International Journal of Mechanical Engineering and Robotics Research

ISSN 2278 – 0149 www.ijmerr.com
Vol. 3, No. 4, October, 2014

Research Paper

NUMERICAL SIMULATION OF GRINDING FORCES BY SIMULINK

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Grinding is one of the main methods of precision machining. Grinding wheel wear, dynamic performance of the manufacture equipment, geometric accuracy and surface quality of work piece are greatly influenced by grinding forces, so some considerable research developments in calculating grinding force were made by various authors. Grinding forces are composed of chip formation force and sliding force. In surface grinding a new mathematical model of grinding forces is developed. Effectiveness of this model is proved by comparison of the experimental results and the model calculation results. Static chip formation energy and dynamic chip formation energy are mainly divided chip formation energy, which is mainly influenced by heat in the metal removal process,shear strain rate and shear strain. By analyzing the relationship between specific chip formation energy and chip formation force a formula for calculating the chip formation force is proposed. A new formula for calculating sliding force considering the influence of processing parameters on friction coefficient is obtained as a combined achievements of other researchers. By using Simulink software the experimental data's are validated. Thus validate the correctness and effectiveness of proposed grinding force model.

Keywords: Grinding, Grinding Force model, Tangential grinding force, Normal grinding force

INTRODUCTION

The most common form of abrasive machining is grinding. This is a material cutting process which engages an abrasive tool whose cutting elements are grains of abrasive material known as grit. Grits are characterized by sharp cutting points, high hot hardness, and chemical stability and wear resistance. The grits are held together by a suitable bonding material to give shape of an abrasive tool.

Advantages

- A grinding wheel requires two types of specification
- dimensional accuracy
- good surface finish
- good form and locational accuracy

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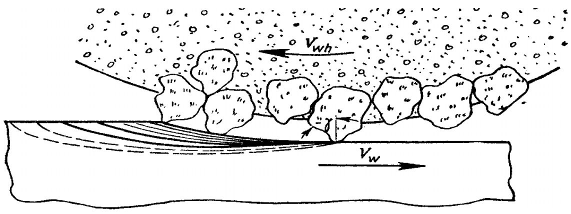
Figure 1: Illustrates the Cutting Action of Abrasive Grits of Disc Type Grinding Wheel Similar to Cutting Action of Teeth of the Cutter in Slab Milling



- applicable to both hardened and unhardened material

Applications

- Surface finishing
- Slitting and parting
- Descaling, deburring
- Stock removal (abrasive milling) finishing of flat as well as cylindrical surface
- Grinding of tools, cutters and resharpening of the same.

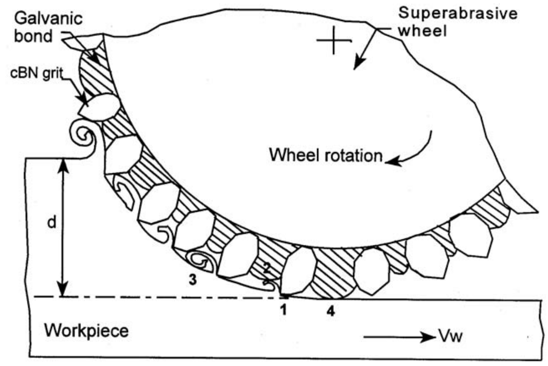
GRINDING WHEEL AND WORKPIECE INTERACTION

The bulk grinding wheel-work piece interaction can be divided into the following

1. grit-workpiece (forming chip)
2. chip-bond
3. chip-work piece
4. bond-work piece

Except the grit work piece interaction is expected to produce chip, the remaining three undesirably increase the grinding force and power requirement. Therefore, efforts should always be made to maximize grit-work piece interaction leading to chip formation and to minimize the rest for best utilization of the available power.

Figure 2: Grinding Wheel and Work-piece Interaction



NEED FOR GRINDING FORCE MODELLING

Grinding is one of the main methods of precision machining. Grinding wheel wear, dynamic performance of the manufacture equipment, geometric accuracy and surface quality of work piece are greatly influenced by grinding forces, so some considerable research developments in calculating grinding force were made by various authors.

Grinding forces are composed of chip formation force and sliding force. In surface grinding a new mathematical model of grinding forces is developed. Effectiveness of this model is proved by comparison of the experimental results and the model calculation results. Static chip formation energy and dynamic chip formation energy are the mainly divided chip formation energy which is mainly influenced by heat in the metal removal process shear strain and shear strain rate . By analyzing the relationship between speci-fic chip formation energy and chip formation force a formula for calculating the chip formation force is proposed. A new formula for calculating sliding force considering the influence of processing parameters on friction coefficient is obtained by combining with achievements of other researchers.

By using Simulink software validating the experimental data provided in this paper.

MATLAB AND SIMULINK

A language for technical computing Matlab is utilized. It integrates visualization, computation and programming in easily environment where problems and solutions are expressed in common mathematical notation. Simulink, integrated with Matlab, is a software package for analyzing dynamic systems modelling and simulating. It provides a graphical environment that let one design, simulate, implement, and test dynamic systems.

Simulation and Model-based Design

A block diagram environment for multidomain simulation and Model-Based Design is Simulink®. It supports system-level design, automatic code generation, simulation and continuous test and verification of embedded systems. Simulink provides a customizable block libraries, graphical editorand solvers for modeling and simulating dynamic systems. Simulink is integrated with MATLAB®, & enabling you to incorporate MATLAB algorithms into models and also export simulation results to MATLAB for further analysis.

Key Features

- Graphical editor for building and managing hierarchical block diagrams
- Libraries of predefined blocks for modeling continuous-time and discrete-time systems
- Simulation engine with fixed-step and variable-step ODE solvers
- Scopes and data displays for viewing simulation results
- Project and data management tools for managing model files and data
- Model analysis tools for refining model architecture and increasing simulation speed
- MATLAB Function block for importing MATLAB algorithms into models
- Legacy Code Tool for importing C and C++ code into models

METHODOLOGY

By using simulink software the validity of this grinding force model is examined. Experimental conditions are as follows: work piece is TC4100×20×20. Grinding wheel type is 1A1300×20×75×5CBN100/120B75. Grinding coolant is 10% emulsifying liquid.

Experimental conditions as follows:

Wheel type 1-200×16×32-WA100K5V-35

Test piece material 22CrMoH

Wheel velocity 12-30 m/s

Work piece velocity 0.03-0.2 m/s

Grinding depth 0.001-0.006mm

Coolant Water-base coolant

Calculation Formula of Grinding Force

$$Ft = \left(237433 - 30990 \ln \frac{Vs^{1.5}}{ap^{0.25} Vw^{0.5}}\right)\left(\frac{Vwap}{Vs}\right) + \left(0.837 + 6066 \frac{Vw}{deVs}\right) (deap)^{1/2} \quad ...(1)$$

$$Fn \left(\frac{Vwap}{Vs}\right) + 24175 \frac{Vv}{Vs} \quad ...(2)$$

Table 1: Experimental Data

V_s(m/s) Grinding wheel velocity	V_w (m/s) Work piece feed velocity	a_p(mm) grinding depth	F_t(N/mm) Tangential grinding force	F_n(N/mm) Normal grinding force
20	0.182	0.001	0.6638	1.1020
20	0.182	0.005	2.5109	4.1669
12	0.2	0.005	6.0035	9.8987
20	0.05	0.005	1.0464	1.8485

The deviation between experimental data and calculation data, which depend on the grinding force formula proposed, is validated by using simulink. Graphs are plotted with above condition and results obtained in the journal paper are validated.

RESULTS AND DISCUSSION

The tangential grinding force model and normal grinding force model are formulated on the Simulink, that is Eq(1) and Eq(2). The following 8 circuit diagram shows the tangential and normal grinding forces of the formulated circuit in Simulink, and check with experimental results (Jinyuan Tanga *et al.*, 2009).

Figure 3: Circuit Diagram1

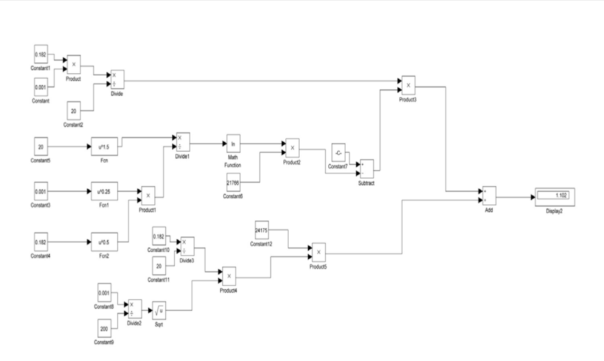


Figure 4: Circuit Diagram2

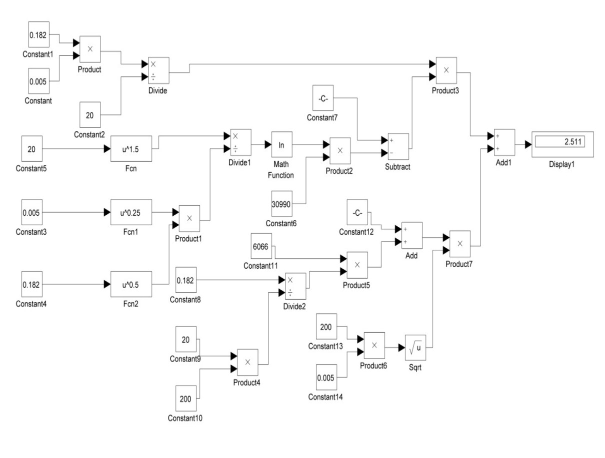


Figure 5: Circuit Diagram3

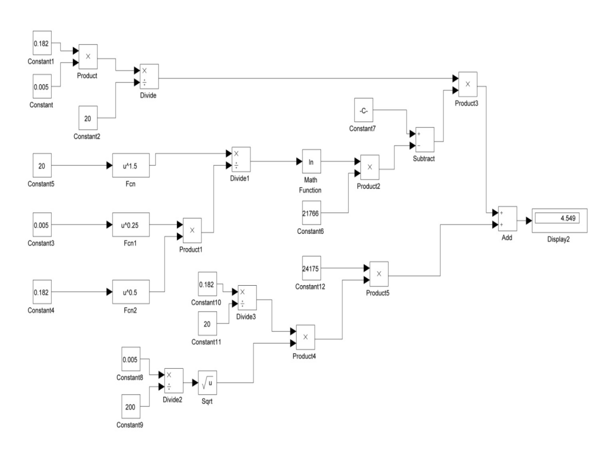


Figure 6: Circuit Diagram4

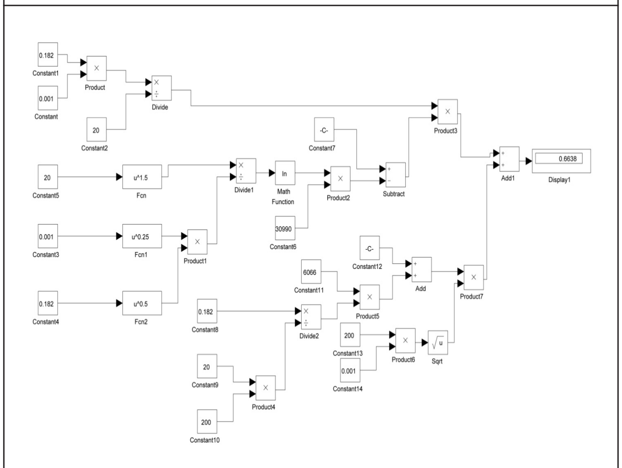


Figure 7: Circuit Diagram5

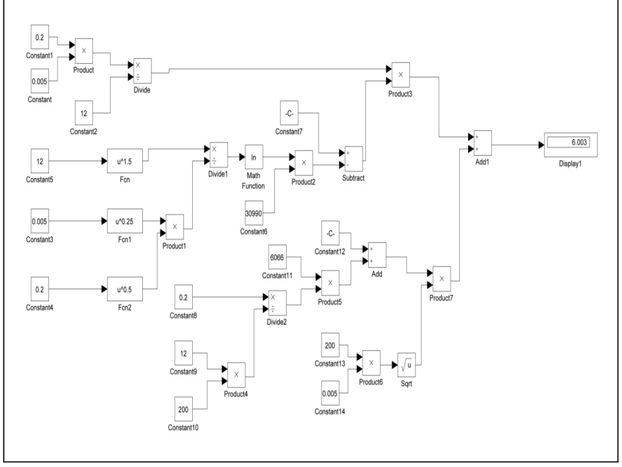


Figure 8: Circuit Diagram6

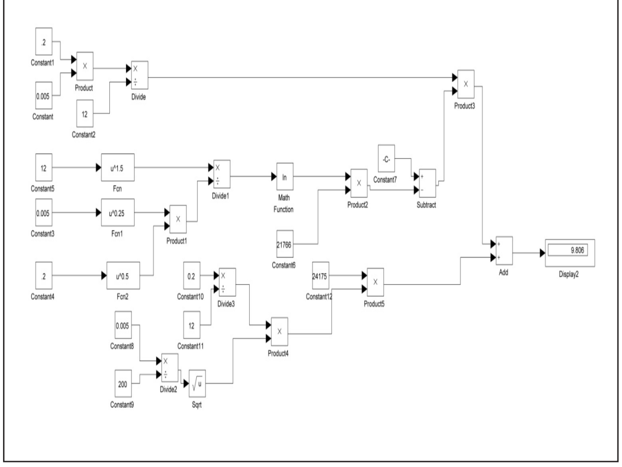


Figure 9: Circuit Diagram7

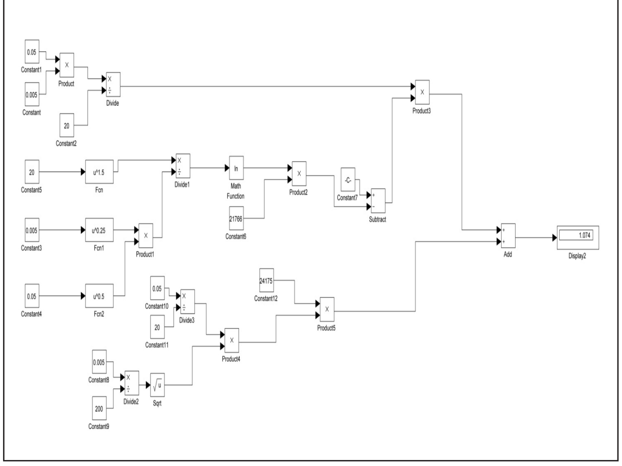
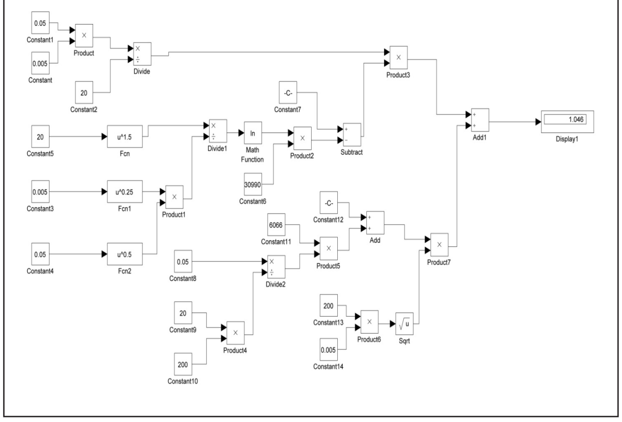


Figure 10: Circuit Diagram8



SIMULATED DATA

Table 2: Simulated Data From the Above Circuit Diagram the Simulated Result are Represented in the Tabular from

V_s(m/s) Grinding wheel velocity	V_w (m/s) Work piece feed velocity	a_p(mm) grinding depth	F_t(N/mm) Tangential grinding force	F_n(N/mm) Normal grinding force
20	0.182	0.001	0.6638	1.102
20	0.182	0.005	2.511	4.549
12	0.2	0.005	6.003	9.806
20	0.05	0.005	1.046	1.074

From the above circuit diagram the simulated result are represented in the tabular from.

CALCULATED DATA

Table 3: Calculated Data Calculated Manually by Putting the Experimental Values on the Eq(1)and Eq(2). The Tangential and Normal Grinding Forces Obtained are Shown Above

V_s(m/s) Grinding wheel velocity	V_w (m/s) Work piece feed velocity	a_p(mm) grinding depth	F_t(N/mm) Tangential grinding force	F_n(N/mm) Normal grinding force
20	0.182	0.001	0.6638	1.102
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Calculated manually by putting the experimental values on the Eq(1)and Eq(2).The tangential and normal grinding forces obtained are shown above.

CONCLUSION

By using simulink software the equivalent circuit diagram for equations of tangential force (F_t) and normal force (F_n) are drawn. By putting the values of grinding wheel velocity (V_s), work piece feed velocity(V_w),grinding depth (a_p), de equivalent diameter of wheel in simulink the values obtained are compared with the experimental data. The result obtained for all values except one value are same. By using MATLAB software graphs are plotted the graphs obtained are similar to referred graphs. The result of simulated and calculated data's are coincide with the experimental data. This proves the correctness and effectiveness of proposed grinding force model.

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