Mapana – Journal of Sciences
2022, Vol. 21, No. 1, 63-71
ISSN 0975-3303/https://doi.org/10.12723/mjs.60.5

Addressing the Energy Consumption Factors in Job Shop Scheduling using MEESA

Anandapadmanabhan Kumaresan*

Abstract

In Job shop Scheduling Energy conservation is a key factor to be considers for minimizing the lateness and makespan of the shop here in this paper a new technic Modified Energy Efficiency Scheduling Algorithm (MEESA) is used in the proposed work it is divided into two parts analysing effective rate and modified scheduled aware mechanism, the MEESA algorithm enhances the efficiency rate, makespan, in job shop scheduling.

Keywords: Lateness, Makespan, Energy Efficiency, JSS, MEESA

1. Introduction

Job Shop scheduling is an all-time typical decision-making problem, that occurs in the job scheduling process in some machines during some time.

Energy consumption is one of the current issues in our society. The energy demand in the world has increased tremendously in the past 10 years. In general, the industry is one of the primary consumers of energy. Energy is a daily need that the industry relies on for its safety and ease of accessibility.

The rising energy cost is one of the significant factors with increased production costs of manufacturing. Industrial experts handle this in different manners. Energy efficiency is one of the issues still that occur in many manufacturing industries.

*Dean, Sri Vasavi College (SFW), Erode, Tamil Nadu, India; kapn0305@gmail.com

The power on and off of a machine can be done based on its waits period for the next job is a good energy-conservation measure. Because of less consideration to the ecological influence in the past, the research works addressing Energy Saving have considered the energy consumption or environmental impact is limited and mostly focused on machine and flow shop types.

2. Scope of Research

Energy Efficiency (EE) is one of the issues that still occurs in many manufacturing units, and it has its importance for all job types. It is important to formulate the problem of when to power on and off of a machine after its waits for the next is addressed in this paper.

MEESA is proposed for effective EE and optimization of makespan. This algorithm is addressed to maintain optimal makespan and improve efficiency rate in job shop scheduling. EC, makespan, and production efficiency are chosen as an optimization parameters. The proposed algorithm contains two subparts analysing effective rate and modified scheduled awareness mechanism.

3. Improving Energy Efficiency using Scheduling Techniques

The proposed work is mainly focused to improve the makespan and efficiency in the production of manufacturing companies. Some of the major issues in existing work such as problem variations, NP-hardness, problem representation, Scheduling efficiency, the problem of infinite cost, makespan minimization, the EC of the machine, and makespan prediction

4. Modified Energy Efficiency and Scheduling Algorithm

As illustrated in Fig 1.0 MEESA consist of two parts: (i) Analysis effective rate and (ii) Modified schedule aware mechanism. The proposed algorithm is used to improve the efficiency and performance in the job shop problems

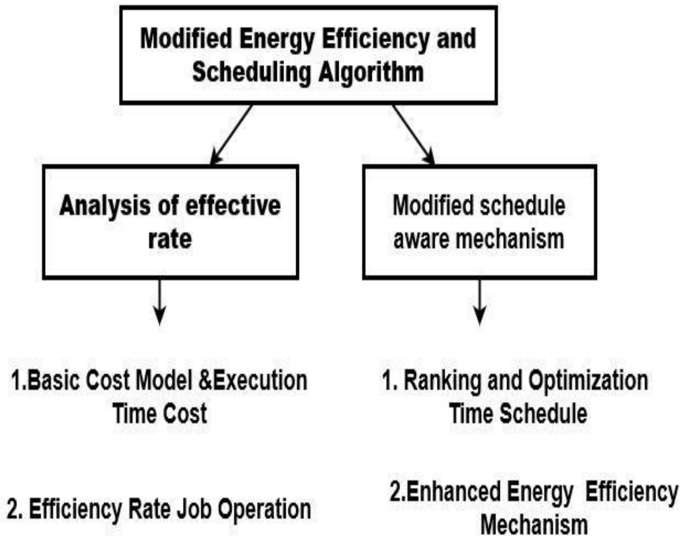

Fig. 1.0: MEESA Algorithm

The purpose for ranking is to execute the job first with more dependencies, first. The first phase finalizes the execution order. The second phase assigns the jobs according to the priority value of the jobs.

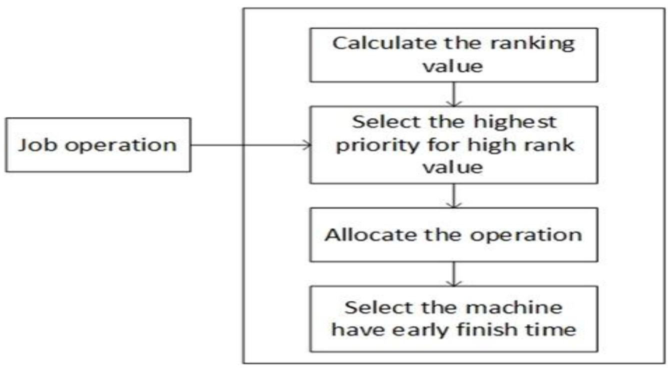

Fig. 1.1: Optimizing Job Operation on the Priority Level

Fig. 1.1 represents the optimizing job operation on the priority level. For each job J is defined with two-parameter, 1) a particular job's minimum finish time on a particular interval of time, and 2) a constant value is allocated as a minimum finish time which depends on a job type. Constant value is changed depending on the job type and the execution cost also changes, adding a task to the machine does not increases the running time of the machine in a full hour, the machine running cost will remain unchanged.

5. Mathematical Model for Makespan Setup and EC

Consider an 'm' machines and 'j' jobs in a typical Energy-efficient job shop problem and every job is represented as (a =1, 2…h) It encompasses a sequence of operation $O_{ab}, b = 1, 2 \dots, H_a$, where H denotes the no of operations in 'j'. The operations which can be executed on the machine on X (X= 1, 2 . . . l) from a set U_S and each operation O_{ab} will have its corresponding processing time and E_{TP} and QF represents EC respectively.

W is a large definite number. R_{ab}, $P_{a,b}$ and QF_{abX} C_{abX} are denoted as decision variables, where R_{ab}, and $P_{a,b}$ indicates the initial and terminal time of O_{ab} respectively, an integer variable C_{abX} whose value is 1 and if machine X executes O_{ab} is 0.

Equation 1.1 makespan of all job's calculated by analysing the time boundaries of EC

$$Total\ makespan = \{l_{a,b}\}, \forall_{a,b} \tag{1.1}$$

Thus, the total EC of all machines, given as in equation 1.2

$$Total_{\ energy} = \sum_{X=1}^{Y} \quad [E_N + E_{TP}] \tag{1.2}$$

Where E_N is the sum of EC in standby time of machine X and total processing E_{TP} represented in equation 1.3

$$E_{TP} = \sum_{\{(a,b):O_{a,b} \in U_S\}} \quad QF_{abX} C_{abX} \ \forall X \tag{1.3}$$

All machines cannot be allowed to powered-off during idle time E_N this is expressed in equation 1.4

$$E_N = y\left[\{D_{ab}\} - mini\,\{R_{ab}\} - \sum_{\{(a,b):O_{a,b}\in U_S\}} QF_{abX}\,C_{abX}\right] \forall X \quad (1.4)$$

The machine distribution of each operation is determined by a scheduling scheme, G_X and on a machine X is the number of operations executed can be calculated through the equation 1.5

$$G_X = \sum_{\{(a,b):O_{a,b}\in U_S\}} C_{abX}, \forall X \quad (1.5)$$

If G_X operations processed on machine X, $G_X - 1$ idle interval between adjacent operations will be there.

O_{ab} is the Z^{th} $(1 \leq Z \leq G_X - 1)$ operation performed on machine X, $O_{a'b'}$ is its subsequent operation on machine X, and the parameters, S0 , R_{ab}^{ZX}, W_{ab}^{ZX} , $R_{a'b'}^{(Z+1)X}$ $and\ W_{a'b'}^{(Z+1)X}$ $represented$ respectively,

For a Machine X the EC of each idle interval while applying an energy-efficient mechanism is expressed in equation 1.6

$$E_N^Z = \{EC^{setup} \quad if\ Y_Z\left(R_{a'b'}^{(Z+1)X} - W_{ab}^{ZX}\right) > EC^{setup}\ \left(R_{a'b'}^{(Z+1)X} - W_{ab}^{ZX}\right) >$$
$$T_X^{setup}\ Y_X\left(R_{a'b'}^{(Z+1)X} - W_{ab}^{ZX}\right) \qquad otherwise \quad (1.6)$$

$$\forall X, (a,b)(a',b'): O_{a,b} \in U_S, O_{a'b'} \in U_S$$

6. Makespan

Makespan is the total length of the schedule from beginning time to finish time for completing a set of jobs, i.e. all jobs maximum completion time.

Table 1.1 contains the Makespan and total energy of a machine in the manufacturing industry in the EES, MEESA, and APS algorithms. Makespan Time is presented the below Fig. 1.

Total Energy	Makespan (milliseconds)		
	EES	MEESA	APS Algorithm
7500	560	512	580
8000	590	530	600
8500	600	540	620
9000	620	550	650
9500	640	565	670
10000	680	590	700
10500	700	600	720

Table 1.1 Makespan time in EES, MEESA, and APS algorithm

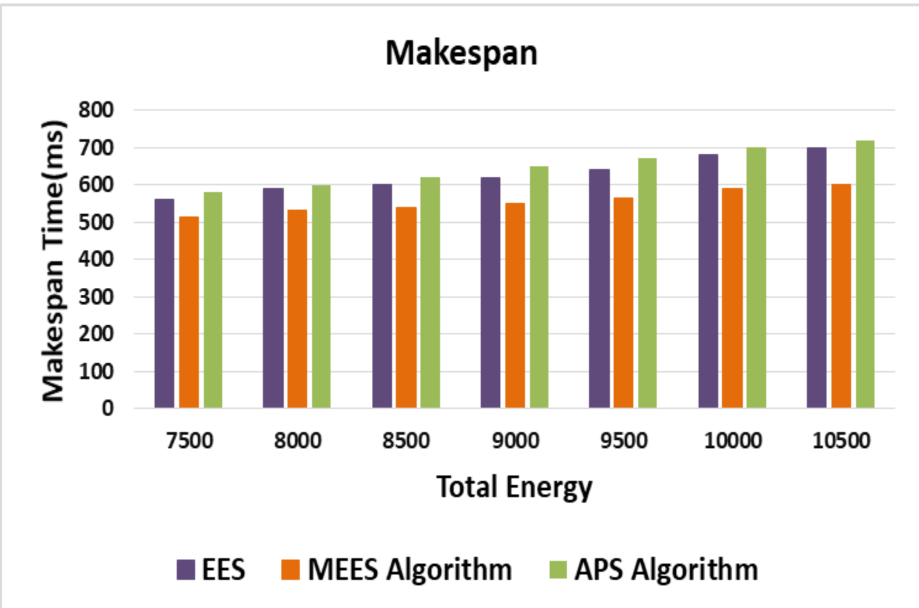

Fig. 1.2 Makespan Time

Fig. 1.2 shows the makespan time and it is compared to the existing algorithms like EES and APS algorithm. An enhanced energy-efficient mechanism is proposed to optimize the energy level in job operation. The effective makespan is determined. The EC of the machine is based on the operating mechanism and initial time setup and makespan time is minimized according to the EC of the machine. This work optimizes the EC and makespan parameter. The proposed algorithm attains less makespan time for different energy levels when compared to the existing techniques.

7. Conclusion

Job-shop Scheduling Problem (JSP) is considered one of the hardest manufacturing problems in the industry. This work addressed the makespan issues as well the efficiency factors. It showed improvision in this work using a modified EE algorithm. Finally, makespan and processing time factors are used to improve the efficiency of the proposed work. This work achieves less processing time and makespan values when compared to the other algorithms.

References

{1] Sharath C. H. Somashekhara, Arun K. Y. Setty, Srinath M. Sridharmurthy, Poornima Adiga, Ulavathi S. Mahabaleshwar, Giulio Lorenzini (2019), “Makespan reduction using dynamic job sequencing combined with buffer optimization applying genetic algorithm in a manufacturing system”, Mathematical Modelling of Engineering Problems, Volume 6, Issue 1, pp. 29-37.

[2] Vineet Kumar, Dr. Om Pal Singh (2016), “Review Study to Minimize the Make Span Time for Job Shop Scheduling of Manufacturing Industry by Different Optimization Method”, Proceedings of the Institution of Mechanical Engineers Part B Journal of Engineering Manufacture, Volume 5, Issue 4.

[3] Henry Lamos-Díaz, Karin Aguilar-Imitola, Yuleiny Tatiana Pérez-Díaz, Silvia Galván-Núñez (2017), “A memetic algorithm for minimizing the makespan in the Job Shop Scheduling problem”, Rev. Fac. Ing., Vol. 26 (44), pp. 113-123, Ene.

[4] Pisut Pongchairerks (2019), “A Two-Level Metaheuristic Algorithm for the Job-Shop Scheduling Problem”, Complexity, Issue 4, pp. 1-11.

[5] Ajendra Kumar, Preet Pal Singh, Dipa Sharma, Pawan Joshi (2019), "Grid Computing Model to Solve Job Shop Scheduling and Flow Shop Scheduling by Fuzzy C-Mean Algorithm", International Journal of Engineering and Advanced Technology (IJEAT), Volume 9, Issue 1.

[6] Ma, D. Y., He, C. H., Wang, S. Q., Han, X. M., Shi, X. H. (2013), "Solving fuzzy flexible job shop scheduling problem based on fuzzy satisfaction rate and differential evolution".

[7] N Selvamalar, V Vinoba (2019), "Role of Heuristic Algorithms in Minimizing the Makespan of Fuzzy Flow shop Scheduling Problem", International Journal of Recent Technology and Engineering (IJRTE), Volume 8, Issue 3.

[8] Kanate Ploydanai, Anan Mungwattana (2010), "Algorithm for Solving Job Shop Scheduling Problem Based on machine availability constraint", International Journal on Computer Science and Engineering, Volume 2, Issue 5.

[9] T Varun Kumarand, B Ganesh Babu (2014), "Optimizing of Makespan in Job Shop Scheduling Problem: A Combined New Approach", International Journal of mechanical engineering and robotics research, Volume 3, Issue 2.

[10] Mohsen Ziaee (2014), "Job shop scheduling with makespan objective: A heuristic approach", International Journal of Industrial Engineering Computations.

[11] R Sanjeev Kumar, K P Padmanaban, and M Rajkumar (2015), "Minimizing makespan and total flowtime in permutation flow shop scheduling problems using modified gravitational emulation local search algorithm", Journal of engineering and manufacture.

[12] Zineb Ibn Majdoub Hassani, Abdelouahhab Jabri, Abdellah El Barkany, Abdel Moumen Darcherif, Ikram El Abbassi (2019), "New Model of Planning and Scheduling for Job-Shop Production System with Energy Consideration", Management and Production Engineering Review, Volume 10, Issue 1.

[13] Hua Zhang, Ziwei Dai, Wenyu Zhang, Shuai Zhang, Yan Wang, and Rongyu Liu (2017), "A New Energy-Aware Flexible

Job Shop Scheduling Method Using Modified Biogeography-Based Optimization", Mathematical Problems in Engineering.

[14] Zhongwei Zhang, Lihui Wu, Tao Peng, and Shun Jia (2019), "An Improved Scheduling Approach for Minimizing Total Energy Consumption and Makespan in a Flexible Job Shop Environment", MDPI, Volume 11, Issue 1.

[15] Songling Tian, Taiyong Wang, Lei Zhang, And Xiaoqiang Wu (2019), "An Energy-Efficient Scheduling Approach for Flexible Job Shop Problem in the Internet of Manufacturing Things Environment", Special Section On Green Communications On Wireless Networks, Volume 7.

[16] Dominik Kress, David Müller, and Jenny Nossack (2017), "A worker constrained flexible job shop scheduling problem with sequence-dependent setup times", OR Spectrum.

[17] Ying Liu, Michael Farnsworth, and Ashutosh Tiwari (2018), "Energy-efficient scheduling of flexible flow shop of composite recycling", The International Journal of Advanced Manufacturing Technology 97, pp 117–127.