Decision Making Tools: Part: III-

Sequencing of Manufacturing Process

By:
Sunil Kumar Puri

Decision Making Tools: Part III

Sequencing of Manufacturing Process

By: Sunil Kumar Puri

Gates is the ultimate programming machine. He believes everything can be defined, examined, reduced to essentials, and rearranged into a logical ***sequence*** *that will achieve a particular goal."* Stewart Alsop quotes

Our brain works consciously, subconsciously as well as unconsciously and what ever our brain does consciously is what our mind does. We all use our conscious minds to process series of information in order to make decisions needed to survive. The Process is known as decision making process. However because of many uncertainties, at times we become afraid of making wrong decisions and therefore tend not to take a decision and avoid decision making. We all live in a shadow of fear and yet little was known about fear until Sigmund Freud began the study of unusual phobias. The fear of making wrong decisions combined with nervous agitation is called decidophobia.

Decision making process is a conscious effort and is about facing a situation or a question. Good decisions are efficient and effective and are made by putting to use a well engineered plan and a well focused process by defining a model. The model shall represent a way of looking at the problem considering a set of assumptions that enable us to understand and evaluate the predictable outcome.

In every day business we often come across situations when we need to make sound decisions about how to conduct day to day business effectively and efficiently. In our previous examples we discussed the problem "which orders to execute when we have a multiple choices and production constraints". In this paper we shall discuss the problem of how to sequence the production process. After going through this paper one shall be able to understand that when the production times on different machines, are different for different products by understanding the sequencing method a correct sequence of production can save a lot of production time by reducing the waiting time to minimum or close to minimum. Lean Manufacturing talks about the seven deadly wastes and one of these wastes is nothing but waiting. All processes have different time frame. All operators take different time to complete a job. Most of the times, a job is followed by another job, these two jobs have different time frame or completion time. An arbitrary sequencing of job assignment can result in a lot of waiting by the following processes.

Let us try a simple example of a printing press, the press has two machines one printing press for printing and the other a binding machine for binding the books. The Press has received orders in the sequence given below:

Sr. No.	Printing Time	Binding Time
1	20 Days	25 Days
2	90 Days	60 Days
3	80 Days	75 Days
4	20 Days	30 Days
5	120 Days	90 Days
6	15 Days	35 Days
7	65 Days	50 Days

If the printer would work on first come first served basis the Calculation of processing time can be calculated as.

Sr. No	Printing		Binding		Time Idle for Binding Mc	Idle Time for Books
	In	Out	In	Out		
1	0	20 (0 +20)	20	45 (20 + 25)		
2	20	110 (20 + 90)	110	170 (110 + 60)	65	
3	110	190 (110 + 80)	190	265 (190 + 75)	20	
4	190	210 (190 + 20)	210	295 (265 + 30)		55
5	210	330 (210 + 120)	330	410 (330 +90)	35	
6	330	345 (330 + 15)	345	445 (410+35)		65
7	345	410 (345 + 65)	410	495 (445 + 50)		35
					120	155

From the above example it is clear that for 120 days there was no work for the Binding Machine and for 155 days the books were lying waiting for their turn to get bound.

Correct sequencing may not eliminate the waiting time but will definitely reduce it to bare minimum making the working efficient. Many heuristic methods have been proposed for it.

Johnson's Rule is a technique that can be used to minimise the completion time for a group of jobs that are to be processed on two machines or at two successive work centres. The Objectives of the Johnson's Rule are:

- To minimise the processing time for sequencing a group of jobs through two work centres.
- To minimise the total idle times on the machines.
- To minimise the flow time from the beginning of the first job until the finish of the last job.

In order for the technique to be used, following conditions must be satisfied:

- Job time (including setup and processing) must be known and constant for each job at each work centre.
- Job times must be independent of the job sequence.
- All jobs must follow the same two-setup work sequence.
- Job priorities cannot be used.

The Johnson's Rule involves four steps

1) All jobs are listed, and the processing time of each machine is listed.
2) Select the job with the shortest processing time.
   If the shortest time lies on the first machine/work centre, the job is scheduled first.
   If the shortest time lies on the second machine/work centre, the job is scheduled at the end.
   Ties in activity times can be broken arbitrarily.
3) Once the job is scheduled, go to step 4
4) Repeat steps2 and step3 to the remaining jobs, working towards the centre of the sequence.

Let us try to solve the problem of the printing press using the Johnson's Rule.

Let us try a simple example of a printing press, the press has two machines one printing press for printing and one binding machine for binding the books. The Press has received orders in the sequence given below:

S. No.	Printing Time	Binding Time
Book 1	20 Days	25 Days
Book 2	90 Days	60 Days
Book 3	80 Days	75 Days
Book 4	20 Days	30 Days
Book 5	120 Days	90 Days
Book 6	15 Days	35 Days
Book 7	65 Days	50 Days

The Book No 6 has minimum time for printing and as it is the first process therefore this book shall be printed first, we put job no 6 in the first place.

Sequence	1	2	3	4	5	6	7
Job	6						

The next Books with minimum number of working days of 20 are 1 and 4 in this case the decision can be arbitrary but we decide on the number of days for the following job i.e.,

binding, and place book number 1 before book number 4 as it takes lesser number of days for binding and select Book No 1 followed by Book No 4.

Sequence	1	2	3	4	5	6	7
Job	6	1	4				

The Book No 7 of the remaining jobs has minimum 50 days as time period in the second work i.e., binding and therefore the sequence no 7 shall be assigned to this job.

Sequence	1	2	3	4	5	6	7
Job	6	1	4				7

Similarly the Book No 2 also has minimum no of working days for the binding job and therefore the sequence no 6 shall be assigned to this Book.

Sequence	1	2	3	4	5	6	7
Job	6	1	4			2	7

We are now left with Book No. 5 and three and following the above rule the Book No. 5 and three shall be assigned sequence 4 and five respectively.

Sequence	1	2	3	4	5	6	7
Job	6	1	4	5	3	2	7

With the above mentioned sequence derived by applying the Johnson's Rule we can now calculate the printing and binding schedule with both in and out timings. We can prepare the activity table which is given below:

S. No	Printing		Binding		Time Idle for Binding Mc	Idle Time for Books
	In	Out	In	Out		
6	0	15 (0 +15)	15	50 (15 + 35)		
1	15	35 (15 + 20)	35	75 (50 + 25)		15
4	35	55 (35 + 20)	55	105 (75 + 30)		20
5	55	175 (55 + 120)	175	265 (175 + 90)	70	
3	175	255 (175 + 80)	255	340 (265 +75)		10
2	255	345 (255 + 90)	345	405 (345+60)	5	
7	345	410 (345 + 65)	410	460 (410 + 50)		5
				460	75	50

If we compare it with the previously arranged sequence, the job of printing all seven books can now be finished in 460 days as compared to 505, the idle time for the binding machine gets reduced to 70 days against 120 days. It is quite evident that by applying simple rules of sequencing a lot of time and money can be saved. This was a simple example but in knitwear manufacturing we encounter relatively more difficult situations everyday and still we make arbitrary decisions. If we follow these decision making tools a lot of waiting time can be reduced which will result in reduced lead times.

However in garment manufacturing there are not just two operations but in fact the number of operations at times exceed twenty. The chart given below lists number of operations needed to manufacture sweaters.

S. N.	Operation	Time in minutes for Operations Styles 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Knitting	120	106	121	112	134	138	104	136	91.2	104	149	96	143	142	112	96	113	150	142	132
2	Inspection	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
3	Mending	3	3.5	3.5	3.25	3.75	3.5	3.5	3.25	2.75	2.75	2.75	2.75	2.5	3.5	3.25	3.5	3.75	3.75	3.25	3
4	Basting	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
5	Wash	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
6	Dry	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45
7	Press	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
8	Inspection	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
9	Cutting	4	3.5	3.75	3.5	2.5	2.75	3.25	3.5	2.75	3.75	4	4.25	4.5	3	3.75	4	4.35	3.5	3.25	4
10	Linking	40	44	36.8	35.2	32.8	47.6	41.2	33.2	50	32.4	47.2	48	36.8	39.6	48.4	50	31.2	44.4	40	40.4
11	Hand Sew	10	7.8	8.5	11.4	9.6	10.3	12.4	12.5	9.2	8.1	8.4	7.6	8.3	10.6	11.1	11.2	10	10.3	12	12.2
12	Inspection	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
13	Value Add	20	15.6	19.8	17.4	11.4	22.8	12.4	23.8	27.4	27.8	27.6	28.6	18.6	28	26.2	16.6	23	14.8	17.6	24
14	Inspection	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
15	Trim	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
16	Wash	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
17	Dry	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45
18	Press	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
19	Inspection	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
20	Label	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
21	Tag	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
22	Fold	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
23	Pack	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

If we make a close observation of this list we can safely deduce from the data above that most of the operations the time difference is not big enough to make a noticeable difference in the reduction of waiting time by having a correct sequence, however we also observe that many a operations have almost same timings and a few have a little time variations and about three operations have different timings.

We can therefore safely make three groups of these operations in sequence and these three groups are marked in the table given below:

S. N	Operation	Time in minutes for Operations																			
		Styles																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Knitting	120	106	121	112	134	138	104	136	91.2	104	149	96	143	142	112	96	113	150	142	132
2	Inspection	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
3	Mending	3	3.5	3.5	3.25	3.75	3.5	3.5	3.25	2.75	2.75	2.75	2.75	2.5	3.5	3.25	3.5	3.75	3.75	3.25	3
4	Basting	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
5	Wash	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
6	Dry	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45
7	Press	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
8	Inspection	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Sum 1	203	189	205	195	218	222	188	219	174	187	232	179	225	225	195	180	197	234	225	215
9	Cutting	4	3.5	3.75	3.5	2.5	2.75	3.25	3.5	2.75	3.75	4	4.25	4.5	3	3.75	4	4.35	3.5	3.25	4
10	Linking	40	44	36.8	35.2	32.8	47.6	41.2	33.2	50	32.4	47.2	48	36.8	39.6	48.4	50	31.2	44.4	40	40.4
11	Hand Sew	10	7.8	8.5	11.4	9.6	10.3	12.4	12.5	9.2	8.1	8.4	7.6	8.3	10.6	11.1	11.2	10	10.3	12	12.2
12	Inspection	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Sum 2	57	58.3	52.1	53.1	47.9	63.7	59.9	52.2	65	47.3	62.6	62.9	52.6	56.2	66.3	68.2	48.6	61.2	58.3	59.6
13	Value Add	20	15.6	19.8	17.4	11.4	22.8	12.4	23.8	27.4	27.8	27.6	28.6	18.6	28	26.2	16.6	23	14.8	17.6	24
14	Inspection	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
15	Trim	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
16	Wash	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
17	Dry	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45
18	Press	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
19	Inspection	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
20	Label	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
21	Tag	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
22	Fold	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
23	Pack	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	Sum 3	120.0	115.6	119.8	117.4	111.4	122.8	112.4	123.8	127.4	127.8	127.6	128.6	118.6	128.0	126.2	116.6	123.0	114.8	117.6	124.0

The consolidated timings of these three groups is given below:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Sum 1	203	189	205	195	218	222	188	219	174	187	232	179	225	225	195	180	197	234	225	215
Sum 2	57	58.3	52.1	53.1	47.9	63.7	59.9	52.2	65	47.3	62.6	62.9	52.6	56.2	66.3	68.2	48.6	61.2	58.3	59.6
Sum 3	120	115.6	119.8	117.4	111.4	122.8	112.4	123.8	127.4	127.8	127.6	128.6	118.6	128	126.2	116.6	123	114.8	117.6	124

To solve the problem using Johnson's Rule we need to reduce these three operations to two and for this we add us Time of operation 1 with operation 2 and time of operation 2 with time of operation 3 and reduce the number of operations to two as given in table below:

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Sum 1+2	260	247	257	248	266	286	248	271	239	234
Sum 2+3	177	174	172	171	159	187	172	176	192	175

	11	12	13	14	15	16	17	18	19	20
Sum 1+2	295	242	278	281	261	248	246	295	283	275
Sum 2+3	190	192	171	184	193	185	172	176	176	184

From the above table using the Johnson's Rule We can select the correct sequencing order as given in the tables below.

Rank	11	16	12	13	9	3	13	8	19	20	1	18	6	5	10	13	17	1	4	7
Sum 1+2	260	247	257	248	266	286	248	271	239	234	295	242	278	281	261	248	246	295	283	275
Sum 2+3	177	174	172	171	159	187	172	176	192	175	190	192	171	184	193	185	172	176	176	184
Rank	9	14	15	18	20	5	15	10	2	13	4	2	18	7	1	6	15	10	10	7

Sequence	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
No																				

About the Author:

The author is the Executive Director of Sportking Institute of Fashion Technology, Ludhiana and has working experience of over thirty years in knitting. He is also a qualified professional in Total Quality Management, Kaizen and Lean Production. He has his own company in the name and of M/s Techknit Overseas Pvt. Ltd. and has worked as Indian agent of the top three computerized flat bed knitting machine manufacturers for many years. Currently he also looks after the interests of Toyota Tsusho India Pvt. Ltd. an associate company of the famous Toyota Automobile Company of Japan for Punjab and surrounding areas. He is also working as a marketing consultant for a Chinese Machinery Manufacturing Company and as TQM consultant for a few Knitwear Companies.

Click here to read Part II