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FEED RATE CHECKS ON NUMERICAL
CONTROLLED MACHINES

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THE DOW CHEMICAL COMPANY
ROCKY FLATS DIVISION
U.S. ATOMIC ENERGY COMMISSION
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**FEED RATE CHECKS ON NUMERICAL
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by

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ABSTRACT

The effects of various feed rates on the intended tool path of numerically controlled boring and turning machines were investigated. The tests were conducted on several types of precision machines at Rocky Flats Plant. The amount of tool overshoot and vibration was recorded.

CONCLUSIONS

Each machine checked has its own characteristics. To compensate automatically for these characteristics it would be necessary to have a different tape preparation for each machine. The characteristics are not necessarily constant with time; therefore, a continuous check of the machine response would be necessary to assure proper input to the tape. The problem of overshoot can be minimized by judicious choice of feed rates and by not using feed rates which produce overshoots greater than part tolerances allow. Conservatively, this would imply not exceeding a feed rate of 1/8-in. per minute when turning a square corner.

The tests also pointed out that it is possible for a machine tool to go out of calibration, with resultant "hunting" action and slow response. This should be checked periodically to assure maximum accuracy from the machines.

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INTRODUCTION

The dynamic characteristics of a machine tool affect the ultimate accuracy, precision, and surface finish of a piece it machines. On a numerical controlled machine it is possible to compensate for the characteristics which are adverse to the final product.

When the program tape calls for a corner to be machined, it is advantageous to know the actual path that the tool will follow, thereby enabling the part programmer to compensate by changing feed rates, dimensions, etc.

Test Set-Up (See Figure 1)

The transducer holder was fastened to the spindle of each machine checked and held two Sheffield electro-jets at right angles. The signals were fed through a three-meter Accutron into a Honeywell 1508 Visicorder. A special gage block was made to fit a one-half-inch tool holder. By bringing the block into contact with the transducer, a graph of the slide-motion versus time was obtained.

Figure 1. TEST SET-UP

DISCUSSION

The following machine tools were used in the study.

#156	(Ex-Cell-O 920)	Single spindle, independent
#834	"	slides, anti-friction roller
#835	"	bearing, hydraulic servo
		system with quantizer
		feedback.
 #158	 (Ex-Cell-O 922)	 Dual spindle, independent
#159	"	slides, anti-friction roller
#832	"	bearings, hydraulic servo
#833	"	system with quantizer
		feedback.
 #741	 (Ex-Cell-O 905)	 Single spindle, independent
#739	"	slides, anti-friction roller
#768	"	bearings, hydraulic servo
		systems with quantizer
		feedback, dryboxed.
 # 1	 (Heald)	 Combination boring, turning
		and grinding machine, compound
		slides, oil film bearings,
		hydraulic servo system with
		quantizer feedback.

A. OVERSHOOT

The initial investigation used feed rates of 1/8, 1/4, 1/2, 1, 2, 4, 8, and 18 in. per minute. This program produced such large overshoots (0.006 in. at 16-in. per minute) that a second program (Figure 2) was written. The maximum overshoot obtained with this program was 0.0006 in. at 2-in. per minute feed rate. Figure 3 gives the typical response data.

Figures 4 through 9 illustrate the relationship between the feed rate and corresponding overshoot anticipated. The overshoot on the cross slide was determined in both directions with no distinguishable difference in the response. The setup used did not permit this information to be obtained for the main slide.

Figure 2. PROGRAM PATHS

Figure 3. TYPICAL RESPONSE DATA

Figure 4. OVERSHOOT VS FEED RATE,
Y AXIS

Figure 5. OVERSHOOT VS FEED RATE,
X AXIS

Figure 6. OVERSHOOT VS FEED RATE,
Y AXIS

Figure 7. OVERSHOOT VS FEED RATE,
X AXIS

Figure 8. OVERSHOOT VS FEED RATE,
Y AXIS

Figure 9. OVERSHOOT VS FEED RATE,
X AXIS

The duration of the overshoot varies from 0.1 second to 3 seconds. No definite correlation between feed rate and duration of overshoot was apparent. The duration decreases with feed rate on some machines but remains constant on others.

Machine #158 had a higher overshoot on the main slide than other machines of that group. This was probably due to a special milling attachment on the main slide that increased its effective weight.

B. HUNTING - OSCILLATION

If the servo system is not properly adjusted, a "hunting" action can occur. On machine #156 main slide and on machine #834 cross slide this hunting motion was 0.0001 inch. Machine #833's main slide had a damped oscillation with a relatively long time constant for feed rates of 1/32, 1/16, and 1/4-in. per minute. Machine #835 was similar to #833, except the "hunting" was evident on the cross slide and was noticeable through the 1-in. per minute feed rate.

The machine that had "hunting" action also had considerably more overshoot than those properly adjusted.

C. VIBRATION

On machines which did not have their hydraulic supply properly isolated, a relative vibration between the spindle and tool was noticed. The various feed rates did not affect this vibration appreciably. Table I lists the predominant frequency and magnitudes.

TABLE I

VIBRATION BETWEEN SPINDLE AND BLOCK

Machine No.	Axis	Vibration Frequency (cps)	Vibration Amplitude (micro-inches)
159	Y	31	8
	X	31	6
158	Y	None	None
	X	None	None
832	Y	29	30
	X	29	40
833	Y	29	40
	X	29	40
156	Y	29	20
	X	29	40
834	Y	29	15
	X	29	25
835	Y	29	15
	X	29	30
741	Y	30	8
	X	30	10
739	Y	30	9
	X	30	7
768	Y	32	8
	X	32	5
1	Y	None	None
	X	None	None