©2006-2010 Asian Research Publishing Network (ARPN). All rights reserved.

APPLICATION OF JOB SCHEDULING IN SMALL SCALE RICE MILLING FIRM

Odior A .O.[1], Charles-Owaba O. E.[2] and Oyawale F. A.[2]
[1]Department of Production Engineering, University of Benin, Nigeria
[2]Department of Industrial and Production Engineering, University of Ibadan, Nigeria
E-Mail: waddnis@yahoo.com

ABSTRACT

Rice is the edible seed of a plant which is a member of the grass family. It is an annual plant which is grown in many countries throughout the world and is the staple diet for over half the world's population. Rice milling firm has therefore occupied a significant position in the small, medium and large scale enterprises of many nations. In application of job scheduling in rice milling activities a framework for proper scheduling of activities (jobs) in rice milling processing firm in Nigeria has been developed. The methodology addresses this problem by supposing we have (n) customers to be served (where n is large); in what way should customers' order be processed such that the firm's profit is maximized while the customers are not unnecessarily delayed? The problem is addressed by using makespan as a measure of performance while the job orders were sequentially scheduled according to order of priority to achieve optimum results. The results show that CDS and A1 heuristics are preferred to the traditional method of USO. Accordingly, the CDS heuristic, followed by A1 heuristic, gives the best makespan results.

Keywords: rice milling firms, job orders, job scheduling, makespan, optimum results.

INTRODUCTION

Rice milling is a process whereby the rice grain is transformed into a form suitable for human consumption and it has to be done with utmost care to prevent breakage of the kernel and improve the recovery. Rice milling process involves removing the trash and then the husk from the rice, milling the bran off of the endosperm to get the white rice and final removal of broken kernels and other defects. Rice is a well-known cereal grass plant (*Oryza sativa*) which is extensively cultivated in warm climates, and the grain forms a large portion of the food of the inhabitants. Rice from the field, is usually harvested at about 18% to 24% moisture and must be dried down to about 12% to 14% so that it can be safely stored, (Clement *et. al.,* 1994). In most developing countries rice is somehow air-dried and the straw and rice can be dried in the field. It is sometimes stacked in a special manner to allow air to pass through it and cause rain run off quickly. Most often, the paddy rice is spread on some sort of concrete or pavement and raked over until dry and in some developing countries; you will see rice drying all over the roads during harvest season, (Davis, 1944). In developed countries, rice is dried in farm storage bins that have air chambers underneath that force air to pass up through the rice, or rice is dried in large column dryers where the rice makes two to five passes through the dryer in a continuous flow type system. Drying of the rice even while in the field prior to harvest is a critical component in regards to quality. Rice that is cracked during drying will have a lower percentage of head yield and will have a poorer quality after cooking. Most rice varieties are composed of roughly 20% rice hull, 11% bran layers, and 69% starchy endosperm, also referred to as the total milled rice. Total milled rice contains whole grains or head rice, and brokens. The by-products in rice milling are rice hull, rice germ and bran layers, and fine brokens, (Piggott, *et. al.*, 2007).

Rice milling is a crucial step in post-production of rice. The basic objective of a rice milling system is to remove the husk and the bran layers to produce an edible, white rice kernel that is sufficiently milled and free of impurities. Depending on the requirements of the customer, the rice should have a minimum of broken kernels, (Piggott, *et. al.,* 2007). Milling of the rice involves; removing the trash and then the husk from the rice, milling the bran off of the endosperm (leaving white rice), and then removing broken kernels and other defects. There are many ways that rice can be stored and milled, (Autrey, *et. al.*, 1955). Rice milling system can be a simple one or two step process, or a multi stage process. In a one step milling process, husk and bran removal are done in one pass and milled or white rice is produced directly out of paddy. In a two step process, removing husk and removing bran are done separately, and brown rice is produced as an intermediate product. In multistage milling, rice will undergo a number of different processing steps (Matthews, *et. al.*, 1970; Piggott, *et. al.*, 2007).

According to Blazewicz, *et al*. (2005), Johnson's Rule has been the basis of much flow shop scheduling heuristics. Palmer (1965) first proposed a heuristic for the flow shop scheduling problem to minimize makespan. The heuristic generates a slope index for jobs and sequences them in a descending order of the index. Campbell *et al.* (1970) proposed Campbell, Dudek, Smith (CDS) heuristic which is a generalization of Johnson's two machine algorithm; it generates a set of m-1 artificial two-machine problems from an original m-machine problem, then each of the generated problems are solved using Johnson's algorithm.. Du (1993) proposed an AIS approach for solving the permutation flow shop scheduling problem while Liaw, (2008) developed a two-phase heuristic to

©2006-2010 Asian Research Publishing Network (ARPN). All rights reserved.

solve the problem of scheduling two-machine no-wait job shops to minimize makespan..

THEORY

In order to schedule the processing of customers' orders such that maximum profit is obtained, the principles guiding flow shop scheduling are adopted as presented in the mathematical frame work. In this case customers are free to bring their jobs at any time. However, each customer's order (bag of rice) passes through the machines in the same order. Since different quantities are brought for processing and the oil palm bunches have the same surface area characteristics, each order requires different amounts of processing time in hours as presented in the scheduling frame work.

Single Machine Sequencing: A single machine sequencing is a flow shop in which the jobs visit the machines in the same sequence. The shop characteristic of a single machine shop is given as:

N/m // F/ $\bar{F}$

Where n is the number of jobs in the shop
M is the number of machines in the shop
F is the flow shop
$\bar{F}$ is the mean flow time.

N/m is referred to as the hardware and F / $\bar{F}$ is referred to as the software of the system.

Johnson's 2- Machine Algorithm: Johnson's 2-machine algorithm is a process in which the jobs are scheduled in the machines in such a sequence that gives the minimum makespan. A typical case of Johnson's 2-machine algorithm with n jobs is presented in Figure-1.

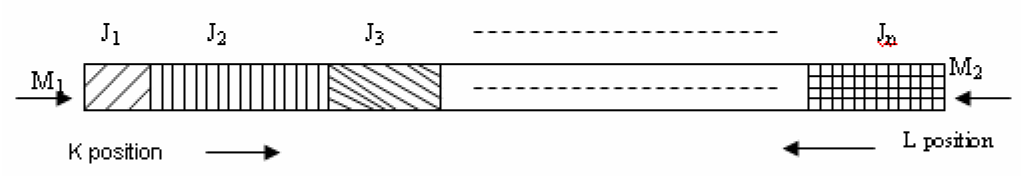

Figure-1. A typical chart for johnson's 2-machine.

The flow time for job J in the kth position is given by

F (k) = P (1) + P (2) + P (3) + ……… + P (k)

$$\therefore \ F(k) = \sum_{i=1}^{k} P(i) \qquad \text{-------------------------------- 1}$$

Where P (i) is the processing time for the job in the ith position in the sequence.

This algorithm supposes that we have (n) jobs to be scheduled on two machines i.e. J1, J2, …, Jn,
Then n positions are possible.

$$\text{Total flow time } F_T = \sum_{k=1}^{n} F(k) = \sum_{k=1}^{n}\sum_{i=1}^{k} P(i)$$

$$\text{Mean flow time } \bar{F} = \frac{\sum_{k=1}^{n}\sum_{i=1}^{k} P(i)}{n} \qquad \text{---------------------------- 2}$$

Generally, for n position we have;

$$\sum_{i=1}^{n} (n-i+1)P(i)$$

$$\frac{\sum_{k=1}^{n}\sum_{i=1}^{k} P(i)}{n} = \frac{\sum_{i=1}^{n} (n-i+1)P(i)}{n} \qquad \text{-------------3}$$

The optimizing sequence can be obtained from the following process:

In this case we have (n) jobs to be scheduled on two machines i.e. J1, J2, …, Jn. The optimal solution by Johnson algorithm is obtained as follows:

Step 1: Set k =1, l = n
Step 2: Set the list of unscheduled jobs = {J1, J2, ..., Jn}
Step 3: Find the smallest processing times on first and second machines for the currently unscheduled jobs
Step 4: If the smallest processing time obtained in step 3 for Ji is on the first machine then schedule Ji in kth position of processing sequence. Then delete the Ji job from the list of unscheduled and decrease k by 1.
Step 5: If the smallest processing time obtained in step 3 for Ji is on the second machine then schedule Ji in the lth position of processing sequence. Then delete the Ji job from the current list of unscheduled jobs and decrease l by 1.
Step 6: Repeat steps 3 to 5 for the remaining unscheduled jobs until all the J jobs are scheduled.
Summing up the various processing times gives the makespan for the optimum scheduling.

MATERIALS AND METHODS

This study was conducted on a rice milling firm with basic operational activities as presented in Figure-2, while the key to the various unit operations is presented in Table-1.

©2006-2010 Asian Research Publishing Network (ARPN). All rights reserved.

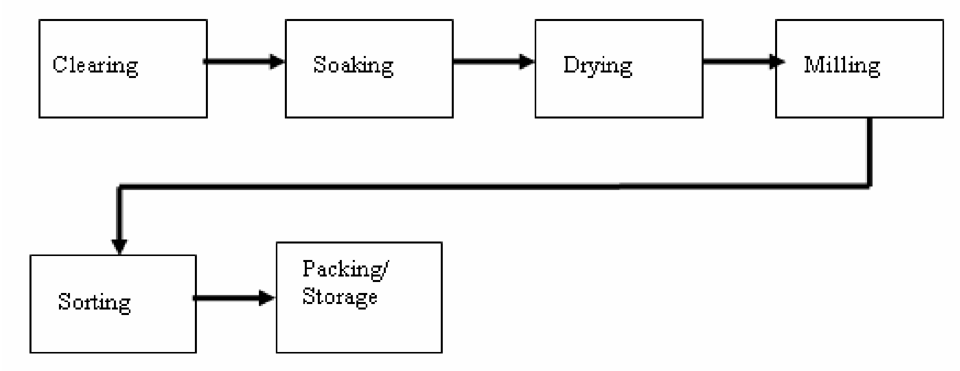

Figure-2. Summary chart for rice milling process.

Table-1. Key to the various unit operations.

Unit operation	Purpose
Clearing	Removes foreign objects, such as hey, stone, tree stump, from the paddy rice.
Soaking	Soaking takes place in stationery tanks, in hot water and steaming for a short duration at a controlled temperature.
Drying	Final drying performed in the continuous flow vertical dryer getting adequate moisture to the following milling process.
Milling	The milling, or whitening, stage removes the bran layer from brown rice. The modern multi-break, vertical whiteners use both abrasion and friction to gently and efficiently convert brown rice to milled white kernels. The bran layer is by air ventilation, which sucks in the brand layer process usually takes 2 to 3 cycles, depending on the required milling degree.
Sorting	Removes rice defects, such as discolorations, seeds, red rice, glass, stones etc, to ensure that only the cleanest rice is passed.
Packing / storage	The finished rice will be packed and stored in individual bags, according to its grade, and the rice is ready for delivery to customers.

Data was collected for a period of 24 different weeks for 24 jobs (orders). The processing time, which is the amount of time (hours) required to process each customer's order on each machine, is considered close to reality. The scheduling period covers one week which implies that all customers' orders for a week are considered and the scheduling activities are prepared on Monday morning before processing of jobs commences. Normally the processing of customer's orders (jobs) are on a first-come-first-serve basis. Therefore, the first customer to arrive for service is given a serial order 1; the second customer is given serial order 2, while the third is given serial order 3, etc. However, since it was discovered that the firm processes jobs using this serial order, we referred to this method as usual serial order (USO). The method was included in the program so that it can be evaluated alongside the solution methods. The principle here is to monitor the completion time of the last scheduled customer's order. The three methods are adopted and they include: the A1, CDS, and USO, which represent two methods developed by Oluleye and Oyetunji (Oluleye *et al*., 2007) and the traditional method used by the firm.

RESULTS AND DISCUSSIONS

Table-2 shows the makespan obtained for the three methods (A1, CDS and USO) for the 24-week study period. For all the three methods, the makespan obtained at the ninth period were the minimum, showing 43.49 hrs, 43.40 hrs, and 46.42 hrs, respectively for the A1, CDS and USO methods. Similarly, the makespan obtained for the three methods at the eleventh week were the maximum, showing 50.00 hrs, 48.42 hrs, and 53.26 hrs, respectively. It is seen that from the minimum makespan for instance, A1 and CDS methods performed good with CDS the best, while the traditional approach of USO performed poorly. This implies that if the old approach is continued the jobs for fourteenth week would still stay for an excess of 3.02 hrs in the process before being completed which is equivalent to about an extra half a day wasted in a day of 8 working hours.

©2006-2010 Asian Research Publishing Network (ARPN). All rights reserved.

Table-2. Makespan results for 24 weeks.

Week	Makespan results		
	A1	CDS	USO
1	46.38	47.25	50.24
2	45.32	45.32	50.24
3	45.32	45.33	50.45
4	45.12	45.12	52.42
5	46.04	46.06	51.52
6	47.20	47.18	51.46
7	46.52	46.54	51.08
8	45.33	45.54	51.42
9	43.49	43.40	46.42
10	47.42	47.40	50.54
11	45.82	45.80	51.28
12	45.24	45.24	51.54
13	45.70	45.72	52.50
14	46.04	46.00	53.16
15	50.00	48.42	53.26
16	45.72	45.70	53.22
17	46.32	46.30	50.54
18	45.16	45.18	51.27
19	45.18	44.94	51.34
20	45.24	44.26	51.28
21	46.32	46.02	48.42
22	45.82	45.64	49.08
23	48.26	48.12	48.96
24	46.12	47.08	50.02

Table-3 shows the gain in scheduling length when pair-wise comparison of (SO and A1) and (SO and CDS) are made. A critically look through weekly gains reviews that on the average, the gains on (SO-CDS) is more than the (SO-A1) gains. Table-4 shows the mean values and standard deviations of the makespan. Thus the method with the least mean makespan is CDS, having a mean of 45.98 hrs and standard deviation 1.16. This is closely followed by A1 with a mean makespan of 46.05 hrs and standard deviation 1.26. The worst method remains the traditional SO with a mean makespan of 50.90 hrs and standard deviation 1.59. Thus, it is attractive to utilize the CDS method of scheduling jobs on machines for the firm being considered. A further analysis was carried out to find the number of times the various solution methods give the best result as presented in Table-5. It was found that in none of the 24 occurrences did the SO method give the best result. The A1 method shows the best results in 7 occurrences, while for all the 24 occurrences, the CDS method showed the best results in 14 occurrences and this gives credence to the CDS method.

Table-3. Gains in scheduling operation.

Week	Scheduling gains	
	USO-A1	USO-CDS
1	3.86	2.99
2	4.92	4.92
3	5.13	5.12
4	7.30	7.30
5	5.48	5.46
6	4.26	4.28
7	4.56	4.54
8	6.09	5.88
9	2.93	3.02
10	3.12	3.14
11	5.46	5.48
12	6.30	6.30
13	6.80	6.78
14	7.12	7.16
15	3.26	4.84
16	7.50	7.52
17	4.22	4.24
18	6.11	6.09
19	6.16	6.40
20	6.04	7.02
21	2.10	2.40
22	3.26	3.44
23	0.70	0.84
24	3.90	2.94

Table-4. Process mean and standard deviation.

Method	Mean makespan	Standard deviation
A1	46.0454	1.2572
CDS	45.9817	1.1648
SO	50.9025	1.5930

Table-5. The best solution method.

Methods	Number of times
A1 8	7
CDS	14
SO	0
CDS = A1	3

©2006-2010 Asian Research Publishing Network (ARPN). All rights reserved.

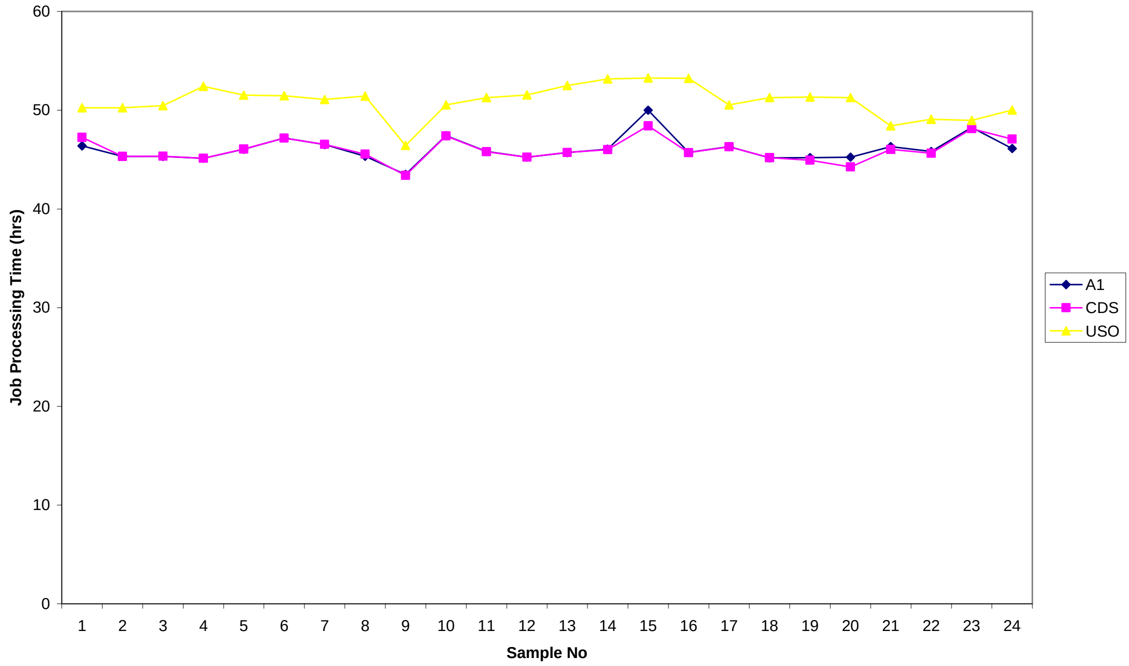

Figure-3. Graph of processing time for the three methods.

CONCLUSION AND RECOMMENDATIONS

Johnson 2-machine algorithm has been successfully applied to job scheduling in a rice milling firm. It has been demonstrated that the conventional approach in scheduling customer orders for rice milling in a rice milling firm based on the firm usual serial order method in which jobs are scheduled as they arrive for processing fails to satisfy the profit maximization objective of the firm. Three methods were used to analyze the data collected for the rice milling firm. The three methods are A1, CDS, and USO, which represent two methods (A1 and CDS) developed and the traditional method (USO) used by the firm. Evidently, CDS performs best, followed by A1, while the worst performance was observed with USO, this is clearly seen in Table-2 and Figure-3. Adopting the CDS method will increase the optimum performance of the firm and it was therefore recommended.

REFERENCES

Autrey H. S., Grigorief W. W., Altschul A. M. and Hogan J. T. 1955. Effect of milling conditions on breakage of rice grains. Journal of Agricultural Food Chemistry. 3: 593-599.

Blazewicz J., Pesch E., Margozata S. and Werner F. 2005. The two-machine flow-shop problem with weighted late work criterion and common due date. European Journal of Operational Research. 165: 408-415.

Campbell H.G., Dudek R.A., Smith M.L. 1970. A heuristic algorithm for n-job, mmachine sequencing problem. Journal of Management Science. 16: 630-637.

Clement G. and Seguy J.l. 1994. Behaviour of rice during processing. Journal of Agriculture and Development. 16: 38-46.

Davis L. L. 1944. Harvesting rice for maximum milling quality in California. Rice Journal. 47(3): 3-4, 17-18.

Du J. 1993. Minimizing mean flow time in two-machine open shops and flow shops. Journal of Algorithms. 14: 24-44.

Liaw C. F. 2008. An efficient simple metaheuristic for minimizing the makespan in two-machine no-wait job shops. Journal of Computers and Operations Research. 35(10): 3276-3283.

Matthews J., Abadie T.J., Deobald H.J. and Freeman C.C. 1970. Relation between Head Rice Yields and Defective Kernels in Rough Rice. Rice Journal. 73(10): 6-12.

Oluleye A. E., Oyetunji E., Ogunwolu L. and Oke S.A. 2007. Job Scheduling in a Small Scale Gari Processing Firm in Nigeria. Pacific Journal of Science and Technology. 8(1): 137-143.

Piggott J.R., Morrison W.R. and Clyne J. 2007. Changes in Lipids and in Sensory Attributes on Storage of Rice Milled to Different Degrees. International Journal of Food Science and Technology. 26(6): 615-628.