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DYNAMIC MANAGEMENT OF MANUFACTURING ORDERS

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ABSTRACT

A key requirement for the make-to-order (MTO) manufacturing companies to remain competitive is the ability to assess incoming orders in terms of performance and to determine the best orders that they should accept.

In this paper, we propose a method to control the entire production process, from customer enquiry up to product delivery, for the MTO manufacturing systems. In practice, decisions on order acceptance and on production planning are often made separately. Sales department is responsible for accepting orders, while the production department is in charge of production planning for implementation of accepted orders.

The system environment provides on-line data on the actions undertaken which, properly analyzed and correlated, will further generate solutions in order to develop said system and make it competitive.

KEYWORDS: competitiveness, manufacturing system, dynamic management

1. INTRODUCTION

Order acceptance problem is usually treated in the literature considering the single resource case with deterministic processing time [1,2]. The acceptance criterion is based mostly on capacity-driven approach. We cannot take into consideration that company performance is essentially dependent on the manner in which accepted orders are appropriate to all characteristic elements of the manufacturing system. In accordance with the method proposed in this paper, order acceptance is Earning Power-driven, while work-load, due-date and price are considered as restrictions.

In present, machine control is made independently to of order features, such as price. This is why, although the local control of the machine is optimal, the order performance level is not maximum. The method presented in this paper removes the disadvantage in that the machine control is based on simultaneous optimization of all manufacturing processes caused by order fulfillment.

Finally, in the present order acceptance, planning and scheduling of the production process, and machine control can be solved separately. In this paper, we propose an integrated control method for the three aspects where Earning Power is used as decision criterion when accepting or rejecting the order.

One customer’s order can include several jobs.

Knowing the price P_j (2), the cost c_{ijk}, the asset A_{ijk} and the time t_{ijk}, we can build the order modeling, meaning the EP for each order (1).

$$EP_i = \frac{P_i - \sum_j \sum_k c_{ijk}\left(p_{jkn}\right)}{\sum_j \sum_k A_{ijk} \cdot t_{ijk}\left(p_{jkn}\right)} \quad \left[\frac{Euro}{Euro \cdot \min}\right] \tag{1}$$

The price of order, P_i, (2) can be distributed on each job, j, then each operation that composes the job.

$$P_i = \sum_j \sum_k P_{ijk} \tag{2}$$

Based on EP_i determined for each order, the order can be accepted or rejected the order.

Therefore, there are going to be accepted only those orders that can bring significant profit and can increase the market share. This modeling can provide a better order management and increase the company's competitiveness.

2. CASE STUDY

We consider that we have to manufacture the part in Fig. 1 and the manager must decide whether to accept this order. The technological process needed to process the part consists of the following operations: turning, drilling and welding.

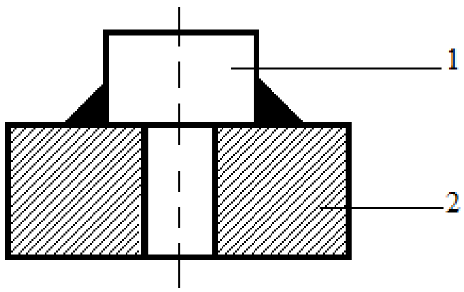


Fig. 1. Manufacturing part
1- rod, 2- plate

In order to evaluate the order EP we have to calculate job EP and operation EP. To do this, the order will be divided in job 1 (rod 1, Fig. 1) and job 2 (plate 2, Fig. 1). To perform job 1 it is necessary to use the turning operation. For job 2 we need drilling and welding operations.

In order to evaluate the order EP we will use the relation (1) and if this is adapted to order *i* it becomes:

$$EP_i = \frac{P_i - \sum_j \sum_k c_{ijk}\left(p_{jkn}\right)}{\sum_j \sum_k A_{ijk} \cdot t_{ijk}\left(p_{jkn}\right)} = \tag{3}$$

$$= \frac{(P_{i11} + P_{i21} + P_{i22}) - (c_{i11} + c_{i21} + c_{i22})}{A_{i11} \cdot t_{i11} + A_{i21} \cdot t_{i21} + A_{i22} \cdot t_{i22}} \left[\frac{Euro}{Euro \cdot \min}\right]$$

where:

P_{i11} - is the price of turning operation;

c_{i11} – the cost of turning operation;

A_{i11} – the asset of turning operation;

t_{i11} – is the time to perform a turning operation;

P_{i21} - is the price of welding operation;

c_{i21} - the cost of welding operation;

A_{i21} – the asset of welding operation;

t_{i21} - is the time to perform a welding operation;

P_{i22} - is the price of driling operation;

c_{i22} - the cost of driling operation;

A_{i22} - the asset of driling operation;

t_{i22} - the asset of driling operation.

These data are given in Fig.2 and Fig.3.

By numerical simulations (Fig.2, Fig. 3), for the cases of 14 cutting speed values, 11 drilling speed values and 13 rate of welding values were obtained 2002 EP's values of order *i*. Maximum value for EP was obtained for a turning speed, $v=50$ m/min, drilling speed, $v=200$ rev/min and welding speed, $v=5.2$ mm/s. Maximum value for EP is $7.25 \cdot 10^{-8}\left[\frac{Euro}{Euro \cdot \min}\right]$.

We can calculate the EP for the other orders in the order entry pool in a similar manner. In the end, all EP values of all orders are ordered in a decreasing sequence.

The orders with a maximum calculated EP that brings economical effect to the company would be kept.

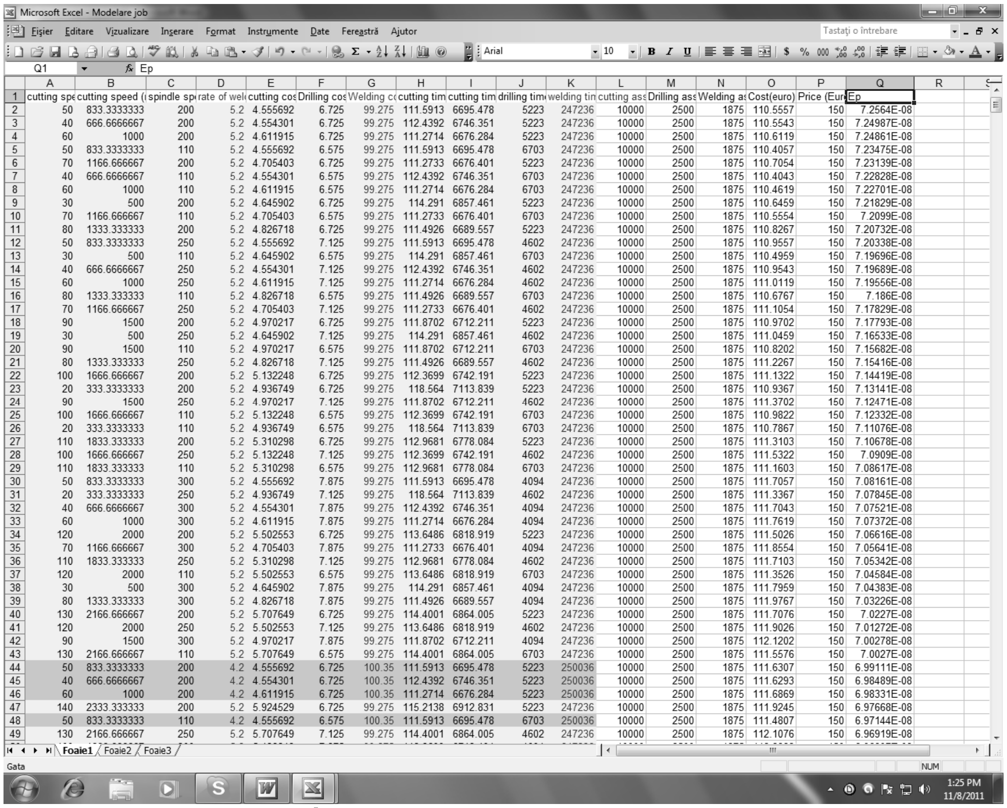
The other orders will be outsourced to other manufacturing companies.

It results that the manager will have an overview of the order EP to make an order acceptance. Order acceptance will be made after evaluation of maximal EP values and after selecting only those orders that may bring profit to the company.

Analyzing data in table 1 according to the maximum value of EP, the manager can decide whether or not to perform all jobs necessary to achieve order in the company.

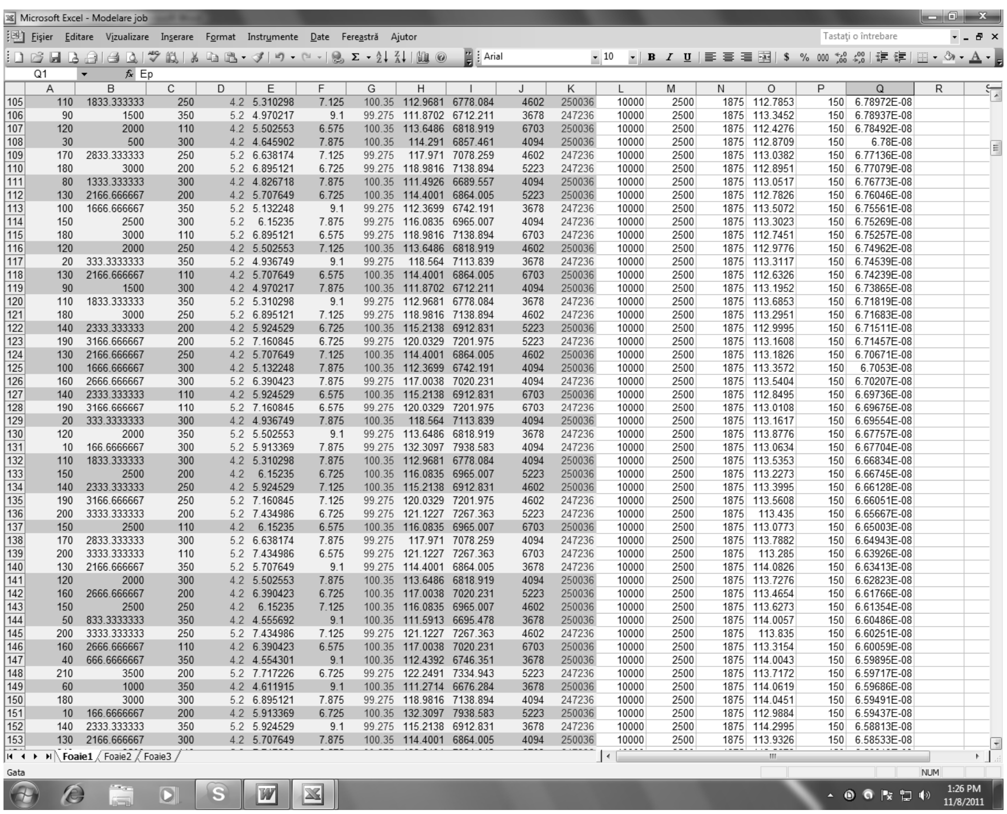
Table 1. Order EP maximum

Order price [Euro]	Operation order			Order EP max [Euro/Euro·min]
	turning	drilling	welding	
150	x	x	x	7.256·10-8
136.25	x		x	6.11·10-8
22.5	x	x		14·10-8
141.25		x	x	7.4·10-8
127.5			x	6.09·10-8
8.75	x			6.26·10-8
13.75		x		57.5·10-8



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	cutting spe	cutting speed (i	spindle sp	rate of wel	cutting cos	Drilling cos	Welding c	cutting tim	cutting tim	drilling tim	welding tin	cutting ass	Drilling ass	Welding as	Cost(euro)	Price (Eur	Ep
2	50	833.3333333	200	5.2	4.555692	6.725	99.275	111.5913	6695.478	5223	247236	10000	2500	1875	110.5557	150	7.2564E-08
3	40	666.6666667	200	5.2	4.554301	6.725	99.275	112.4392	6746.351	5223	247236	10000	2500	1875	110.5543	150	7.24987E-08
4	60	1000	200	5.2	4.611915	6.725	99.275	111.2714	6676.284	5223	247236	10000	2500	1875	110.6119	150	7.24861E-08
5	50	833.3333333	110	5.2	4.555692	6.575	99.275	111.5913	6695.478	6703	247236	10000	2500	1875	110.4057	150	7.23475E-08
6	70	1166.666667	200	5.2	4.705403	6.725	99.275	111.2733	6676.401	5223	247236	10000	2500	1875	110.7054	150	7.23139E-08
7	40	666.6666667	110	5.2	4.554301	6.575	99.275	112.4392	6746.351	6703	247236	10000	2500	1875	110.4043	150	7.22828E-08
8	60	1000	110	5.2	4.611915	6.575	99.275	111.2714	6676.284	6703	247236	10000	2500	1875	110.4619	150	7.22701E-08
9	30	500	200	5.2	4.645902	6.725	99.275	114.291	6857.461	5223	247236	10000	2500	1875	110.6459	150	7.21829E-08
10	70	1166.666667	110	5.2	4.705403	6.575	99.275	111.2733	6676.401	6703	247236	10000	2500	1875	110.5554	150	7.2099E-08
11	80	1333.333333	200	5.2	4.826718	6.725	99.275	111.4926	6689.557	5223	247236	10000	2500	1875	110.8267	150	7.20732E-08
12	50	833.3333333	250	5.2	4.555692	7.125	99.275	111.5913	6695.478	4602	247236	10000	2500	1875	110.9557	150	7.20338E-08
13	30	500	110	5.2	4.645902	6.575	99.275	114.291	6857.461	6703	247236	10000	2500	1875	110.4959	150	7.19696E-08
14	40	666.6666667	250	5.2	4.554301	7.125	99.275	112.4392	6746.351	4602	247236	10000	2500	1875	110.9543	150	7.19689E-08
15	60	1000	250	5.2	4.611915	7.125	99.275	111.2714	6676.284	4602	247236	10000	2500	1875	111.0119	150	7.19556E-08
16	80	1333.333333	110	5.2	4.826718	6.575	99.275	111.4926	6689.557	6703	247236	10000	2500	1875	110.6767	150	7.186E-08
17	70	1166.666667	250	5.2	4.705403	7.125	99.275	111.2733	6676.401	4602	247236	10000	2500	1875	111.1054	150	7.17829E-08
18	90	1500	200	5.2	4.970217	6.725	99.275	111.8702	6712.211	5223	247236	10000	2500	1875	110.9702	150	7.17793E-08
19	30	500	250	5.2	4.645902	7.125	99.275	114.291	6857.461	4602	247236	10000	2500	1875	111.0459	150	7.16533E-08
20	90	1500	110	5.2	4.970217	6.575	99.275	111.8702	6712.211	6703	247236	10000	2500	1875	110.8202	150	7.15682E-08
21	80	1333.333333	250	5.2	4.826718	7.125	99.275	111.4926	6689.557	4602	247236	10000	2500	1875	111.2267	150	7.15416E-08
22	100	1666.666667	200	5.2	5.132248	6.725	99.275	112.3699	6742.191	5223	247236	10000	2500	1875	111.1322	150	7.14419E-08
23	20	333.3333333	200	5.2	4.936749	6.725	99.275	118.564	7113.839	5223	247236	10000	2500	1875	110.9367	150	7.13141E-08
24	90	1500	250	5.2	4.970217	7.125	99.275	111.8702	6712.211	4602	247236	10000	2500	1875	111.3702	150	7.12471E-08
25	100	1666.666667	110	5.2	5.132248	6.575	99.275	112.3699	6742.191	6703	247236	10000	2500	1875	110.9822	150	7.12332E-08
26	20	333.3333333	110	5.2	4.936749	6.575	99.275	118.564	7113.839	6703	247236	10000	2500	1875	110.7867	150	7.11076E-08
27	110	1833.333333	200	5.2	5.310298	6.725	99.275	112.9681	6778.084	5223	247236	10000	2500	1875	111.3103	150	7.10678E-08
28	100	1666.666667	250	5.2	5.132248	7.125	99.275	112.3699	6742.191	4602	247236	10000	2500	1875	111.5322	150	7.0909E-08
29	110	1833.333333	110	5.2	5.310298	6.575	99.275	112.9681	6778.084	6703	247236	10000	2500	1875	111.1603	150	7.08617E-08
30	50	833.3333333	300	5.2	4.555692	7.875	99.275	111.5913	6695.478	4094	247236	10000	2500	1875	111.7057	150	7.08161E-08
31	20	333.3333333	250	5.2	4.936749	7.125	99.275	118.564	7113.839	4602	247236	10000	2500	1875	111.3367	150	7.07845E-08
32	40	666.6666667	300	5.2	4.554301	7.875	99.275	112.4392	6746.351	4094	247236	10000	2500	1875	111.7043	150	7.07521E-08
33	60	1000	300	5.2	4.611915	7.875	99.275	111.2714	6676.284	4094	247236	10000	2500	1875	111.7619	150	7.07372E-08
34	120	2000	200	5.2	5.502553	6.725	99.275	113.6486	6818.919	5223	247236	10000	2500	1875	111.5026	150	7.06616E-08
35	70	1166.666667	300	5.2	4.705403	7.875	99.275	111.2733	6676.401	4094	247236	10000	2500	1875	111.8554	150	7.05641E-08
36	110	1833.333333	250	5.2	5.310298	7.125	99.275	112.9681	6778.084	4602	247236	10000	2500	1875	111.7103	150	7.05342E-08
37	120	2000	110	5.2	5.502553	6.575	99.275	113.6486	6818.919	6703	247236	10000	2500	1875	111.3526	150	7.04584E-08
38	30	500	300	5.2	4.645902	7.875	99.275	114.291	6857.461	4094	247236	10000	2500	1875	111.7959	150	7.04383E-08
39	80	1333.333333	300	5.2	4.826718	7.875	99.275	111.4926	6689.557	4094	247236	10000	2500	1875	111.9767	150	7.03226E-08
40	130	2166.666667	200	5.2	5.707649	6.725	99.275	114.4001	6864.005	5223	247236	10000	2500	1875	111.7076	150	7.0227E-08
41	120	2000	250	5.2	5.502553	7.125	99.275	113.6486	6818.919	4602	247236	10000	2500	1875	111.9026	150	7.01272E-08
42	90	1500	300	5.2	4.970217	7.875	99.275	111.8702	6712.211	4094	247236	10000	2500	1875	112.1202	150	7.00278E-08
43	130	2166.666667	110	5.2	5.707649	6.575	99.275	114.4001	6864.005	6703	247236	10000	2500	1875	111.5576	150	7.0027E-08
44	50	833.3333333	200	4.2	4.555692	6.725	100.35	111.5913	6695.478	5223	250036	10000	2500	1875	111.6307	150	6.99111E-08
45	40	666.6666667	200	4.2	4.554301	6.725	100.35	112.4392	6746.351	5223	250036	10000	2500	1875	111.6293	150	6.98489E-08
46	60	1000	200	4.2	4.611915	6.725	100.35	111.2714	6676.284	5223	250036	10000	2500	1875	111.6869	150	6.98331E-08
47	140	2333.333333	200	5.2	5.924529	6.725	99.275	115.2138	6912.831	5223	247236	10000	2500	1875	111.9245	150	6.97668E-08
48	50	833.3333333	110	4.2	4.555692	6.575	100.35	111.5913	6695.478	6703	250036	10000	2500	1875	111.4807	150	6.97144E-08
49	130	2166.666667	250	5.2	5.707649	7.125	99.275	114.4001	6864.005	4602	247236	10000	2500	1875	112.1076	150	6.96919E-08

Fig. 2. Order EP sequence



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
105	110	1833.333333	250	4.2	5.310298	7.125	100.35	112.9681	6778.084	4602	250036	10000	2500	1875	112.7853	150	6.78972E-08
106	90	1500	350	5.2	4.970217	9.1	99.275	111.8702	6712.211	3678	247236	10000	2500	1875	113.3452	150	6.78937E-08
107	120	2000	110	4.2	5.502553	6.575	100.35	113.6486	6818.919	6703	250036	10000	2500	1875	112.4276	150	6.78492E-08
108	30	500	300	4.2	4.645902	7.875	100.35	114.291	6857.461	4094	250036	10000	2500	1875	112.8709	150	6.78E-08
109	170	2833.333333	250	5.2	6.638174	7.125	99.275	117.971	7078.259	4602	247236	10000	2500	1875	113.0382	150	6.77136E-08
110	180	3000	200	5.2	6.895121	6.725	99.275	118.9816	7138.894	5223	247236	10000	2500	1875	112.8951	150	6.77079E-08
111	80	1333.333333	300	4.2	4.826718	7.875	100.35	111.4926	6689.557	4094	250036	10000	2500	1875	113.0517	150	6.76773E-08
112	130	2166.666667	200	4.2	5.707649	6.725	100.35	114.4001	6864.005	5223	250036	10000	2500	1875	112.7826	150	6.76046E-08
113	100	1666.666667	350	5.2	5.132248	9.1	99.275	112.3699	6742.191	3678	247236	10000	2500	1875	113.5072	150	6.75561E-08
114	150	2500	300	5.2	6.15235	7.875	99.275	116.0835	6965.007	4094	247236	10000	2500	1875	113.3023	150	6.75269E-08
115	180	3000	110	5.2	6.895121	6.575	99.275	118.9816	7138.894	6703	247236	10000	2500	1875	112.7451	150	6.75257E-08
116	120	2000	250	4.2	5.502553	7.125	100.35	113.6486	6818.919	4602	250036	10000	2500	1875	112.9776	150	6.74962E-08
117	20	333.3333333	350	5.2	4.936749	9.1	99.275	118.564	7113.839	3678	247236	10000	2500	1875	113.3117	150	6.74539E-08
118	130	2166.666667	110	4.2	5.707649	6.575	100.35	114.4001	6864.005	6703	250036	10000	2500	1875	112.6326	150	6.74239E-08
119	90	1500	300	4.2	4.970217	7.875	100.35	111.8702	6712.211	4094	250036	10000	2500	1875	113.1952	150	6.73865E-08
120	110	1833.333333	350	5.2	5.310298	9.1	99.275	112.9681	6778.084	3678	247236	10000	2500	1875	113.6853	150	6.71819E-08
121	180	3000	250	5.2	6.895121	7.125	99.275	118.9816	7138.894	4602	247236	10000	2500	1875	113.2951	150	6.71683E-08
122	140	2333.333333	200	4.2	5.924529	6.725	100.35	115.2138	6912.831	5223	250036	10000	2500	1875	112.9995	150	6.71511E-08
123	190	3166.666667	200	5.2	7.160845	6.725	99.275	120.0329	7201.975	5223	247236	10000	2500	1875	113.1608	150	6.71457E-08
124	130	2166.666667	250	4.2	5.707649	7.125	100.35	114.4001	6864.005	4602	250036	10000	2500	1875	113.1826	150	6.70671E-08
125	100	1666.666667	300	4.2	5.132248	7.875	100.35	112.3699	6742.191	4094	250036	10000	2500	1875	113.3572	150	6.7053E-08
126	160	2666.666667	300	5.2	6.390423	7.875	99.275	117.0038	7020.231	4094	247236	10000	2500	1875	113.5404	150	6.70207E-08
127	140	2333.333333	110	4.2	5.924529	6.575	100.35	115.2138	6912.831	6703	250036	10000	2500	1875	112.8495	150	6.69736E-08
128	190	3166.666667	110	5.2	7.160845	6.575	99.275	120.0329	7201.975	6703	247236	10000	2500	1875	113.0108	150	6.69675E-08
129	20	333.3333333	300	4.2	4.936749	7.875	100.35	118.564	7113.839	4094	250036	10000	2500	1875	113.1617	150	6.69554E-08
130	120	2000	350	5.2	5.502553	9.1	99.275	113.6486	6818.919	3678	247236	10000	2500	1875	113.8776	150	6.67757E-08
131	10	166.6666667	300	5.2	5.913369	7.875	99.275	132.3097	7938.583	4094	247236	10000	2500	1875	113.0634	150	6.67704E-08
132	110	1833.333333	300	4.2	5.310298	7.875	100.35	112.9681	6778.084	4094	250036	10000	2500	1875	113.5353	150	6.66834E-08
133	150	2500	200	4.2	6.15235	6.725	100.35	116.0835	6965.007	5223	250036	10000	2500	1875	113.2273	150	6.66745E-08
134	140	2333.333333	250	4.2	5.924529	7.125	100.35	115.2138	6912.831	4602	250036	10000	2500	1875	113.3995	150	6.66128E-08
135	190	3166.666667	250	5.2	7.160845	7.125	99.275	120.0329	7201.975	4602	247236	10000	2500	1875	113.5608	150	6.66051E-08
136	200	3333.333333	200	5.2	7.434986	6.725	99.275	121.1227	7267.363	5223	247236	10000	2500	1875	113.435	150	6.65667E-08
137	150	2500	110	4.2	6.15235	6.575	100.35	116.0835	6965.007	6703	250036	10000	2500	1875	113.0773	150	6.65003E-08
138	170	2833.333333	300	5.2	6.638174	7.875	99.275	117.971	7078.259	4094	247236	10000	2500	1875	113.7882	150	6.64943E-08
139	200	3333.333333	110	5.2	7.434986	6.575	99.275	121.1227	7267.363	6703	247236	10000	2500	1875	113.285	150	6.63926E-08
140	130	2166.666667	350	5.2	5.707649	9.1	99.275	114.4001	6864.005	3678	247236	10000	2500	1875	114.0826	150	6.63413E-08
141	120	2000	300	4.2	5.502553	7.875	100.35	113.6486	6818.919	4094	250036	10000	2500	1875	113.7276	150	6.62823E-08
142	160	2666.666667	200	4.2	6.390423	6.725	100.35	117.0038	7020.231	5223	250036	10000	2500	1875	113.4654	150	6.61766E-08
143	150	2500	250	4.2	6.15235	7.125	100.35	116.0835	6965.007	4602	250036	10000	2500	1875	113.6273	150	6.61354E-08
144	50	833.3333333	350	4.2	4.555692	9.1	100.35	111.5913	6695.478	3678	250036	10000	2500	1875	114.0057	150	6.60486E-08
145	200	3333.333333	250	5.2	7.434986	7.125	99.275	121.1227	7267.363	4602	247236	10000	2500	1875	113.835	150	6.60251E-08
146	160	2666.666667	110	4.2	6.390423	6.575	100.35	117.0038	7020.231	6703	250036	10000	2500	1875	113.3154	150	6.60059E-08
147	40	666.6666667	350	4.2	4.554301	9.1	100.35	112.4392	6746.351	3678	250036	10000	2500	1875	114.0043	150	6.59895E-08
148	210	3500	200	5.2	7.717226	6.725	99.275	122.2491	7334.943	5223	247236	10000	2500	1875	113.7172	150	6.59717E-08
149	60	1000	350	4.2	4.611915	9.1	100.35	111.2714	6676.284	3678	250036	10000	2500	1875	114.0619	150	6.59686E-08
150	180	3000	300	5.2	6.895121	7.875	99.275	118.9816	7138.894	4094	247236	10000	2500	1875	114.0451	150	6.59491E-08
151	10	166.6666667	200	4.2	5.913369	6.725	100.35	132.3097	7938.583	5223	250036	10000	2500	1875	112.9884	150	6.59437E-08
152	140	2333.333333	350	5.2	5.924529	9.1	99.275	115.2138	6912.831	3678	247236	10000	2500	1875	114.2995	150	6.58813E-08
153	130	2166.666667	300	4.2	5.707649	7.875	100.35	114.4001	6864.005	4094	250036	10000	2500	1875	113.9326	150	6.58533E-08

Fig. 3. Order EP sequence

If obtaining an unsatisfactory value of EP for the company, the manager may choose to outsource those operations. Thus, if the company run only drilling and outsourced the other two operations, it would be observed that this case is the most profitable (*EP*=57.5·10-8 Euro/Euro·min).

If they perform the welding operation, the worst EP (*EP*=6.09·10-8 Euro/Euro·min) is obtained.

3. CONCLUSION

Order acceptance will be made only after evaluating the maximal values of EP and selecting those orders-that could be positive for the company.

As far as the order is concerned, if the company only performed the drilling operation and outsourced the other two operations, the effect on the company would be a positive one (*EP*=57.5·10-8 Euro/Euro·min). If the company would only performed the welding operation it would have the worst EP (*EP*=6.09·10-8 Euro/Euro·min). Therefore, the manager will have an overview of the order EP in order to perform the order acceptance.

This analysis will help the manager of a make-to-order companies, on one hand, to accept an order, and on the other hand, to perform an optimal control of the processing system.

In other words, the paper suggests a method for integrated control for a make-to-order manufacturing system where EP is used as a decision making criterion.

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