTE,
OR CUBIC FEET PER MINUTE (Y/N) ? N

ANY CHANGE IN DRUM DIMENSIONS, BIT PARAMETERS,
OR OPERATING CONDITIONS (Y/N) ? N
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