International Journal of Pure and Applied Mathematics
Volume 114 No. 6 2017, 235 - 239
ISSN: 1311-8080 (printed version); ISSN: 1314-3395 (on-line version)
url: http://www.ijpam.eu
Special Issue

SINGLE-MACHINE SCHEDULING WITH RELEASE DATES AND FAMILY SETUP TIMES

ANANTA PRAVEEN KUMAR MVR, DAVID MAXIM GURURAJ A, AND S.HARIHARAN

Abstract. Production scheduling of a single machine with release and due dates in a cold forging organisation involving multiple product is a complex problem. The making of products has major practical issues with the availability of raw material at high setup time and unexpected tool breakage time. The current machine utilization is on and average 20% of the overall production in a 8 hours shift for a week. In this paper, a heuristic approach to improve the efficiency of the machine by reducing the setup time and improving the lead time of products have been proposed.

1. Introduction

Forging of metal is a manufacturing process which involves the shaping of metal by compressive forces. The small and medium scale organizations generally prefer to make-to-order rather than make-to-stock due to high inventory cost and oxidation of metal. The customer places order for parts with a varying quantity of demand. The next step begins with the production planning and scheduling department. By end of every cycle (may be a week, a month or an year), the department plans the products, quantity for each part and due dates, subject to the available raw material. In this study, a company with the period of one month as its cycle has been considered. The reorder time of raw material usually takes 2 weeks for arrival. For the sake of anonymity the Cold forging Manufacturer, manufactures various types of screw and bolts, in bulk quantities. The machine has high setup times for each product, due to which each products are made in batches. The time duration of placing an order and delivering is termed as lead time. With the constraint of raw material, setup times, lead times, and due-date criteria for delivery of various parts to various customers, the management faces a tough task in making a production schedule. Pinedo [1] discuss in detail about the scheduling theory, algorithms and systems. Christoph et al. [2], Ali Allahverdi [3] and Muminu et al. [4] discuss about the survey of scheduling problems with setup times. Janez et al.

[5], Ajit Kumar Sahoo et al. [6] and M K Omar et al. [7] discuss the importance of batching and job family setup times and its reduction.

In this paper, Section 2 describes the problem followed by the terminologies involved in scheduling is explained in Section 3. Section 4 briefs about the implementation, algorithm and results. Finally, the conclusion is given in Section 5.

2. Problem

It's a general policy in organizations which expects high efficiency, will tend to make batch size large, so that items can be made without wasting set up time due to shifting of jobs. However, with long production runs for one item, other items get delayed beyond their due date. On the other hand, when the priority goes with due date, the batch size will become small and hence increases the number of setups in a cycle. In this process, the most urgent due-date criteria have been satisfied with the cost of production efficiency which is a crucial factor in scheduling.

This inherent conflict between efficiency and due dates performance, presents a challenge to any scheduling procedure that is used for short-term scheduling of production batches. Few products are made every month & few are made once in 2-4 months. The problem is quiet difficult to optimize, so there is good reason to look for heuristic procedures that will reliably produce good solution In this paper, we examine a scheduling problem to improve the efficiency of the machine.

3. Terminologies

The floor shop manager is given the details of part name , production quantity, due date, available dates of raw material. He then schedules the order of manufacturing the parts which is termed as production schedule. The production schedule depends on the following factors.

3.1. **Job Setup time:** This time involves in setting up the machine with tools and dies and is absolutely essential for the product that needs to be manufactured. The time components involved in job setup time are given as follows:

i. Tool and Die removal (of the earlier job).
ii. Tool and Die mounting (of the current job).
iii. Quill Cutter fixing of the current job.
iv. Sample setting.
v. Transfer setting.

3.2. **Coil Change time:** When the product is being setup by Team A, Team B takes care of coil loading. Hence no additional time is required for coil change when the first coil is mounted on the machine. For all successive coils, there is a time requirement of 10-20 minutes to change the coil.

3.3. **Production Time:** The machine runs at varying speeds ranging from 35 pieces per minutes to 60 pieces per minute. The speed depends on the shape, weight , size and the complexity of the product. The average speed is 45/50 pieces per minute.

3.4. **Tool Breakage / stoppage time:** Due to the impact of a 2 ton hammer on the tool and die while manufacturing the product, the components of the tool and die are subject to wear and tear and breakage. Any change of these components or repair of the same would be classified as tool breakage or stoppage time.

3.5. **Others:** All other time spend like, machine repair time, power cut time, getting the approval from the customer time etc, shall be classified as other times.

The current break-up of the time is as follows

SL NO	FUNCTION	Percentage time
a	Job Setup time	38%
b	Production time	20%
c	Coil Loading time	5%
d	Tool Breakage /Stoppage Time	18%
E	Others	19%

4. Scheduling

4.1. **Factors affecting scheduling:** Based on the one year history data of manufacturing of the order of scheduling depends on following four factors
a) Inventory of products.
b) Availability of raw material
c) Scheduling using setup matrix
d) Demand and lead time

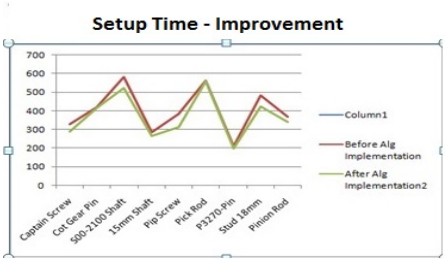
4.2. **Scheduling implementation:** Based on the above factors the following approaches to improve efficiency of machine are implemented
a) Modified batch size formula: Production batch size = Closing stock +Current Sales - opening sales
Closing stock for current month (will be opening stock for next month)=

50% of Current sale.
b) Setup time matrix : Currently there are 44 unique parts to be manufactured for 50 customers using 33 different raw materials. The setup matrix gives the change over time between the products. We initially constructed the 44×44 setup matrix covering all the 44 unique products. The resultant matrix is a sparse matrix, the value '0' in a position of the matrix represents that the change over does not take place between the parts. The following changes in setup related decisions are implemented
c) Improvement in setup-matrix: Instead of setup matrix based on products, the products are grouped according to their raw-materials. This is termed as family of parts. Few parts which have the same raw-material will take reduced setup time when it is moved inside the same family.
d) Reducing the number of Setups per month: By avoiding frequent occurrence of repeated setups in a month or two, we can save some time. To do so the planning department need to combine the production outcome into a single run. The main reason for repeated setups are due to lack of required raw material and its availability and tight due dates. To avoid this we introduce release dates along with family setup times and due dates of each part.

4.3. **Algorithm and Results.** The scheduling algorithm objective is to reduce the setup times. After thorough analysis, the factors resulting in low inventory, frequent setups in same month, availability of raw material contribute to the reduced setup times of the parts.

Algorithm

```
Take input for Product[], Raw_Mat[], Qty[], Due_Date[]
Groupby(Due_Date).['Product','Raw_Mat','Qty'].sorted()
i = 1
cur_date = sys.current_date()
While Product not empty:
    If Release_Date[Raw_Mat[i]] <cur_date:
        START production[Product[i]]
cur_date += Prodn_Time[Product[i]]
        Product[i].remove(), Raw_Mat[i].remove(), Qty[i].remove(),
        Due_Date[i].remove()
Else:
i++
```



The Graph shows that the setup time of each parts are reduced by 3%. The improvements are reflected on the change over times of the parts

5. Conclusion:

In this paper a heuristic approach is implemented to optimize the lead time and ensure the availability of each product. The implemented

algorithm based on release time is helpful to identify the raw-materials readiness for production line. Based on the demand a closing and opening stocks are maintained in order to keep up the lead times active to dispatch all the time.

References

[1] Pinedo M, Scheduling-theory, algorithms, and systems, 4th edn. Springer, Berlin,(2012).
[2] Christoph W. Pickardt and J.Branke, Setup-oriented dispatching rules a survey,(2012)
[3] Ali Allahverdi, The third comprehensive survey on scheduling problems with setuptimes/costs,(2015)
[4] Muminu O. Adamu, Aderemi O. Adewumi, A survey of Single Machine scheduling to Minimize weighted number of tardy jobs(2014)
[5] Janez Kusar, Tomaz Berlec, Ferdinand Zefran and Marko Starbek, Reduction of Machine Setup Time, (2010)
[6] Ajit Kumar Sahoo, N.k.Singh, Ravi Shankar, M.K.Tiware, Lean Philosophy:Implementation in a forging Company, (2008)
[7] Mohamed K. Omar, Yasothei Suppiah, Batching and sequencing of Incompatible Job Families for a single Machine Problem(2013)

Department of Mathematics, SRM University, Chennai, India
E-mail address: anantapraveen.k@vdp.srmuniv.ac.in

School of Advanced Sciences, VIT University, Chennai, India
E-mail address: davidmaxim.gururaj@vit.ac.in

Department of Mathematics, Amrita School of Engineering-Coimbatore, Amrita Vishwa Vidyapeetham, Amrita University,India
E-mail address: s_hariharan@ch.amrita.edu