MODELING AND SIMULATION

Volume 16

Part 5: General Modeling, Physical & Human Systems

MODELING AND SIMULATION
VOLUME 16

Part 5: General Modeling, Physical and Human Systems

Proceedings of the Sixteenth Annual Pittsburgh Conference

Library of Congress Catalog Card Number 73-85004

ISBN Part 5 0-87664-888-X
ISSN 0198-0092

Distributed by

INSTRUMENT SOCIETY OF AMERICA
67 Alexander Drive
P.O. Box 12277
Research Triangle Park, N.C. 27709
Phone: (919) 549-8411
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Printed in U.S.A.
By
Technical Communication Services

MODELING AND SIMULATION
VOLUME 16
Part 5

Proceedings of the Sixteenth Annual Pittsburgh Conference

Held
April 25-26, 1985
University of Pittsburgh
Sponsored by
The Department of Electrical Engineering
School of Engineering
University of Pittsburgh
In Cooperation with
The Pittsburgh Sections
of the
Institute of Electrical and Electronic Engineers
and
The Instrument Society of America
and
The Systems, Man and Cybernetics Society
The Society for Computer Simulation
The International Association for Mathematics
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Edited by

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An international conference such as the Modeling and Simulation Conference owes its success to many people. To list each of those who helped and the manner in which he helped would likely require a volume the size of the PROCEEDINGS. But we can mention some who have been of particular help.

First, our special thanks to the Instrument Society of America for help in many ways during the past year, and particularly for editorial help.

The editors wish to express sincere thanks to Professor H. B. Hamilton, Acting Chairman of the Department of Electrical Engineering, University of Pittsburgh, for his support of this Conference in many ways.

The School of Engineering of the University of Pittsburgh has supported the Modeling and Simulation Conference in a variety of ways. Accordingly, the editors wish to thank Acting Dean Y. T. Shah.

A special thanks also to Kathy Tamenne, Sandy Weisberg and Madeline Nuzzo, each of whom helped with enthusiasm and grace. An extra special thanks to Betty Victor and Barb Dippold for help in many ways.

A final thanks goes to all the others who organized sessions, chaired sessions, operated audio-visual equipment, made signs, helped with registration and handled efficiently those many situations and problems, some of which could have meant disaster to the Conference, but each of which were satisfactorily handled in a truly professional spirit.

William G. Vogt
Marlin H. Mickle
Editors

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PART 5

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OF POOR QUALITY

GENERAL MODELING, PHYSICAL AND HUMAN SYSTEMS

APPLICATION OF EXTERNALLY PRESSURIZED BEARINGS INTO MILLING MACHINE SLIDEWAYS

E. A. Salem* , S. M. Serag** , [redacted]sser*** , and A. M. Mansour****

* Professor, Mech. Engg. Dept., Faculty of Engg., Alexandria University, Alexandria, Egypt.

** Associate Professor, ***Assistant Professor, **** Graduate Student, Prod. Engg. & Mach. Design Dept., Faculty of Engg. & Technology, Menoufia University, Shebin El-Kom, Egypt.

ABSTRACT

In metal machining the surface quality generally depends on the stability of the relative motion between the tool and workpiece, that is mostly affected by the slideways and their methods of lubrication.

In this paper, the influences of both externally and conventionally lubricated slideways, feed rates, and depth of cut on the produced surface roughness of free machining brass were investigated.

An experimental investigation has been carried out on a horizontal milling machine. Special table and saddle for that machine were designed and manufactured to be capable for applying both methods of lubrications. Wide ranges of depth of cut and feed rates were used. Both surface roughness and vibration parameters were measured.

An experimental investigation has been carried out on a horizontal milling machine. Special table and saddle for that machine were designed and manufactured to be capable for applying both methods of lubrications. Wide ranges of depth of cut and feed rates were used. Both surface roughness and vibration parameters were measured.

It was found that, when using externally pressurized oil bearings, slideways have significant effects on the machine productivity, product surface finish, and vibration parameters.

INTRODUCTION

In metal machining generally the surface quality depends on the stability of the relative motion between the tool and workpiece. This relative motion between the tool and workpiece is directly affected by both the type and condition of the slideway. Slideways may be classified as conventional, roller element, and externally pressurized. Conventionally lubricated slideways have their own problems which are the high friction, wear, stick-slip and chatter.

Friction dissipates energy, causes heat generation and wear. Wear causes changes in dimensions that may lead to less product accuracy and poor surface finish and eventual breakdown of the machine elements.

Such wear is not always evenly distributed over the full length of the fixed part. Its distribution depends upon the use of the slideway and the position during various opertions. Wear is a function of material properties of the moving parts, surface condition of the slideway and pressure exerted on the slideways. Self excited vibration, which is spontantoneous and causes poor work surface finish, increases tool wear, causes lower production rates, and draws the energy for its maintenance from the tool or workpiece drive. Self excited vibration may be reduced in both design and production stages by using light, stiff and well damped structure. Damping can be introduced into a machine tool structure in many ways and it is largely a matter of the application of common sense by the designer. It is well known that most of the damping in any machine tool structure is developed in the slideways and in the joint interfaces. Stick-Slip is a low frequency self excited vibration instigating non-uniform motion at low feed rates of the machine tool slides. Many ways are used to reduce stick-slip phenomenon as increasing of the stiffness of the drive without reducing damping, lowering friction coefficient, increasing damping ability of the system and preventing seizure of the rubbing surfaces.

Efforts have been directed to reduce friction, wear and self-excited vibration and to eleminate stick-slip as much as possible through the use of fluid film lubrication in machine tool slideways which is also avoids all scavenging requirements.

Several investigations [1-5] have studied the application of externally pressurized bearing into machine tools and measuring instruments slides. They showed that most of problems involved in slideways have been solved. In addition , problems such as heavy cutting operations, good alignment for large beds and high accuracy during travel have been achieved [6-12].

It was found from the thoroughly reviewed of the up-to-date published literature that there is a lack of information about the effects of the type of lubrication on the produced surface texture.

Consequently, in this work, an attempt is made to study the influence of the lubrication method on the surface roughness of free machining brass workpieces.

EXPERIMENTS

A Milling machine was developed to be suitable for carrying out the experiments. The milling machine (VEB Fritz-Heckart-Serk, VMV) was having a table (160 cm. long and 60 cm. wide) which was guided in dovetail slides with conventional lubrication. A new table with a new saddle were designed, manufactured, and were fitted into the milling machine. The new table-saddle system was capable to apply both the conventional and the externally pressurized lubrication methods. Figure 1 shows a photograph of the experimental set-up.

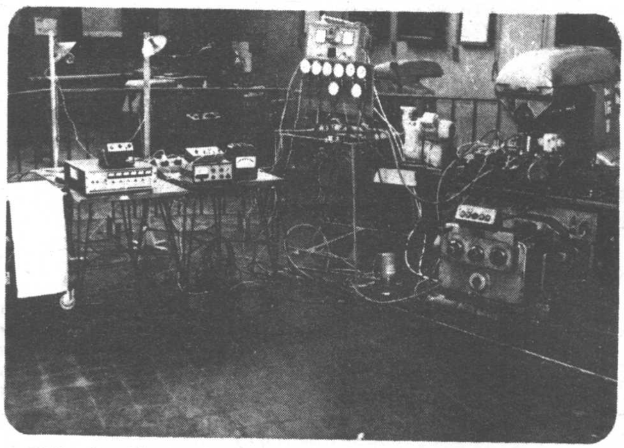

FIG. 1. Photograph of The Experimental Set-Up.

Wide ranges of depth of cut, feed rate and cutter speed were used. Depths of cut of 0.4, 0.6, 0.8, and 1 mm, and feed rates of 28, 48, 68, 88, and 116 mm/min. were employed. High speed steel cutter, rotating at 71, 90, 112, 140, 180, 240, 280, and 335 r.p.m., was used. The cutter was helical and having a diameter of 80 mm, a width of 63 mm, and 12 tooth. Free machining brass workpieces in shape of plates having a thickness of 20 mm and a width of 50 mm were machined under dry conditions.

Vibration parameters in the vertical direction such as vibration displacements, its velocity, and its acceleration, were measured using a vibration measuring system Philips-2000 . It is believed that these parameters have great influence on the machined surface roughness.

The results were recorded using a multi-channel recorder. The surface roughness of the machined samples were measured using a Talysurf-5M-60 system, taking centre line average as a reference for the comparison between the products. Surface roughness measurements was made in the longitudinal direction of feed. All the above procedure was made when applying both conventional and externally pressurized oil bearings.

RESULTS AND DISCUSSION

The variations of the surface roughness with feed per tooth (as a fuction of r.p.m.), depth of cut and the traverse feed "mm/min." were determined under conventionally and externally pressurized oil bearings slideways. Most of these result are presented in the Appendix.

1. EFFECT OF FEED PER TOOTH

The variation of the surface roughness with the feed per tooth was determined. A typical results for a sample that has been milled at feed of 28 mm/min. and depth of cut that equals to 0.4 mm is shown in Fig. (2).

It can be seen that surface roughness of the machined samples, first increases with an increase in feed per tooth to a maximum, about 3.2 μm for externally pressurized oil bearings slideways. With a further increase in the feed per tooth the surface roughness rapidly decreases, that for small values of feed per tooth. Figure (3) presents the variation of the surface roughness with feed per tooth for larger values of traverse feed (88 min/mm) and a depth of cut of 0.6 mm.

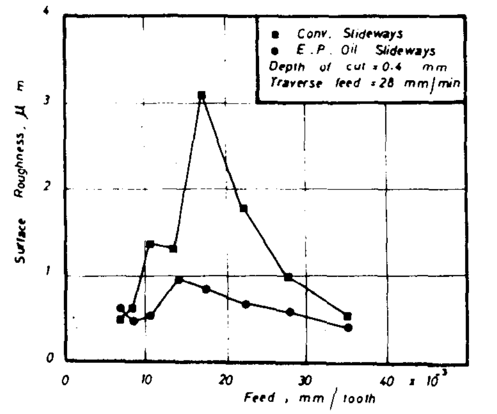

FIG.2. Variation of surface roughness with feed per tooth

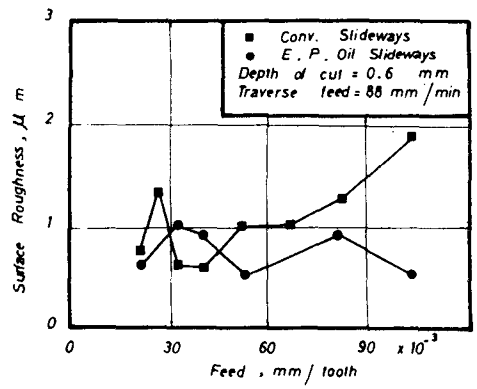

FIG. 3. Variation of surface roughness with feed per tooth

From this figure, it is clear in case of using conventionally lubricated slideways that as the feed per tooth increases, the surface roughness first increases, soon after this it decreases again. With a further increase in the feed per tooth, the surface roughness increases with an increase in feed per tooth. When employing externally pressurized oil bearing slideways, the surface roughnesses are fluctuating with the increase in the feed per tooth (between 1 μm and 0.5 μm).

The latter case may be due to the high values of damping (vibration velocity), vibration amplitude, and vibration frequency. The vibration was assumed to be sinusoidal and was found that the vibration frequency of the externally-pressurized oil slideways is larger than that for the conventinally lubricated slideways as it can be seen in Fig. (4).

2. EFFECT OF DEPTH OF CUT

The variations of the surface roughness with the depth of cut at the different feeds per tooth, traverse feed rates and depths of cut for both cases of lubrication were found. Figure (5) shows a typical result for surface roughness against depth of cut under a feed of 81 x 10^{-3} mm/tooth and a traverse feed of 88 mm/min. It can be observed that the surface roughness first increases with an increase in depth of cut to a maximum, at 0.6 mm depth of cut. With a further increase in the depth of cut, the surface roughness decreases again.

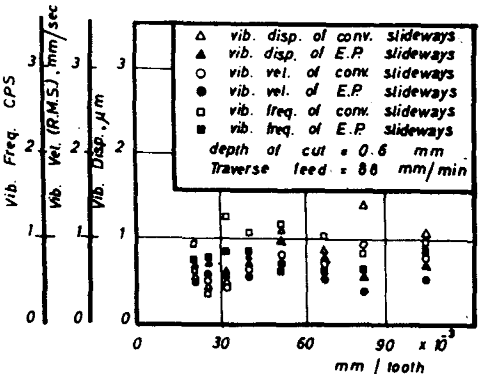

FIG.4 Vibration parameters with feed rate for conventional and externally pressurized slideways

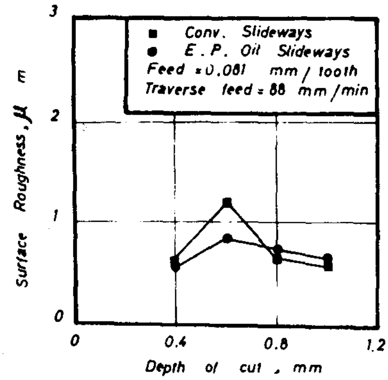

FIG.5. Variation of surface roughness with depth of cut

3. THE EFFECT OF WORK TABLE SLIDING VELOCITY

The effect of the traverse feed of the work table on the surface roughness of the machined workpieces under all test conditions were investigated. Figure (6) shows the relationship between the center-line average of the workpieces, that were machined at a cutter rotating speed of 90 r.p.m., a depth of cut of 0.8 mm, and the traverse feed. It can clearly be seen when using conventionally lubricated system that the surface roughness decreases with an increase in the traverse feed, then tends to be constant at feeds in the range from 48-88 mm/min. At a feed rate higher than 88 mm/min., surface roughness values increase. Surface roughness ranges between 0.65 and 1.65 μm . On the other hand, when using the externally-pressurized lubrication method, the surface roughness, again, fluctuates (between 0.5 - 0.8 μm) with the increase in the traverse feed.

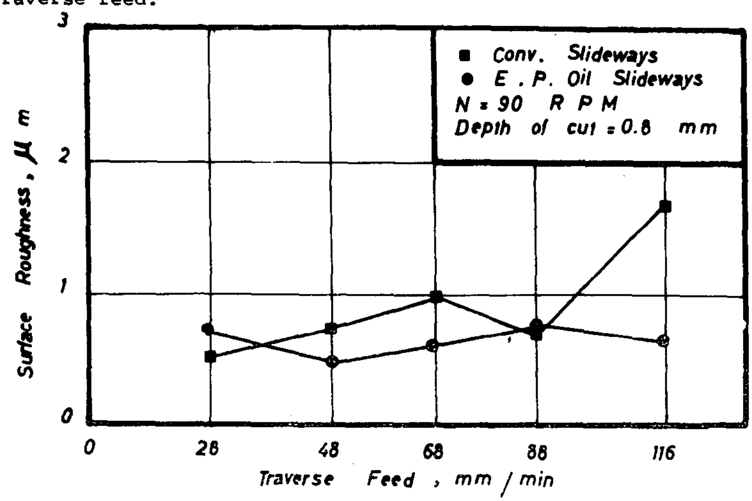

FIG.6. Variation of surface roughness with traverse Feed

From the same figure (Fig. 6) it can be seen that when using externally-pressurized bearing, the surface roughness is lower (better surface finish) than that when using the conventionally-lubricated method, at the same conditions. This would lead to an increase in the machine productivity when using externally-pressurized slideways.

From the previous results and discussion, it can be seen that the produced surface is a result of many conflecting factors such as cutting velocity, feed rate, depth of cut, work material, tool material, tool geometry, machining process, machine tool condition (slideways, bearings), the various types of vibration on the machine elements, and method of lubrication of the slides.

The surface finish in milling process, from the point of theoretical result, depends on the chip formation and geometry of the process. That means, the surface roughness in the case of peripheral milling increases with the traverse feed and decreases with the cutter diameter, number of tooth and number of rotational speed.

In addition, the surface roughness measurements, when applying the conventionally-lubricated slideways, are found to be in agreement with the general theoretical trends, whereas they are not consistent in case of emplying the externally-pressurized slideways.

CONCLUSIONS

The results of this comparative study cleared that the using of externally-pressurized oil slideways in a slab milling, when cutting free machining, brass gives more finer surfaces than that produced on the some machine having conventionally-lubricated slideways. Furthermore, externally-pressurized slideways have the inherent advantages of virtually zero static and dynamic friction, negligible maintenancne, no scavenging requirements, no stick-slip and higher damping. The using of externally pressurized oil bearings slideways improves the productivity of the machine for good surfaces.

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APPENDIX

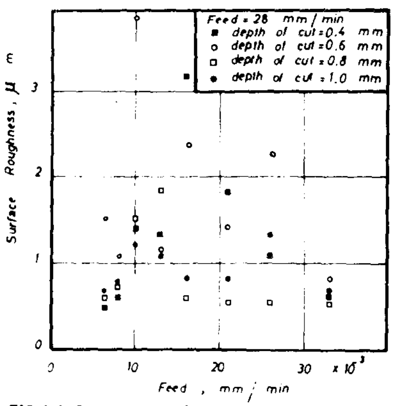

FIG A.1 Surface roughness produced on a slab milling (Conventional slideways)

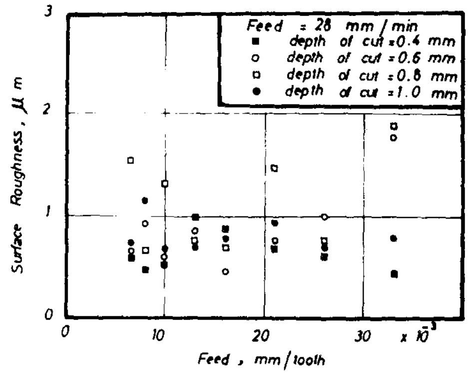

FIG A.2 Surface roughness produced on a slab milling (Externally pressurized slideways)

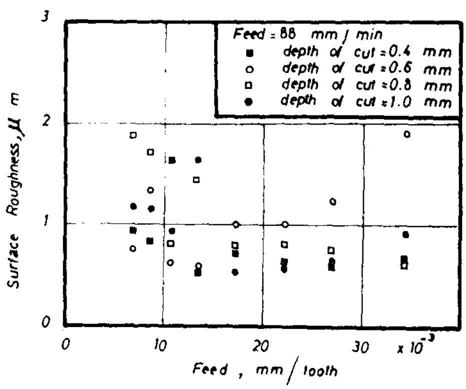

FIG. A.3 Surface roughness produced on a slab milling (Conventional slideways)

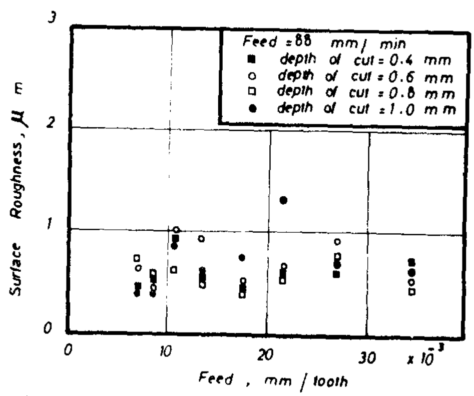

FIG. A.4 Surface roughness produced on a slab milling (Externally pressurized slideways)

A STUDY OF THE EFFECTS OF SOME SHAPING PARAMETERS ON SURFACE CHARACTERISTICS

M. M. El-Khabeery* and M. A. Nasser*

* Assistant Professor, Department of Production Engineering and Machine Design, Faculty of Engineering and Technology, Menoufia University, Shebin El-Kom, Egypt.

ABSTRACT

The effects of depth of cut and cutting stroke speed on some surface characteristics during cutting free machining brass by shaping process were investigated. Workpieces in shapes of plates having a thickness of 1.5 mm and a length of 80 mm were machined under dry orthogonal conditions. High speed steel tools having straight sharp edges were used with rake and clearance angles of 17 and 10 degrees, respectively. Eight stroke speeds in the range from 12 to 140 str./min. were employed with six depths of cut in the range from 0.15 to 0.70 mm.

Examination of the surface characteristic of machined workpieces was conducted over ten, equally-spaced, regions along each workpiece length using a Talysurf 5.M system and an optical microscope.

Results showed that surface quality increases with an increase in the workpiece length to a maximum, at the middle range, then decreases with a further increase in the length of workpiece. Moreover, increasing of stroke speed leads to a substantial reduction in both surface roughness and surface damages throughout the workpiece length. Furthermore, a considerable improvement in the surface characteristics was achieved by decreasing the depth of cut. An interesting result is that a fine surface (about 1.0 μm) could be produced in shaping process.

INTRODUCTION

For many years the problem of finish-shaping has been a very real one. The fact that the surfaces obtained are worse than expected on theoretical grounds, is disconcerting. It is believed that these poor results are due to the location of the workpiece relative to the stroke length and the nature of interaction between the tool nose region and both the chip and workpiece.

It is generally accepted in metal cutting that surface characteristics are of paramount importance. Surface condition can ultimately affect the economics and human safety. This subject has been given considerable attention, especially in turning processes, in many investigations[1-5]. There is, however , a rare published work concerning the study of surface characteristics of components that produced by shaping. This area is where the greatest need for further fundamental research exists.

In this paper, an attempt is made to study the effects of depth of cut and cutting stroke speed on some aspects of surface characteristics during shaping free machining brass.

EXPERIMENTAL INVESTIGATION

In the experimental investigation, work material of free machining brass was used. Each workpiece was prepared in shape of a plate that having a thickness of 1.50 mm and a length of 80 mm. These plates were rigidly clamped to a specially-made vise and then were machined on a shaper under dry conditions.

Orthogonal machining was used as the cutting method in this investigation. Tests were conducted at working stroke rates in the range from 12 to 140 stroke/min. High speed steel tool with sharp edges and having rake and clearance angles of 17 and 10 degrees, respectively, were used. The tools were held in a special tool holder that was designed to enable the tool to approach the workpiece at the required angles, with a minimum overhang to minimize tool chatter. Depths of cut in the range from 0.15 to 0.70 mm were used. A complete summary of the test conditions is given in Table (1).