STUDY ON FACTORS INFLUENCING WHEEL WEAR IN GRINDING PROCESS

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ABSTRACT

Grinding is well known process in manufacturing and is widely employed for finishing of engineerin g components. .During grinding process acute problems such as wheel loading high cutting temperature, wheel wear occurs. Undesirable phenomenon called wheel wear has a great impact on the surface roughness and work piece quality. This project work provides the mathematical model for estimating the parameters which largely affect wheel wear. A number of independent variables such as tangential force, depth of cut, contact length, wheel speed, work piece speed, grit density affect the wheel wear directly or indirectly are correlated. Dimensional analysis tool has been used to estimate the relationship between independent variables and wheel wear. The conclusion drawn from this study is that Pi terms obtained through dimensional analysis gives the link between parameters and wheel wear

Keyword: *Grinding, Condition monitoring, wheel wear, Mathematical Model ling, and Wheel wear detection methods*

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1. INTRODUCTION

Grinding involves the removal process of material and modifying the surface of a work piece to some desired finish which might otherwise be unachievable through conventional machining processes. A grinding wheel cuts through the work piece passes underneath Normal and tangential forces are generated between grinding wheel and work piece. The overall wheel wear is the humiliation of individual wear events from encounters of abrasive grain with the work piece. Aluminum oxide, the most popular abrasive by a wide margin, is usually recommended for grinding most steels, annealed malleable and ductile iron, and non-ferrous cast alloys. The principal use of dimensional analysis is to deduce from study of dimensions of variables in any physical system certain limitations on the form of any possible relationships between those variables. Dimensional analysis is concept of similarity. This paper demonstrates relationship between wheel wear and independent variables Literature survey was carried out on the basis of following gist.

Warkentin [2] in this paper, study on effect of wheel wear on the contact length, uncut chip thickness, and contact forces was performed. Li Xue [3] an intelligent sensor system for on-line estimation of surface roughness in the grinding process is developed. Vijay kumar Mishra [4] in the present paper, analysis of the effects of process parameters, tribology, work material and auxiliary equipment on grinding forces and specific energy has been carried out. Rupesh Patil [7].develops mathematical for solar reflector.

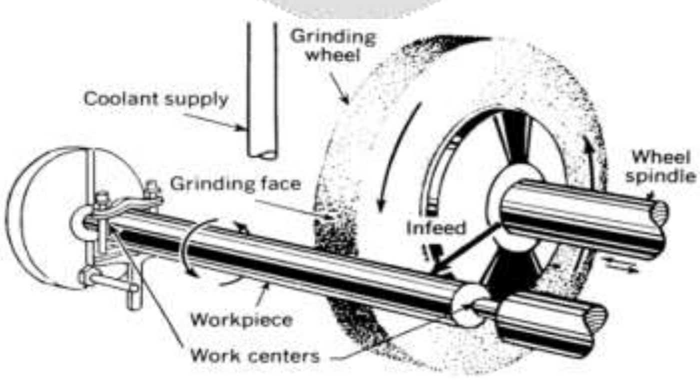

Fig -1: Grinding Operation

2. FORMULATION OF MATHEMATICAL MODEL FOR WHEEL WEAR

The mathematical model for wheel wear can be formed by determining independent and dependent variables. A dimensional analysis tool is utilized to construct a mathematical model for wheel wear which ultimately reduces set of equations to pi terms. Each pi term is a group of independent variables and relates its variation with wheel wear.

Table -1: List of dependent and independent variables and their dimensions

S. No	Variable	Symbol	Dependent/Independent	Dimension In SI unit	M L T Dimensions
1	Wheel Wear	W	Dependent	m	L
2	Tangential Force	F_t	Independent	N	$M L T^{-2}$
3	Work piece velocity	V_w	Independent	m/s	$L T^{-1}$
4	Wheel velocity	V_s	Independent	m/s	$L T^{-1}$
5	Depth of cut	a_c	Independent	m	L
6	Grit density	C	Independent	Kg/m3	$M L^{-3}$
7	Material removal rate	Q	Independent	m3/s	$L^3 T^{-1}$
8	Contact length	L	Independent	m	L
9	Traverse Feed	V_f	Independent	m/s	$L T^{-1}$

Wheel wear can be expressed as function of

$W = f (F_t, V_s, V_w, a_c, C, Q, L, V_f)$

$f (W, Ft, V_s., V_w, a_c, C, Q, L, Vf) = 0$

Total number of variables=9

n =9

Number of basic dimensions m=3

By Buckingham pi theorem

Number of Pi terms =n-m=9-3=6

$f (\pi_1, \pi_2, \pi_3, \pi_4, \pi_5, \pi_6) =0$

Choosing m+1 repeating variables as L, Vs, C

$\pi_1 = L^{a1}, Vs^{b1}, C^{c1}, W$

$\pi_2 = L^{a2}, Vs^{b2}, C^{c2}, F_t$

$\pi_3 = L^{a3}, Vs^{b3}, C^{c3}, V_w$

$\pi_4 = L^{a4}, Vs^{b4}, C^{c4}, a_c$

$\pi_5 = L^{a5}, Vs^{b5}, C^{c5}, Q$

$\pi_6 = L^{a6}, Vs^{b6}, C^{c6}, V_f$

<u>First π -Term (π_1):</u>

$\pi_1 = L^{a1}, Vs^{b1}, C^{c1}, W$

Writing each variable in terms of their respective basic dimension

$M^0L^0T^0 = [L]^{a1} \; [L T^{-1}]^{b1} \; [M L^{-3}]^{c1} [L]$

Equating powers of M

$0 = c_1$

$c_1 = 0$

Equating powers of L

$0 = a_1 + b_1 + 1$ → A

Equating powers of T

$0 = -b_1$

$b1 = 0$

Substitute in A

$a_1 = -1$

$\pi_1 = L^{-1}, Vs^0, C^0, W$

$$\pi 1 = \frac{W}{L}$$

$$\pi 1 = \frac{W}{L}$$

<u>Second π - Term(π_2)</u>

$\pi_2 = L^{a2}, Vs^{b2}, C^{c2}, F_t$

$M^0L^0T^0 = [L]^{a2} \; [L T^{-1}]^{b2} \; [M L^{-3}]^{c2} [M L T^{-2}]$

Equating powers of M

$0 = c_2 + 1$

$c_2 = -1$

Equating powers of L

$0 = a_2 + b_2 - 3c_2 + 1$ → B

Equating powers of T

$0 = -b_2 - 2$

$b_2 = -2$

Substitute in B

$a_2 = -2$

$\pi_2 = L^{-2}, Vs^{-2}, C^{-1}, F_t$

$$\pi 2 = \frac{Ft}{C \times L^2 \times Vs^2}$$

$$\boxed{\pi 2 = \frac{Ft}{C \times L^2 \times Vs^2}}$$

Third π - Term (π3):

$\pi_3 = L^{a3}, Vs^{b3}, C^{c3}, V_w$

$M^0L^0T^0 = [L]^{a3}\ [L\ T^{-1}]^{b3}\ [M\ L^{-3}]^{c3}\ [L\ T^{-1}]$

Equating powers of M

$0 = c_3$

$c_3 = 0$

Equating powers of L

$0 = a_3 + b_3 - 3c_3 + 1 \longrightarrow C$

Equating powers of T

$0 = -b_3 - 1$

$b_3 = -1$

Substitute in C

$a_3 = 0$

$\pi_3 = L^0, Vs^{-1}, C^0, V_w$

$$\pi 3 = \frac{Vw}{Vs}$$

$$\boxed{\pi 3 = \frac{Vw}{Vs}}$$

Fourth π - Term (π 4):

$\pi_4 = L^{a4}, Vs^{b4}, C^{c4}, a_c$

$M^0L^0T^0 = [L]^{a3}\ [L\ T^{-1}]^{b3}\ [M\ L^{-3}]^{c3}\ [L]$

Equating powers of M

$0 = c_4$

$c_4 = 0$

Equating powers of L

$0 = a_4 + b_4 - 3c_4 + 1$ ⟶ D

Equating powers of T

$0 = -b_4$

$b_4 = 0$

Substitute in D

$a_4 = -1$

$\pi_4 = L^{-1}, Vs^0, C^0, a_c$

$$\pi 4 = \frac{ac}{L}$$

$$\boxed{\pi 4 = \frac{ac}{L}}$$

Fifth π - Term ($\pi 5$):

$\pi_5 = L^{a5}, Vs^{b5}, C^{c5}, Q$

$M^0L^0T^0 = [L]^{a5} \; [L\,T^{-1}]^{b5} \; [M\,L^{-3}]^{c5} \, [L^3\,T^{-1}]$

Equating powers of M

$0 = c_5$

$c_5 = 0$

Equating powers of L

$0 = a_5 + b_5 - 3c_5 + 3$ ⟶ E

Equating powers of T

$0 = -b_5 - 1$

$b_5 = -1$

Substitute in E

$a_5 = -2$

$\pi_5 = L^{-2}, Vs^{-1}, C^0, Q$

$$\pi 5 = \frac{Q}{Vs \times L^2}$$

$$\boxed{\pi 5 = \frac{Q}{Vs \times L^2}}$$

Sixth π - Term (π_6)

$\pi_6 = L^{a6}, Vs^{b6}, C^{c6}, V_f$

$M^0L^0T^0 = [L]^{a6} \; [L\,T^{-1}]^{b6} \; [M\,L^{-3}]^{c6} \, [L\,T^{-1}]$

Equating powers of M

$0 = c_6$

$c_6 = 0$

Equating powers of L

$0 = a_6 + b_6 - 3c_6 + 1 \longrightarrow F$

Equating powers of T

$0 = -b_6 - 1$

$b_6 = -1$

Substitute in F

$a_6 = 0$

$\pi_6 = L^0,\ Vs^{-1}, C^0, V_f$

$$\pi 6 = \frac{Vf}{Vs}$$

$$f\left(\frac{W}{L}, \frac{Ft}{C \times L^2 \times Vs^2}, \frac{Vw}{Vs}, \frac{ac}{L}, \frac{Q}{Vs \times L^2}, \frac{Vf}{Vs}\right) = 0$$

$$\frac{W}{L} = \varphi\left(\frac{Ft}{C \times L^2 \times Vs^2}, \frac{Vw}{Vs}, \frac{ac}{L}, \frac{Q}{Vs \times L^2}, \frac{Vf}{Vs}\right)$$

3. RESULTS AND DISCUSSIONS

A mathematical model has been deduced to ascertain the relationship between wheel wear and independent parameters. The number of variables has reduced by applying the concept of dimensional analysis. The Pi terms obtained gives the variation of independent variables with the wheel wear. Hence several independent variables have been grouped into Pi terms which are dimensional less. Pi terms describe overall effect of parameters on wheel wear.

4. CONCLUSIONS

In order to determine effect of various parameters on the wheel wear mathematical model using dimensionless analysis is developed. The relation between wheel wear and variables also could be used to estimate the wheel wear for correct estimation of dressing operation. Dependency of numerous variables on wheel wear can be converged and optimum parameter affecting the wheel wear can be determined. Hence the attempt has been made to evaluate the relation between variables and wheel wear in terms of Pi terms.

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