FLOW SHOP SCHEDULING PROBLEMS – A SURVEY

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Abstract: This paper emphasized on various machine scheduling techniques by using flow shop scheduling problems. In this paper single machine scheduling and n-jobs m- machines scheduling problem specially the case of two machines arranged in series with transporting agent between these two machines is explained with the help of the example by considering the setup time, processing time, transporting time , returning time. Heuristic approach is used for finding the optimal solution. Johnson's rule of sequencing is used for finding the new sequence of schedule so that the total production time is minimized.

Key words – Flow shop scheduling, open shop scheduling ,heuristic approach , machine scheduling , NP complete, Johnson's rule.

Introduction - Scheduling is the branch of Operational Research. OR is very important topic for mathematics as well as engineering students. We know that for performing any activity efficiently or successfully there is need of planning. Without planning, we could not achieve our desired goal. This planning is nothing but the scheduling. Hence scheduling is the process of assigning the set of tasks with available resources. Sequencing is a defined way of process in order to complete the processing of jobs. Hence sequencing and scheduling are related terms in any machine problem. In machine scheduling, machines are arranged in series and parallel. There are three types of scheduling problems flow shop, open shop, and job shop scheduling problems. Inflow shop scheduling problems every job is independent and all jobs have the same process sequence. The numbers of machines are more than one. And each job is processed on each machine i.e. number of operations for each job is equal to the number of machine. In job shop scheduling problems all jobs have different process sequences. Each job is related with a particular order assigned for its operation. In open shop problem there is not a particular order for operating the jobs. Jobs are operated according to our convenience. The completion of job has been according to their importance. As in flow shop problems all jobs have to be processed through every machine and each job has equal importance most of the research work has been done in this area.

Methods or techniques used for scheduling problems –

1. Branch and bound technique – It is one of the important technique used on large scale in optimization problems. It is commonly used for solving combinatorial problem. This method consists of two processes branching and bounding. In this technique a given problem divides into set of few new problems. The method of solving these problems is similar to the method of original problem. The sequence problems are assigned by the points which denotes the vertices and their positions denotes the nodes of tree which is called as the branching tree formed for finding the optimal solution of the problem.

2. LPT (least production time) rule of scheduling-Here the jobs are scheduled in such a way that the time required for finishing second job is less than the time taken by first job that is in decreasing order of processing time .This is called LPT rule of scheduling. As it gives the process completion in least time it is strongly NP-hard.(LPT finish time) (Minimum finish time) = 4/3- 1/3m where m is number of machines.

3 Two level mixed optimization method- Anil Rana2 It is one of the best method of scheduling as it decides the priority of machines to be used for operations and is considered as first level .The second level decides the extra time required for particular machine for getting maximum output. This type of scheduling is useful in machine shops specially run by government, as because of worker union no worker is ready to work for more than 8 hours and there is no planning of extra work schedule.

4. Deterministic scheduling theory- R.L.Graham presented optimization and approximation algorithm in terms of computational complexity theory for single unrelated parallel machine scheduling, open shop, job shop, and flow shop scheduling. Machine arrangement is identical, uniform and the results of the computational theory are widely used for getting the required result. The deterministic scheduling theory links the computer theory and operational research theory.

Flow shop scheduling problems- The main objective of scheduling is to achieve the maximum output in minimum time, within given due date, and to fulfill the requirements of customers up to the mark .For satisfying the desired target, n-jobs are processed on m-machines with the assumptions that each machine is allowed to execute only one job at a time, once a job start processing it should be completed and all jobs should be of equal importance and all jobs are independent of each other. Each machine is provided with sufficient waiting time. Every job takes fixed time for completion which includes setup time, processing time, transporting time, returning time, loading time, unloading time, slack time, delay time etc. A heuristic approach is used for finding the optimal solution.

Single machine scheduling- When the whole production of any item takes place on single machine the case of single machine scheduling arises in sequencing problem,as the total time given for complete process is fixed which is equal to the total time required for processing of the machine. In single machine scheduling the priority is given to the jobs having least processing time should be processed first ie.LPT rule is used. By this we can reduced the total waiting time and total tardiness of jobs. For eg. Flour mill, number of programs waiting for running on computer etc.

Flow shop scheduling problems when two machines are arranged in series-

Ali Allahverdi (1999-2006) had published above 300 papers and in 2008 he has done a lot of work towards the concept of set up time between two machines .He has considered the same problem in different ways and using various techniques particularly genetic algorithm , for finding the optimal solution. Johnson has proved that a feasible solution can be obtained for two machine scheduling problem. Modrak has given the algorithm for conversion of n-machine problem in to two machine problem. During 1980's the concept of transporting agent between two machines was introduced by Maggu and Das.

In this problem we consider the case of two machine arrangements in series and in between two machines there is a mediator who transports the articles from first machine to second machine and after delivering the articles to second machine instantly came back to machine one which is referred as transporting agent. Also the time required for coming back to machine one is considered as returning time. The problem consideration is with the processing time means the time taken by each machine to complete the production of particular article, setup time means the time of readiness of the machine for producing the next article, returning time from second to first machine .These type of the problems are raised in the industries where the production of different parts of the machines takes place. Heuristic approach is used for getting the optimal solution and algorithm is developed.

In this problem two machines M_1 and M_2 are considered in series such that the articles A_1, A_2, A_3, ------ A_n are transported by transporting agent from machine M_1 to machine M_2 in such a way that after delivering the articles to machine M_2 without delay come back to machine M_1 for transferring the next item. Let T_i denotes the time required for transportation of the articles from M_1 to M_2 that is transporting time. For producing the articles both machines required the set up time which is denoted by P_i and Q_i respectively. Let R_i is the time required for the transporting agent from M_2 and M_1 which is called as the returning time. When the machine M_1 has completed the production of A_{i-1} article and the transporting agent delivering this article to machine M_2 come back to machine M_1 but if the processing of last article by machine M_1 is completed as it starts this processing instantly after giving out of previous article then machine M_1 has to wait for the transporting agent if it didn't come back by that time. Also the processing time of machine M_1 and M_2 are considered and are denoted by M_{1i} and M_{2i} respectively. Supposed two machines U and V are assumed with the service time U_i and V_i resp.

Where, $U_i = P_i + M_{1i} + T_i + R_{i-1}$

and $V_i = Q_i + M_{2i} + T_i + R_{i-1}$

The scheduling of all the course of action is in such a way that the minimum time should be required for getting the optimum solution or whole production For finding the algorithm the above information can be symbolized and represented in table for finding the sequence by using Johnson's rule of sequencing.

Example - Let us consider the machine sequencing problem in tabular form:

articl	**P_i**	**M_{1i}**	**T_i**	**R_i**	**R_{i-1}**	**Q_i**	**M_{2i}**
A_1	3	6	3	2	-	4	7
A_2	2	5	4	3	0	3	6
A_3	4	7	3	2	0	3	6
A_4	4	4	5	4	0	2	5
A_5	2	5	3	2	2	1	4

Solution: As discussed earlier about two fictitious machines U and V and their service times U_i and V_i. The problem is reduced and it is given in the following table.

Articl	**$U_i = P_i + M_{1i} + T$**	**$V_i = Q_i + M_{2i} + T$**
A_1	12	14
A_2	11	13
A_3	14	12
A_4	13	12
A_5	10	10

By Johnson's rule the optimal sequence obtained for above reduced times is 5, 2, 1 ,4, 3. Then the time required for total processing of articles by using above scheduling sequence i.e minimum time for entire production can be calculated by considering the time required by the transporting agent when it returns back to machine M_1 to load the next article and also the time when it reaches to machine M_2 for unloading of an article. Let this time be denoted by B_{i-1} and L_i, where

$B_{i-1} = M_{1i} + T_i + R_i$ and $L_i = M_{1i} + T_i$.

article	P	M In-	T	R	B	L	Q	M In-	Id M
A_5	2	2-	3	2	-	1(	1	11	0
A_2	2	9-	4	3	12	18	3	18	0
A_1	3	17	3	2	21	2(	4	2(	0
A_4	4	27	5	4	28	3(	2	37	0
A_3	4	3!	3	2	4(	4!	3	44	1(

Conclusion:- From above table it is shown that the time get reduced for total production by using the sequence obtained with the help of Johnson's rule. The time required for the complete process is 50 hrs and machine M_1 takes 10 hrs, hence it is 80% active of the total time and machine M_2 takes 21 hrs i.e. 58% active of total time. Also the transportation agent is taking 15 hrs i.e. 70% to the total time.

Since the processing of machine M_1 starts directly after transporting the previous one which is not always possible in every type of production and therefore there is a condition on machine M_1 that it should not start processing until the transporting agent has not carried the article to the next machine. This way we can consider the case of two machines arrangement along with the consideration of loading and unloading time in addition to setup, transporting and returning time and similarly for three machines.

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