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THE COLLEGE OF AERONAUTICS

DEPARTMENT OF PRODUCTION AND INDUSTRIAL ADMINISTRATION

MANUFACTURING PROCESSES LABORATORY

HORIZONTAL BAND-SAW

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SUMMARY

The effect of various parameters on the performance of the band saw when cutting mild steel with a 10 t.p.i. raker-set blade were established over a limited range. These are discussed fully in the 'conclusions'. With this limited survey it was not found possible to establish the optimum conditions of operation.

Horizontal band saw experiment

Introduction

This experiment was intended as a preliminary investigation into the parameters which might affect the performance of the band saw, to establish whether a further investigation would be worthwhile.

Object

To determine the effect the following parameters have an cut-off time, power and surface finish.

(1) cutting speed
(2) Vertical cutting load
(3) Damping
(4) Cutting lubricant
(5) Material geometry.

Apparatus

Meba horizontal band-saw machine
10 T.P.I. raker-set saw-blade
Cutting lubricant
Weights and weight carrier
Watt meter
Stop watch
1″ square M.S.; ½″ square M.S.; 1″ round M.S. bar.

Procedure

To get a reasonably accurate idea of the vertical cutting load on the saw, the counterbalancing spring was released and the saw arm was counterbalanced by overhanging weights. Changing these weights changed the vertical force in a known ratio.

With the vertical cutting force set to 20 lb, damping set to its minimum value (setting 4), and using cutting lubricant, lengths of the 1″ square bar were cut off at various cutting speeds. The power required and cut-off time were noted for each cutting speed.

This was repeated with vertical cutting forces of 30 and 40 lb.

Changing the damping to its maximum value (setting 1), the procedure was repeated for vertical cutting loads of 20 and 40 lb.

With the damping set to 4 and vertical load of 30 lb, pieces were cut off without lubricant.

See graphs 'A' and 'B' for power-speed and time-speed curves.

It was not possible to obtain a figure for surface finish on the talysurf, as the finish was too rough. There was apparently no variation in the finish of any of the specimens, when examined by eye.

Pieces were then cut off the $\frac{1}{2}''$ square rod and 1" dia. round rod, keeping the 10 T.P.l. raker set saw, the damping force constant at setting 4 and cutting with lubricant. The time and power requirements were then noted for various vertical cutting force and cutting speed combinations.

Discussion of results

With the method of applying the moment on the saw arm, by counter-balancing with weights, the vertical cutting force could only be assessed approximately. Two factors being involved:-

(i) The distance from the pivot to the workpiece being cut, and the centre of the counterbalance weights could not be measured very accurately.

(ii) As the saw arm was lowered to the horizontal position, the moment on the arm increased, with increasing cutting force. Thus a high piece of work would have a smaller vertical force at the start of cutting than a low piece.

(a) The power required was found to increase linearly with the cutting speed over the range tested.

The cut-off time was found to decrease rapidly at first with increase in cutting speed, and then flattened out when approaching the maximum speed of the machine of 230 fpm, irrespective of vertical load. No further advantage would be gained by increasing the speed for cutting mild steel.

(b) The results of the power-vertical load tests are somewhat in question (see curves 1, 2 and 3 on graph B). Curves (1) and (2) follow a similar pattern to which curve (2) does not conform, and tends to contradict the hypothesis that power should increase with vertical load. The greater the vertical load, the greater the depth of cut and cutting force, hence the greater the power requirement.

The time to cut off pieces is reduced considerably by increasing the vertical cutting force, although there is some levelling off. This aspect could not be investigated fully due to the power limitations of the machine.

(c) Although it should be possible to get a general relationship between cutting force and depth of cut per tooth from the load-power-speed and load-time-speed relationships it was not practicable in this case, due to the anomalous conditions of the power-speed curves.

(d) From the relationship that depth of cut per tooth is inversely proportional to cut off time, it is found that as the vertical load is increased, the depth of cut per tooth increases proportionally. This point was illustrated further when the $\frac{1}{2}''$ square rod was cut, the cut off time being approximately 25% that for the 1″ square rod with the same conditions; i.e. the depth of cut per tooth was doubled as the vertical load per tooth was doubled, (only half the number of teeth being in contact with the work).

From this it may be seen that, for a given vertical load, the amount of metal removed per tooth per pass for any thickness of material, is always the same.

(e) It appears that both the cut-off time and power requirements were reduced slightly by the use of a cutting lubricant.

(f) Increased damping resulted in greater cut-off time and lower power requirements.

(g) For a given set of conditions, the cut-off time is dependent upon the size and geometry of the part to be cut.

(i) For a given geometry and material, the cut-off time is directly dependent upon the size of the material. This was shown when the cut-off times for 1″ square M.S. and $\frac{1}{2}''$ square M.S. were compared, i.e. the vertical rate of cutting (or feed) was doubled as the thickness of the material was halved.

(ii) Geometry plays a very important part, as was shown when cutting 1″ dia. round rod, the time required to cut off the round rod being in slightly excess of that to cut off the 1″ square rod (although the cross-sectional area of the cut was smaller). It was noted that the power requirements when cutting round rod increased continuously throughout the cutting cycle. This can possibly be explained as follows:- When starting to cut a round bar, the saw is running tangentially to it and instead of cutting into the bar, the blade tends to lift up and slide over the top. The power requirements are low as a result. As the saw cuts into the bar this lifting effect is gradually reduced, as the angle between the saw and the bar surface is increased. As the saw passes thro' the centre of the bar, the angle again starts decreasing, but in the opposite direction, thus tending to pull the tooth into the work. Thus the depth of cut, hence power requirements is gradually increased. The slow start accounts for the longer cut-off time.

10 T.P.I. raker-set blade used throughout to cut mild steel bar.

Test No.	Unit	1	2	3	4	5	11	12	13	14	15
Vert. load	Lb	20	20	20	20	20	20	20	20	20	20
Speed	Ft/min.	230	184	138	92	46	230	184	138	92	46
Time of cut	Sec.	42	50.5	60.5	86	141.5	48	57	70	92	175
No load power	Watts	240	210	195	180	165	240	225	195	180	165
Power Supply	Watts	390	330	300	250	195	330	300	270	240	210
Power for cut	Watts	150	120	105	70	30	90	75	75	60	45
Damping		4	4	4	4	4	1	1	1	1	1
Cooling		Oil	Oil	Oil	Oil	Oil	Oil	Oil	Oil	Oil	Oil
Mat^1 Section		1" sq.	1" sq.	1" sq.	1" sq.	1" sq.	1" sq.	1" sq.	1" sq.	1" sq.	1" sq.

Test No.	Unit	6	7	8	9	10	16	17	18	19	20
Vert. load	Lb.	40	40	40	40	40	40	40	40	40	40
Speed	Ft/min	230	184	138	92	46	230	184	138	92	46
Time of cut	Sec.	17	20	26	35.5	58	21	24	28.5	38	66
No Load Power	Watts	240	210	195	180	165	270	210	195	180	165
Power Supply	Watts	480	420	355	315	270	450	390	330	285	240
Power for cut	Watts	240	210	160	125	105	180	180	135	105	75
Damping		4	4	4	4	4	1	1	1	1	1
Cooling		Oil	Oil	Oil	Oil	Oil	Oil	Oil	Oil	Oil	Oil
Mat^1.Section		1" sq.	1" sq.	1" sq.	1" sq.	1" sq.	1" sq.	1" sq.	1" sq.	1" sq.	1" sq.

Test No.	Unit	21	22	23	24	25	26	27	28	29	30
Vert. load	Lb.	30	30	30	30	30	30	30	30	30	30
Speed	Ft/min.	230	184	138	92	46	230	184	138	92	46
Time of cut	Sec.	26	31	38	53	96	26	33	41	57	102
No Load Power	Watts	240	110	195	180	165	240	225	195	180	165
Power Supply	Watts	360	330	300	270	240	420	360	330	270	240
Power for cut	Watts	120	120	105	90	75	180	135	135	90	75
Damping		4	4	4	4	4	4	4	4	4	4
Cooling		Oil	Oil	Oil	Oil	Oil	Dry	Dry	Dry	Dry	Dry
Mat^1.Section		1" sq.	1" sq.	1" sq.	1" sq.	1" sq.	1" sq.	1" sq.	1" sq.	1" sq.	1" sq.

10 T.P.I. raker-set blade used throughout to cut mild steel bar.

Test No.	Unit	31	32	33	34	35	36	37	38	39
Vertical Load	Lb.	20	20	20	20	20	20	20	20	20
Speed	Ft/min.	230	138	46	230	138	46	230	138	46
Time of cut	Sec.	42	61	141.5	8	12	28	38	56	128
Damping		4	4	4	4	4	4	4	4	4
Cooling		Oil	Oil	Oil	Oil	Oil	Oil	Oil	Oil	Oil
Mat[l]. Section		1" sq.	1" sq.	1" sq.	½" sq.	½" sq.	½" sq.	1" dia.	1" dia.	1" dia.

Test No.		40	41	42	43	44	45	46	47	48
Vert. Load	Lb.	40	40	40	40	40	40	40	40	40
Speed	Ft/min.	230	138	46	230	138	46	230	138	46
Time of cut	Sec.	17	25	58	4	6	15	18	26	66
Damping		4	4	4	4	4	4	4	4	4
Cooling		Oil	Oil	Oil	Oil	Oil	Oil	Oil	Oil	Oil
Mat[l]. Section		1" sq.	1" sq.	1" sq.	½" sq.	½" sq.	½" sq.	1" dia.	1" dia.	1" dia.

Test No.		49	50	51	52	53	54	55	56	57
Vert. load	Lb.	60	60	60	60	60	60	60	60	60
Speed	Ft/min.	230	138	46	230	138	46	230	138	46
Time of cut	Sec.	11	17	40	3	5	12	13	19	51
Damping		4	4	4	4	4	4	4	4	4
Cooling		Oil	Oil	Oil	Oil	Oil	Oil	Oil	Oil	Oil
Mat[l]. Section		1" sq.	1" sq.	1" sq.	½" sq.	½" sq.	½" sq.	1" dia.	1" dia.	1" dia.

Remarks: 10 T.P.I. raker-set blade used throughout to cut mild steel bar

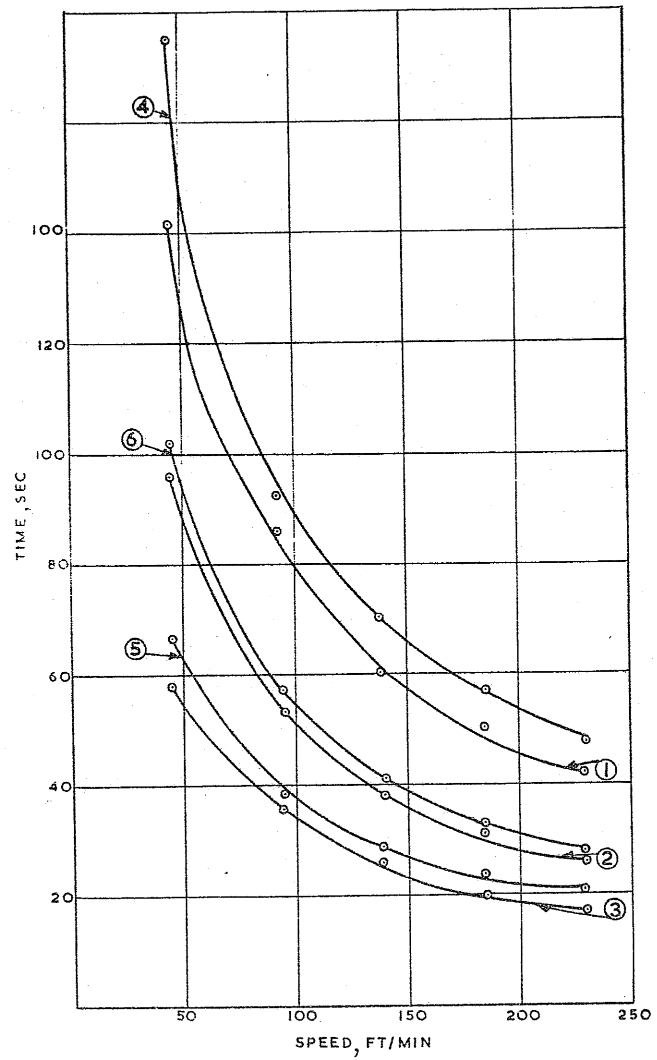
Test No.		58	59	60	61	62	63	64	65
Vert. load	Lb.	20	30	40	60	20	30	40	60
Speed	Ft/min.	46	46	46	46	138	138	138	138
Time of cut	Sec.	141	96	58	40	61	38	25	17
$\frac{1}{\text{Time x Speed}}$		154	231	375	543	119	191	289	427
Damping		4	4	4	4	4	4	4	4
Cooling		Oil	Oil	Oil	Oil	Oil	Oil	Oil	Oil
Section		1" sq.	1" sq.	1" sq.	1" sq.	1" sq.	1" sq.	1" sq.	1" sq.

Test No.		66	67	68	69
Vert. load		20	30	40	60
Speed	Ft/min.	230	230	230	230
Time of cut	Sec.	42	24	17	11
$\frac{1}{\text{Time speed}}$		104	167	256	414
Damping		4	4	4	4
Cooling		Oil	Oil	Oil	Oil
Section		1" sq.	1" sq.	1" sq.	1" sq.

$$T = \frac{\text{Time of cut } \tfrac{1}{2}'' \text{ sq. bar}}{\text{Time of cut } 1'' \text{ sq. bar}}$$

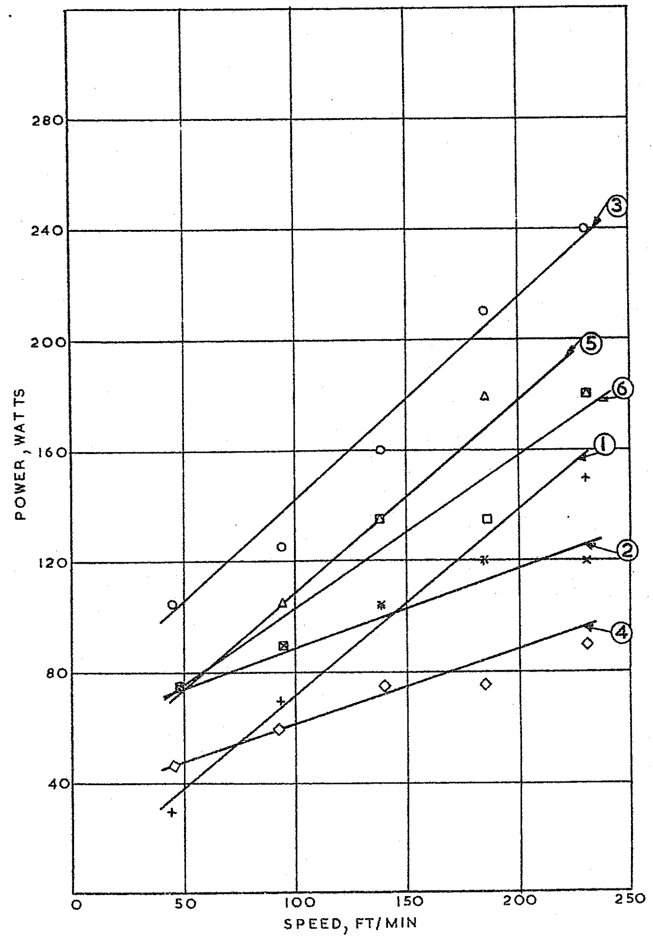
Test No.	Load Lb.	Speed Ft/min.	Mat. Section	Time of cut Sec.	T	Damping	Cooling	Saw Teeth TPI	Tooth Set
34	20	230	½″ sq.	8		4	Oil	10	Raker
31	20	230	1″ sq.	42		4			
					.198				
35	20	138	½″ sq.	12		4			
32	20	138	1″ sq.	61		4			
					.199				
36	20	46	½″ sq.	28		4			
33	20	46	1″ sq.	141.5		4			
					.198				
43	40	230	½″ sq.	4		4			
40	40	230	1″ sq.	17		4			
					.235				
44	40	138	½″ sq.	6		4	DITTO	DITTO	DITTO
41	40	138	1″ sq.	25		4			
					.24				
45	40	46	½″ sq.	15					
42	40	46	1″ sq.	58					
					.259				
52	60	230	½″ sq.	3		4			
49	60	230	1″ sq.	11		4			
					.273				
53	60	138	½″ sq.	5		4			
50	60	138	1″ sq.	17		4			
					.294				
54	60	46	½″ sq.	12		4			
51	60	46	1″ sq.	40		4			
					.300				

Curve	Load	Damping	Cooling
1	20 LBS	Nº 4	OIL
2	30 LB	4	OIL
3	40 LB	4	OIL
4	20 LB	1	OIL
5	40 LB	1	OIL
6	30 LB	4	AIR

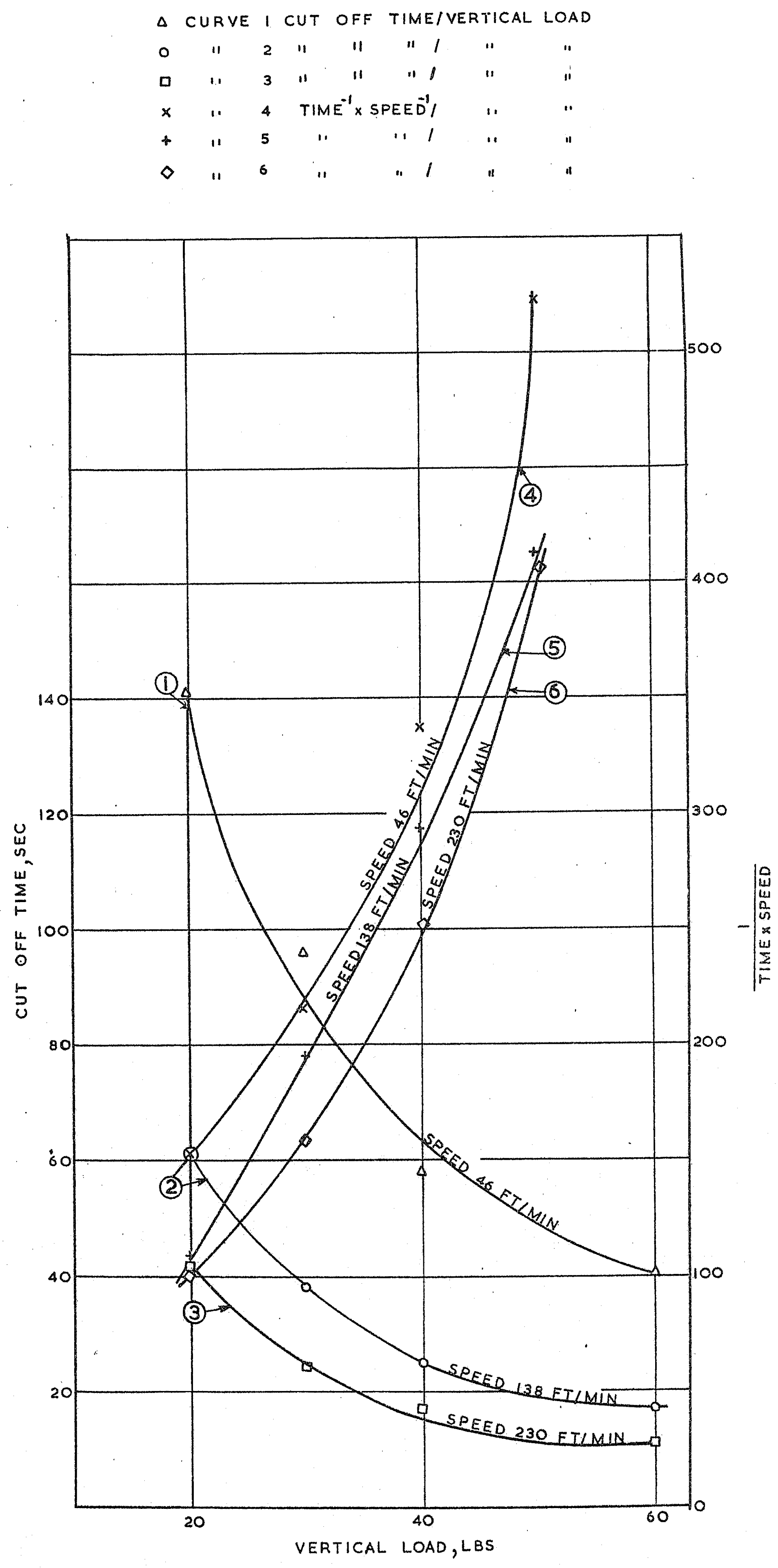


GRAPH 'A' TIME/SPEED.

	Curve	Load	Damping	Cooling
+	1	20 LB	4	OIL
×	2	30 LB	4	OIL
○	3	40 LB	4	OIL
◇	4	20 LB	1	OIL
△	5	40 LB	1	OIL
□	6	30 LB	4	AIR



GRAPH 'B' POWER/SPEED.



Δ CURVE I CUT OFF TIME/VERTICAL LOAD
○ " 2 " " " / " "
□ " 3 " " " / " "
× " 4 TIME⁻¹ x SPEED⁻¹/ " "
+ " 5 " " / " "
◇ " 6 " " / " "
CUT OFF TIME, SEC
1 / TIME x SPEED
VERTICAL LOAD, LBS
SPEED 46 FT/MIN
SPEED 138 FT/MIN
SPEED 230 FT/MIN
SPEED 46 FT/MIN
SPEED 138 FT/MIN
SPEED 230 FT/MIN