Productivity in the corrugated container industry

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ABSTRACT: A measurement of productivity is a necessary tool for the successful operation of corrugated production line. Comparing costs and other components of an operation with industry wide productivity measurements determines machine efficiency.

KEYWORDS: Converting plants, corrugated boxes, costs, efficiency, output, performance, productivity, return on investment.

What is productivity in the boxplant? Is it volume (square feet, square meters, tons, feeds, pieces) per machine hour, or man hour or run hour? Is it average setup time per order or size utilization of a press? Is it labor cost per unit of volume?

The corrugated industry uses some, or all, of these measurements to gauge the performance of the manufacturing department. The measurements also determine pay levels and bonus awards for achieving or exceeding budgeted performance in certain categories. One survey measures productivity by man hours necessary to complete a setup or to run a thousand blanks or a thousand square feet or meters of corrugated board.[1]

This still does not provide the real meaning of productivity. Perhaps we should delay answering this question until we ask, "Why do we operate a boxplant?" Presumably corrugating plants operate to make money and to earn a reasonable return on investment. Now one must ask, "What is our investment?" A probable answer is all the money spent on the purchase of buildings, machinery, parts, raw materials, supplies, labor, etc., necessary to produce the corrugated board, boxes, and allied products.

A dictionary definition of productivity is "the degree of effectiveness of industrial management in using all the facilities for production; especially the effectiveness in using labor and equipment." It is important to emphasize the word all in this definition.

Manufacturing department emphasis

Now we can return to the original question about productivity in a boxplant. The manufacturing arm of the corrugated boxplant has little control over order lengths, flute selection, and basis weight and only limited control over sheet size in the case of multiple-out blanks. It would therefore seem that the main emphasis of the manufacturing department should be the production of what the customers have ordered in the shortest time possible to maximize the efficiency of the total investment. If this is the goal in managing a boxplant, then all efforts should concentrate on increasing the production per hour of the converting equipment. Productivity will therefore be the production per machine hour.

Corrugator production receives much attention. Converting equipment production receives very little attention. In reality converting costs from 1.5 to 5 times the cost of corrugating depending on the relative efficiency of each operation.

Data indicates that the production for an average 2.2 meter corrugator is 11,755 square meters per corrugator hour.[2] The highest production rate is 24,406 square meters. Using an hourly rate of US$ 250 plus US$ 20 for each person in a five member crew, the average total operating cost of corrugating is US$ 2.77 per 9.3 square meters. The minimum is US$ 1.33 per 9.3 square meters.

Corrugated converting cost

The cost of converting corrugated board is the sum of the cost of the flexo–folder–gluer and the cost of the crew. The former is US$ 180/h including depreciation, overhead, and operating costs other than the crew. The crew cost per person is US$ 20/h. Total cost for a crew of two is US$ 220/h and for a crew of three US$ 240/h. The cost of converting board on a flexo–folder–gluer is US$ 7.17 per 9.3 square meters for a crew of two people or US$ 7.82 per 9.3 square meters for a crew which uses three people perform-

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[1] A Measure of Productivity, Report No. 0101R147, TAPPI PRESS, Atlanta, 1985.

I. Ratio of converting cost to corrugating cost

	Industry average	*Top producer*
Corrugating cost	1.00	1.00
Converting cost, crew of 2, industry average	2.59	5.39
Converting cost, crew of 2, top performer	1.24	2.59
Converting cost, crew of 3, industry average	2.82	5.88
Converting cost, crew of 3, top performer	1.35	2.82

II. Crew size vs. man hour and machine hour efficiencies for flexo rotary die cutters

Two person crew			*Three person crew*		
Crew size	Man hour efficiency, %	Machine hour efficiency, %	Crew size	Man hour efficiency, %	Machine hour efficiency, %
2.00	127	96	3.93	96	161
2.00	153	109	3.33	63	126
2.03	82	73	5.00	107	190
2.18	89	87	3.00	146	155
2.02	101	70	4.00	107	184
2.06	95	68	3.00	83	103
2.05	129	112	3.14	63	80
2.00	88	73	3.04	59	78
2.08	110	81	3.25	86	175
2.06	97	79	3.80	73	132
		Average			
2.05	107	85	3.55	88	138

III. Crew size vs. man hour and machine hour efficiencies for flexo–folder–gluers

Two person crew			*Three person crew*		
Crew size	*Man hour efficiency, %*	*Machine hour efficiency, %*	*Crew size*	*Man hour efficiency, %*	*Machine hour efficiency, %*
2.12	116	90	2.63	95	106
2.18	172	130	2.99	67	86
2.00	107	82	3.02	77	97
1.84	126	99	3.03	88	113
2.00	108	95	3.04	73	106
2.00	90	65	3.17	50	72
2.07	82	60	3.00	82	104
2.02	89	75	2.98	95	117
2.05	92	86	3.00	100	147
2.00	93	73	3.00	67	102
		Average			
2.03	108	86	2.99	79	105

IV. Machine hour production output analysis comparison

	Plant A	*Plant B*	*Plant C*
Crew size	2	3	5
Setup time, min/ machine	49	32	24
Feeds/run and downtime	3105	4345	5190
Feeds/total machine h	2394	3414	4167
Square meters per machine h	3820	5455	6658
Square meters per man h	1912	1818	1332
Man h efficiency, %	153	146	107
Production efficiency, %	109	156	190

V. Machine operation performance calculation sheet

Operation:	*127 x 279 cm Flexo–folder–gluer*	
Time reference:	*1991 Third quarter year to date*	
1. Machine hours		*3696*
2 A. Setup hours		*1021*
2 B. Run hours		*2675*
3. Quantity produced:	Orders	*2311*
4.	Sheets fed (impressions)	*7,893,000*
5.	Area, square feet or square meters	*100,564,000*
6.	Pieces produced	*7,983,000*
7. Man hours consumed		*14,331*

Performance vs. usual industry man hours

8. Setup: *1.350* (man hours/setup) x *2311* (Line 3) = *3,119.85*
9. Run_1: _____ (man hours/machine impressions) x _____ (Line 4) =
10. Run_2: *0.047* (man hours/thousand square feet or square meters) x *100,564* (Line 5) = *4,726.51*
11. Total run hours: _____ (Line 9) + *4,726.51* (Line 10) = *4,726.51*
12. Total standard man hours *7,846.36*
13. Efficiency vs. normal: [100 x *7,846.36* (Line 12)] / *14,331* (Line 7) = *55%*
14. Efficiency vs. industry average: [100 x *55* (Line 13)] / *94* (Average performance) *58%*

Performance vs. typical production values

15. Setup hours: *0.470* (man hours/setup) x *2311* (Line 3) = *1,086.17*
16. Run hours: *0.300* (machine hours/impression) x *7,893* (Line 4) = *2,367.90*
17. Total machine hours: (Line 15) + (Line 16) = *3,454.07*
18. Machine hours performance vs. industry average: [100 x *3,454.07* (Line 17)] / *3,696* (Line 1) = *93%*

VI. Machine hour production performance rates

Machine size	*Setup hours per order*	*Feeds per run and downtime*	*Sheet size, square meters*
	Flexo–folder–gluers		
Mini (71 x 182 cm)	0.345	5963	0.503
Small (101 x 254 cm)	0.412	4553	0.679
Medium (127 x 342 cm)	0.470	3330	1.117
Large (190 x 431 cm)	0.554	1871	3.553
Jumbo (>190 x 431 cm)	0.625	990	4.324
	Flexo rotary diecutters		
Small (168 x 203 cm)	0.555	2438	0.950
Medium (168 x 292 cm)	0.541	2551	1.145
Large (168 x 292 cm)	0.554	2489	1.368

ing at the industry average level of productivity of 2852 square meters/h. If the crew performs at the level of the top producer, which is 5948 square meters/h, the cost is US$ 3.44 and US$ 3.75 per 9.3 square meters respectively for the two crew sizes.

The ratio of the cost to convert to the cost of corrugating, as shown in **Table I**, ranges from 1.35 to 5.88. Since converting is so expensive, perhaps there should be greater emphasis on increasing converting equipment production.

Further examination of industry productivity levels reveals that many, many converting machines with larger crew sizes, while generally not measuring well against reported man hour values, do excel in production per machine hour over the machines using smaller crew sizes.

Crew size

Table II shows data for crew sizes of approximately two people and for three or more people. The man hour performance relates to the industry average at 100%, and the machine hour performance relates to industry studies using average setup time and production per machine hour.[2] The man hour efficiencies exceed the machine hour efficiencies for every case for the crews of approximately two people. For a crew of three or more people, however, the machine hour efficiencies always exceed the man hour efficiencies. The change in performance from two persons to three persons decreases 18% for man hour efficiency but increases 62% for machine hour efficiency. Machine hour cost increases 13.5%.

The examples in the table are random selections from reported measurements of productivity[2] and other industry statistics available to the writer. The lower crew size will not necessarily favor the man hour efficiency for every case. Similarly a higher crew size does not always favor machine hour efficiency. The statistics, however, support the general conclusions of the chart.

VII. Industry averages

Machine	Crew Size	Order Size	Square ft./ machine hour	Square meters/ machine hour	Feeds/ machine hour
			Flexo–folder–gluers		
Mini	2.56	10,644	26,560	2467	4997
Small	2.55	8779	27,158	2523	3752
Medium	2.63	5556	30,696	2852	2599
Large	2.79	3340	28,125	2613	1428
Jumbo	2.77	1652	31,517	2928	720
			Rotary diecutters		
Small	2.37	5900	19,761	1836	1983
Medium	2.43	6304	22,407	2082	2093
Large	2.58	5334	31,991	2972	1978

The data in **Table III** is a similar comparison for flexo–folder–gluers. The same efficiency conclusions follow as with the data from Table II.

The change in performance from two persons to three persons decreases 27% for man hour efficiency but increases 22% for machine hour efficiency. Machine hour cost increases 8.7%.

If a typical flexo–folder–gluer has an hourly operating cost (including all fixed costs for building, light, power, supervision, etc.) of US$ 180 and a crew cost of US$ 20 per person, efforts should concentrate on maximizing the production for the combined machine and crew hourly rate rather than maximizing the output for the man hour rate alone.

Table IV provides an example of a rotary die cutting operation that averages a crew of five people. The average feeds per machine hour is over 4100. A comparable operation running with a crew of two people averages approximately 2400 feeds/h. The performance measured against the man hour values in the TAPPI Productivity Survey favors the crew of two people (153% vs. 107%). Using the typical industry averages[2] to calculate the machine hour production performance, the crew of five excels over the crew of two by 190% to 109%. Focussing only on man hour efficiency can be misleading in many instances. Indeed the Productivity Survey Subcommittee of the Corrugated Container Division's Productivity Improvement Committee has decided to embrace machine hour as well as the traditional man hour concepts in future surveys.

Calculation sheet

This article includes a copy of a completed machine operation performance calculation sheet in **Table V**. Using this allows a determination of both man hour and machine hour efficiency. To determine the man hour efficiency, refer to the original industrial survey instructions which provide the values for this calculation.[1] To determine the machine hour production efficiency, use the machine hour production rates shown in **Table VI**. **Table VII** provides various industry averages for different sizes of flexo–folder–gluers and rotary die cutters. In the determination of the machine hour production performance, the standard machine hours calculation considers the actual order size for the converting equipment used. Therefore the comparison is not against an average but against what the typical plant would have done running that order size. In both the man hour and machine hour performance, the average is 100. Thus a performance over 100 is better than average, and a performance below 100 is poorer.

Tom Peters stated, "What gets measured, gets done." Therefore, if we want to increase the return on our boxplant investment, should we not focus on machine hour production in measuring performance? ■

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[1] A Measure of Productivity, Report No. 0101R147, TAPPI PRESS, Atlanta, 1985.

[2] Corrugated Annual Productivity Survey, Report No. R-198, TAPPI PRESS, Atlanta, 1991.