MULTI OBJECTIVE CRITERIA IN FLOW SHOP SCHEDULING USING METAHEURISTICS

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Abstract

In this work, Multi criteria decision making objective for flow shop scheduling with sequence dependent set up time with genetic Algorithm have been proposed. Flow shop scheduling is generally considered to be the one of the most significant issue in the planning and operation of a manufacturing system. Better scheduling system has significant impact on cost reduction, increased productivity, customer satisfaction and overall competitive advantage. In addition, recent customer demand for high variety products has contributed to an increase in product complexity that further emphasizes the need for improved scheduling. Classical flow shop scheduling problems are mainly concerned with completion time related objectives, however, in modern manufacturing and operation management, on time delivery is a significant factor as for the reason of upward stress of competition on the markets. Hence, there is a requirement of multi-objective scheduling system through which all the objectives can be achieved simultaneously. Flow shop with sequence dependent setup times (SDST) with Genetic Algorithm are the most difficult class of scheduling problems. Effective managing of sequence is one of the critical factors to improve manufacturing system performance and hence it must be considered separately from the processing time when dealing with scheduling problems.

Keywords:*Flowshop, Scheduling, Metaheuristics*

1. Introduction

Scheduling is the process of generating the schedule and schedule is a physical document and generally tells the happening of things and shows a plan for the timing of certain activities. Generally, scheduling problem can be approached in two steps; in the first step sequence is planned or decides how to choose the next task. In the second step, planning of start time and perhaps the completion time of each task is performed. In a scheduling process, the type and amount of each resource should be known so that accomplishing of tasks can be feasibly determined. Boundary of scheduling problem can be efficiently determined if resources are specified. In addition, each task is described in terms of such information as its resource requirement, its duration, the earliest time at which it may start and the time at which it is due to complete. Any technological constraints (precedence restrictions) should also be described that exist among the tasks. Information about resources and tasks defines a scheduling problem and its solution is fairly a complex matter.

Scheduling in a manufacturing system

There are several functions that have to be performed to deal with operationalproblems of the manufacturing system during transformation of the raw material into thefinished product. The functions that are generally followed in the management of the manufacturing system are as follows: Aggregate production planning: This function determines the type and quantities of products to be produced in specific time periods.

2. OBJECTIVE FUNCTIONS IN SCHEDULING

Due dates (Dj)

Due date refers to the time at which the particular job is expected to be completed in a manufacturing facility. Meeting duedates is an important aspect of any industry as it is related to customer goodwill.

Completion time (Cj)

Completion time is the time taken for completion of a workpiece from

time t=0 to end of all jobs in all machines.

Setup Time

In actual practice, many problems are encountered in a real world whenever sometime is spent in bringing a given facility to a desired state for processing the job. The time spent is called set up time and its magnitude depends upon the job just completed and job waiting to be processed and hence occupied a substantial percentage of the available production time on the manufacturing equipment. Some example of the above situation includes container manufacturing industry: where the machines are to be adjusted whenever the dimensions of the containers are changed; the paint industry: in which parts of different colors are produced on the same piece or equipment and printing press: where printing in different colors is to be done on the same machine; a paper bag industry: in which a machine is to be switched over from one type of bag to another, a set-up time i incurred.

Sequence dependent setup time (SDST)

There are situations in which it is simply not acceptable to assume that the timerequired to set up machine for the next job is independent of the job was the immediate predecessor on the machine. Infact, the variation of setup time with sequence provides the dominant criterion for evaluating schedule.

3.SDST flow shop scheduling:

i. Flow shop scheduling problems has been dealt with single criteria and however some work has been reported on multi-criteria that also limited to bi-criteria problem. In this dynamic and conflicting markets, industries have to dealt with several criteria for achieving goals and hence multiobjective performance measures has to be given due attention.

ii. Most of the works reported in multi-objective flow shop scheduling have considered SDST including in the processing time but to improve manufacturing system performance managing of sequence-dependent setups has to be considered separate as being one of the critical factors.

iii. The most widely used performance measures considered in SDST flow scheduling are regular in nature such as makespan, total flow time, total tardiness, maximum tardiness, total weighted tardiness and number of tardy jobs etc. as a single or bicriteria. Hence, very limited work for more than two criteria including regular and irregular performance measures with due dates have been reported. As being one of the main irregular measures i.e. earliness is also very important which restrict the early delivery of the jobs and may be harmful for the requirement of Just in Time manufacturing (JIT). Also considering earliness in the multi-objectives reduces the cost involved in handling and storage of the product.

iv. Most of the flow shops scheduling problems with multiple objectives have been considered with single or two machines without SDST. As in real life, more than two

machines are involved in production scheduling and hence is very important as per industrial requirement and need to be addressed.

v. Different metaheuristics like Multi-objective Genetic Algorithm (MOGA) and Multi-objective Simulated Annealing (MOSA) for multi-objective performance measures have been developed but again they are limited to bi-objectives and hence cannot be used for other than designed performance measures.

vi. Performance of most of the developed Hybrid GA and Hybrid SA has beencompared and analyzed without considering computational time limit as thestopping criteria. Stopping limit of the algorithm is the main parameter of anymetaheuristic which decides effectiveness and hence it has to be fixed forpredicting the results accurately among different metaheuristics.

4.Experimental Description

Tube Products of India is one of the units of Tube Investments of India Ltd which is a flagship company of Murugappa Group headquartered in Chennai being one of India's leading business conglomerates. Market leaders in diverse areas of business including Engineering, Abrasives, Finance, General Insurance, Cycles, Sugar, Farm Inputs, Fertilizers, Plantations, Bio-products etc have manufacturing facilities spread across different states in India.

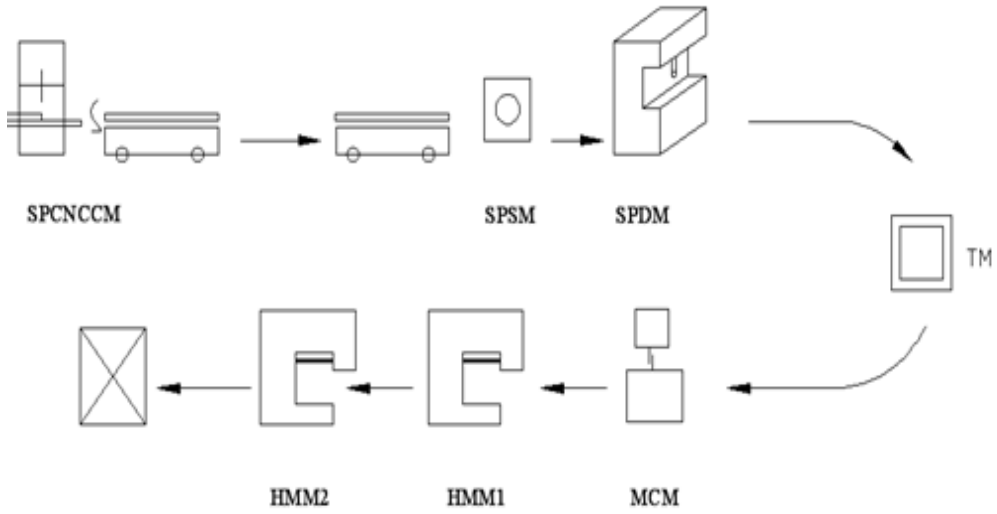

Fig 1 Process diagram of CDS tube

Cold drown seamless (CDS) tube have to undergo the following processesdescribed as under:

• Special Purpose CNC Cutting Machine (SPCNCCM):-It is used to cut the CDS tube according to required length. It is fully automatic machine.

• Special Purpose Hydraulic Operated Swaging Machine (SPSM):-This machine is used to decrease the end diameter of CDS tube through die for required length. CDS tube is forced with the help of hydraulic pressure in the die fixed at both end.

• Special Purpose Hydraulic Operated Horizontal Drilling Machine (SPDM):-This is a special purpose hydraulic operated machine used for drilling at both the ends of CDS tube. Drill is located at both the ends horizontally.

• Tapping Machine(TM):-This machine is manually operated and used to make internal thread in drilled hole at ends of CDS tube.

• Manual Chamfering Machine (MCM):-It is used for chamfering the drilled hole at ends.

• Horizontal Manual Milling Machine (HMM):-This is also manual horizontal milling machines and used for notching and slitting operation on the CDS tube. They are two in numbers one for slitting and one for notching operations and called as HMM1 and HMM2 respectively.

The real data have been collected from the production head that is responsible for production planning for the entire value added centre resulting into 10×7 flow shop scheduling problem. The data such as processing time, due date, weight of the job with demand and sequence dependent set up time have been shown from table below:

Job No.	SPCNCCM	SPSM	SPDM	TM	MCM	HMM1	HMM2
1.	2800	6640	3000	6000	4640	6000	2640
2.	2490	6750	2730	4980	5490	5730	1980
3.	750	2745	870	1875	2490	1875	1125
4.	1160	3320	1160	2660	3820	2000	1500
5.	660	1660	660	1500	1080	1500	580
6.	750	2250	910	1660	1833	1910	660
7.	1740	4980	1740	3990	5730	3000	2250
8.	330	830	330	750	540	750	290
9.	400	1800	728	1328	1464	1528	528
10.	580	1660	580	1330	830	1000	750

The results can been obtained for the real life problem of SDST flow shop scheduling for all the two sets of weight values considered which results in optimal sequence with corresponding values of all the individual objective of optimized fitness function is the best.

SCOPE OF THE FUTURE WORK

In the present work, multi-objective performance measures in a Flow shop scheduling problems with sequence dependent set up time with Genetic Algorithm is proposed. The regular and irregular performance measures have been considered for this dynamic and competitive environment. This work will also benefit the development of optimization techniques that can be applied to other combinatorial optimization problems. Here the focus is on multi criteria flow shop scheduling.

Proposed metaheuristic has also been applied for scheduling the jobs in a Flow shop manufacturing system with SDST, Genetic Algorithm. Output in the form of completion time and idle time of individual job and machine can be obtained with corresponding optimal sequence. The application of the proposed hybrid meta-heuristic has been carried out in Tubular Component Division (TCD) of the Tube Products of India (TPI), which is one of the Tube Products of India (TPI), which is one of the largest integrated manufacturers of quality automobile components in India.

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