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Manpower Scheduling: The Case of Bangladesh

Md Mashum Billal[1], Razoana Islam[2] and Sharmin Akther Diba[3]

This paper considers scheduling of rest breaks in repetitive working areas. Rest break is a major concern in modern manufacturing industries due to its impact on productivity. In repetitive work, without rest break rejection rate increases. Also mental fatigue, Eye pain, musculo-skeletal disorders are common phenomenon due to this repetitive work. So, the main objective is proper scheduling of the rest break time, so that mental and physical problems are mitigated. For this, a repetitive working industry is chosen, where the impact of rest break to productivity and workers mental relief are checked. It is found that, Fragmented rest breaks give more relief than continuous break. But, in the fragmented rest period times, productions remain stop. So, a model is formulated to give proper manpower scheduling in the break times which is solved by lingo software to get minimum cost of allocating manpower.

Keywords: Rest break, Repetitive, Manpower allocation

1. Introduction

In this competitive world, people get less time to take rest. People are forced to work for a long time. It sometimes causes mental as well as physical fatigue. Without rest break or improper rest break, employee suffers from dissatisfaction, mental fatigue, physical disorder and eye pain. In Bangladesh, proper rest schedule is not maintained. Specially, in the repetitive working industry. So, workers suffer from various problems tremendously after working few years. But this is a major issue. So, rest is provided. But continuous break is less helpful for production as well as mental relief and mental relaxation. Again, in the rest break times, production remains stop. So, to keep running the production, manpower scheduling is necessary.

Prolonged working which develop not only mental fatigue and musculoskeletal disorders but also reduce the working efficiency. Again it creates occupational stress. Increased workloads, overtime, hostile work environments and shift works are few of the many causes of stressful working conditions. Job stress produces negative effects for both the organization and the employees. For the organization, the results are disorganization, disruption in normal operations, lowered productivity and lower margins of profit. For the employee, the effects are threefold: increased physical health problems, psychological

[1]Md Mashum Billal, Corresponding author, Department of Industrial & Production Engineering, Rajshahi University of Engineering & Technology, Rajshahi 6204, Bangladesh E-mail: mashum.08ipe@gmail.com, mashum.ipe@ruet.ac.bd, Phone: +8801741238070

[2]Razoana Islam, Department of Industrial & Production Engineering, Rajshahi University of Engineering & Technology, Rajshahi 6204, Bangladesh

[3]Sharmin Akther Diba, Department of Industrial & Production Engineering, Rajshahi University of Engineering & Technology, Rajshahi 6204, Bangladesh

distress, and behavioral changes. An effective work–rest schedule is an economical way to potentially reduce physical and psychological Problems. The prolonged work causes various complaints including eyestrain, musculoskeletal discomfort, headache, and job stress. These symptoms can result from problems with workstation design, work environment (poor air quality, improper lighting, glare, noise, etc.) and job design (force, repetition, duration, lack of rest, and poor posture). Even minor changes in the exercise/rest schedule may imply large changes in physiological and psychophysical responses.

In Various Research papers, it is proved that the performance level reaches its minimum after 45–60 min of work. They also detected an increase in the reaction time and percentage of errors after 2 hour of continuous work. Most of the previous research work is conducted only estimated data and the proposed work implemented the model by realistic primary data. In real industries there are some limitations on the number of workers and in some situations it is unavoidable to schedule employees for break times to minimize labor cost. It is also essential to attend the station by the minimum number of workers while manufacturing desired rate of production. Improper employee scheduling can lead to costly under/over staffing. Overstaffing results in inflated payroll costs and understaffing (inadequate staffing) leads to poor customer service, causing reduced customer conversion rates and a potential loss of profit. For any service organization it is important to schedule its manpower in an efficient manner to minimize labor costs while providing the desired service level.

The rest of this paper is organized as follows; section 2 represents literature review, section 3 represents research methodology, section 4 represents data collection and analysis. Section 5represents problem description of manpower scheduling, section six represents result analysis and section seven represents conclusions and finally references are mentioned after the conclusion portion.

2. Literature Review

Managing workforce, scheduling, optimal rest break, improves productivity and cost minimization is some major concern nowadays. Over the years it has been trying to reach these goals. Sheahan et al. (2015),found that the effect of three different standing rest-break conditions on a group of pain developers (PD) and non-pain developers(NPD) engaged in prolonged seated work vary with one another. Fischer found that Only PD increased in LBP (low back pain) across these conditions but both PD and NPD developed mental fatigue equally across these conditions. The study is applicable only for 60 min of work and simple work system. According to Asefeh (2012),manpower scheduling in break times for employees working in mixed model assembly lines (MMALs) minimizes not only the labor cost but also increases the production rate. He proposed, minimum number of workers should attend the station while manufacturing desired rate of production. Dababneh et al (2010), found 9-min break schedule improved discomfort ratings for the lower extremities. He believes that frequent short rest break is not preferable to workers indicating that workers in general might not as readily accept fragmentation of break time into short, frequent breaks. But this study took long time for research. According to Jack Callaghan(2014),a seated break inserted between bouts of prolonged standing would influence LBP development, posture and movement. A stand to sit ratio of 3:1 did not provide lasting recovery of LBP from standing and pain developers utilized a limited range of their lumbar spine angle and increased thoracic extension, resulting in static postures that caused tissue aggravation that was not resolved after 15 minutes of sitting. Ronald (2007), the strength of research evidence on the effects of exercise and rest breaks on musclo-skeletal discomfort during computer task was reviewed. He found that most evidences support the exercise and rest breaks to reduce the musclo-skeletal discomfort in computer task. Aykin (1996) considered a more general shift scheduling problem with multiple breaks and disjoint break windows. He represented the placement of relief and lunch breaks by considering a break variable for each shift and each possible starting time within its break window. A shift is defined as the combination of a starting time, a length, the break types it contains and the associated break windows. Equality constraints are used to match each shift with the associated type of break and break window. Rekik et al. (2009) developed two other implicit models and managed to improve upon previous approaches among them Aykin's original model. They extended previous work on implicit modeling of break placement to incorporate the concepts of fraction able breaks and work stretch duration restrictions introducing a new formulation of the forward and backward constraints and demonstrated that it considerably reduced the density of the constraint matrix of the two proposed models. Fritz et al. (2013),found that, Recovery from work-related demands could occur during longer breaks away from work (e.g., vacations), during the weekend, on a daily basis after work, and even during certain breaks at work. Organizations that understand their role in facilitating employee recovery, and that encourage their employees to leverage work breaks for the purpose of recharging and unwinding, will benefit from a workforce that is healthy, energized, and ready to work. Shahnazari et al. (2011) proposed a novel bi-objective manpower scheduling problem with the objectives of minimizing the penalty incurred by the employee's assignment at lower skill levels than their real skills and maximizing the employee's utility by assigning them at desired skill levels in some shifts/days. They considered two classifications for employee's specialty and three skill levels in each specialization.

In these previous research works, several criteria's were considered. First Research considered single shifting, second research considered multiple shifting. Again over staffing or under staffing were another important criteria's for model formulation at rest break time proposed by third and fourth research. Workers fatigue, overtime schedule, injury rate, daily or weekly rest break, number of workers assigned to job. Where the various factors, which were also considered by last two researches work. Every research work was for one working hour which didn't show direct impact on productivity & defect reduction was major concern.

In our research work, we have considered rest breaks for repetitive works area, where various physical problems like mental fatigue, eye pain, musculo-skeletal disorder occur frequently. Here three types of rest break are considered for daily repetitive works and among the rest breaks the suitable rest break is found out which gives more flexibility to workers to work with relaxation. Again, a model for manpower scheduling is formulated in the suitable rest break time to reduce machine idle time as well as increase productivity. This manpower allocation is necessary to keep the production running. In this paper the author presented optimal workforce scheduling model, strategic planning model and relevant work for rest break simultaneously. In the previous most of the research works are validate their model using only estimated data but the proposed model the authors validate their model using primary data.A model is formulated for scheduling manpower in rest break time as machines become idle during this time to increases production rate and decreases defects rate that are the first research work in case of Bangladesh that are the uniqueness of these research work.

3. Methodology

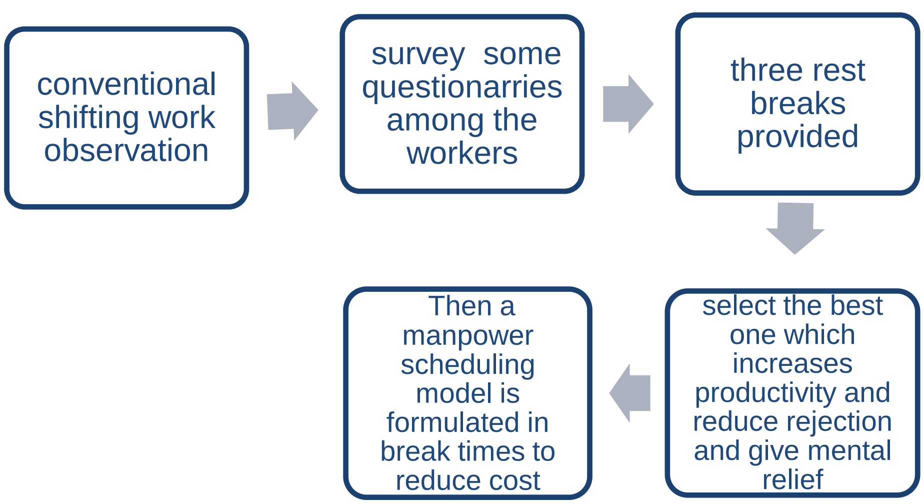
To conduct our thesis work for reducing the effect of prolonged work activities and improving daily production and reducing defects rate we have provided three different rest breaks and for manpower scheduling in break times we have used a mathematical model. For this research Bangladesh Lamps LTD (PHILIPS) has been chosen. The reason of choosing bulb production industry: there is less workstation and no substation. So model formulated considering less constraint and program construction for solving it using LINDO system becomes easier.

In our research, the activities are checked for several days. For each type of break 6 days are provided to check the improvement.

We follow this methodology for our work:

1. Providing three different rest breaks for nine hour shift.
    - Break at 11am-12pm(Provided)
    - breakfast break 10.00am-10.45am and refreshment break 12.45pm-1.00pm
    - a)breakfast break at 8.00 -8.15 am, b)Mid break 11.15 -11.45am and c)refreshment break1.20pm-1.35pm.
2. Checking production and rejection for seven days respectively.
3. After checking, find the best rest break schedule which increase total production and reduce reduction.
4. After finding optimal rest break schedule make a manpower scheduling model during rest period in order to reduce cost.

Figure 1: Flowchart of the Methodology



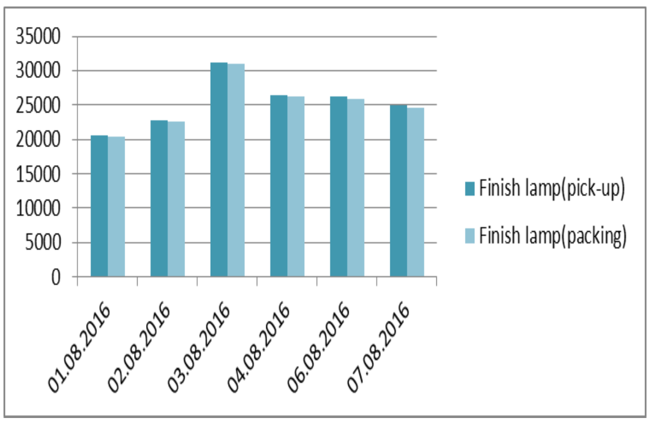
4. Data Collection and Analysis

1. Relief Break at 11am-12pm (Provided)

Table 1: Production and Rejection Data

Line AP1	Line output	Finish bulb	Reject
01.08.2016	20640	20469	171
02.08.2016	22750	22550	200
03.08.2016	31240	30970	270
04.08.2016	26349	26169	180
06.08.2016	26169	25946	223
07.08.2016	24890	24625	265

Figure 2: Line Output versus Finish Bulb

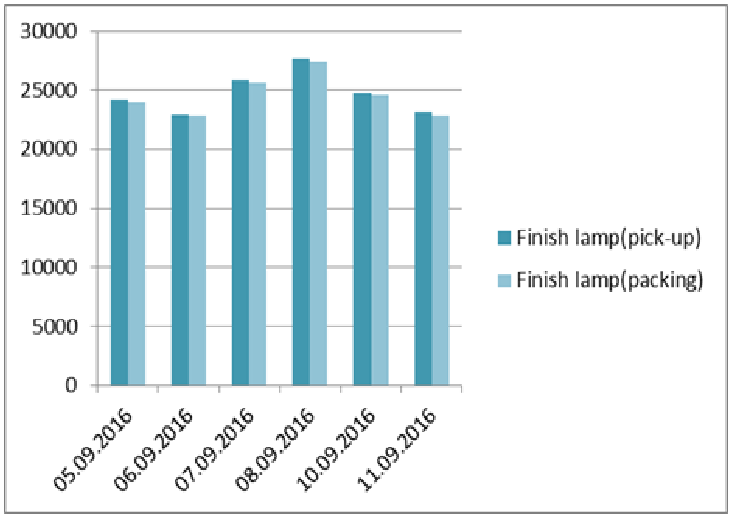


2. Breakfast break at a) 10.00am-10.45am and b) Refreshment break 12.45 pm-1.00pm

Table 2: Production and Rejection Data

Line AP1	Line output	Finish bulb	Reject
05.09.2016	24240	24020	220
06.09.2016	22987	22859	128
07.09.2016	25850	25650	250
08.09.2016	27647	27437	210
10.09.2016	24774	24575	199
11.09.2016	23120	22903	217

Figure 3: Line Output versus Finish

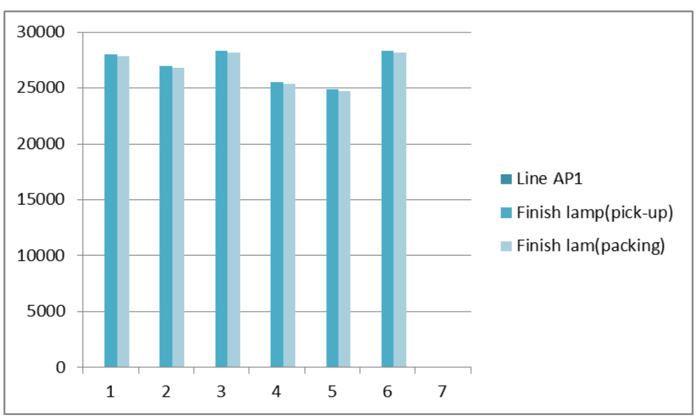


2. (a) breakfast break at 8.00 -8.15 am, b) Mid break 11.15 -11.45am and c) Refreshment breaks 1.20pm-1.35pm.

Table 3: Production and Rejection Data

Line AP1	Line output	Finish bulb	Reject
17.09.2016	27990	27870	120
18.09.2016	26987	26837	150
19.09.2016	28320	28132	188
20.09.2016	25490	25339	151
21.09.2016	24876	24741	135
22.09.2016	28338	28181	157

Figure 4: Line Output versus Finish Bulb



The Analyses of the Above Tables are:

- For conventional rest break it has seen total number of rejection for one week was 1309 pcs lamp.
- For fragmented second rest break it became 1224 pcs.
- For chosen rest break criteria , rejection reduces and becomes 901
- Material cost for a bulb is 25 Tk. So, this rest break saves (1309-1224) = 408 bulbs material cost , that means 10,200 Tk.

After providing three different rest breaks, it has seen that productivity improve for third rest break criteria. In this rest break schedule number of rejection reduces. As prolonged work hour has impact on worker mind and work activity, provided rest break create relief for worker, helps to encourage them for further work

5. Problem Description of Manpower Scheduling

There are permanent and contingent workers on the production line and contingent workers are used when required. When workers begin their break times the producing line is not allowed to reduce the output rate, so contingent workers are used. Contingent workers are divided into two groups such as temporary and casual operators. The yield of temporary operators is more than the casual ones. The number of permanent employees in each station is known in advance and is denoted by b_j. Relief and break fast breaks must start and be completed within the specified time windows.

The supposed assumptions are as follows:

- Shift must receive exactly three sub-breaks; each sub-break constitute of 15minute-periods that are denoted as t.
- The sub-break in the second position that is considered as lunch break must be longer than the ones in the first and third positions, which means that for lunch break two consecutive periods should be assigned to each.
- The output rate of permanent employees is considered as a standard rate and other worker's output is compared with it.
- B1, B2 and BL are the set of possible periods for the first, second and lunch break windows and T_{LB} is denoted as the last period in the window assigned to breakfast break.

Indices and Parameters

I index for break times (i=1, 2, 3 show the first, second and third break)

m Index for Product model (m=1,2,3)

j Index for station (j =1,2,3,4,5)

O Index for employee (O_j the O^{th} operator of station j)

t Index for the relief period considered in each break window

b_j Number of permanent employees in station j

α_{mj} Relative output rate (compared with a permanent worker) for each senior operator in processing model m in station j

β_{mj} Relative output rate (compared with a permanent worker) for each junior operator in processing model m in station j

C_{ij} Cost of assigning a temporary operator in break time i to the station j

C'_{ij} Cost of assigning a casual operator in break time i to the station j

V_r Maximum capacity of relief room

S_e Maximum number of contingent workers (temporary)

Ju Maximum number of contingent workers (casual)

Variables

Y_{ijt} Number of senior worker assigned to break i, station j for period t

Z_{ijt} Number of junior worker assigned to break i, station j for period t

X_{ojt} Binary variable: 1 if employee o in station j goes to the first break at period t

R_{ojt} Binary variable: 1 if employee o in station j goes to second break at period t

Q_{ojt} Binary variable: 1 if employee o in station j goes to the third break at period t

V_{jt} Numbers of employees of station j starting their first relief break in period t

U_{jt} Numbers of employees of station j starting their second relief break in period t

W_{jt} Numbers of employees of station j starting their third break in period t

Mathematical Model

A mixed integer linear programming is presented in this section as the model to schedule workforce in break times.

Min $\sum_i \sum_j C_{ij} \times \sum_{t\in B} Y_{ijt} + \sum_i \sum_j C'_{ij} \times \sum_{t\in B} Z_{ijt}$

=Min [{C_{11} Y_{111} +C_{12} Y_{121} +C_{13} Y_{131} +C_{14} Y_{141} +C_{15} Y_{151} +C_{21} Y_{212} +C_{22} Y_{222} +C_{23} Y_{232} +C_{24} Y_{242} +C_{25} Y_{252} +C_{31} Y_{313} +C_{32} Y_{323} +C_{33} Y_{333} +C_{34} Y_{343} +C_{35} Y_{353}} + {C'_{11} Z_{111}+$C'_{12}$$Z_{121}$ +$C'_{13}$$Z_{131}$+$C'_{14}$$Z_{141}$+$C'_{15}$$Z_{151}$+$C'_{21}$$Z_{212}$+$C'_{22}$$Z_{222}$+$C'_{23}$$Z_{232}$+$C'_{24}$$Z_{242}$+$C'_{25}$$Z_{252}$+$C'_{31}$$Z_{313}$+$C'_{32}$$Z_{323}$+$C'_{33}$$Z_{333}$+$C'_{34}$$Z_{343}$+$C'_{35}$$Z_{353}$ }] ………………………………………………………..(1)

Subject to:

$\sum_o \sum_{t\in B1} X_{ojt} - \sum_{t\in B1} V_{jt} = 0; \forall_j$………………………………………………………….. (2)

$\sum_o \sum_{t\in Bl} R_{ojt} - 2\sum_{t\in B2} U\,jt = 0; \forall_j$…………………………………………………….…….(3)

$\sum_{o} \sum_{t \in B2} Q_{ojt} - \sum_{t \in B3} W_{jt} = 0; \ \forall j$ .... (4)

$\alpha_{mi} + Y_{1jt} + \beta_{mi} + Z_{1jt} \geq 0$ ....(5)

$\alpha_{mj} + Y_{2jt} + \beta_{mj} + Z_{2jt} \geq U_{jt}; \forall t \in B2, j, m$ ....(6)

$\alpha_{mj} + Y_{3jt} + \beta_{mj} + Z_{3jt} \geq W_{jt}; \forall t \in B3, j, m$ ....(7)

$\sum_{t \in B1} X_{ojt} = 1; \ \forall j, o$ ....(8)

$\sum_{t \in B2} R_{ojt} = 2 \ ; \ \forall j, o$ ....(9)

$\sum_{t \in B3} Q_{ojt} = 1; \ \forall j, o$ ....(10)

$\sum_{j} V_{jt} \leq V_r ; \forall t \in B1$ ....(11)

$\sum_{j} U_{jt} \leq V_r ; \forall t \in B2$ ....(12)

$\sum_{j} W_{jt} \leq V_r ; \forall t \in B3$ ....(13)

$\sum_{j} Y_{ijt} \leq S_e ; \forall t, i$ ....(14)

$\sum_{j} Z_{ijt} \leq J_u ; \forall t, i$ ....(15)

$Y_{ijt}, Z_{ijt} \geq 0$ and integer $X_{ojt}, R_{ojt}, Q_{ojt} \in \{0,1\}$ ....(16)

The objective function (1) minimizes the cost of assigning contingent workers for both senior and junior employees.

Constraints (2- 4) determine the number of employees take their break times in period t of break window for all the relief and breakfast break, respectively.

Constraint (5-7) ensure that number of whole workers in each station(including contingent and permanent workers) and in each break cannot be less than a definite number, in order to satisfy customer demand.

Constraints (8- 10) show all the operators should go to the first and second relief break and also breakfast break in the specified break window respectively.

Constraint (11-13) ensure that number of workers go to break at a certain time cannot exceed the capacity of relief room.

Constraint (14) and (15) state a limitation about the maximum number of contingent workers assigned to stations respectively.

Constraint (16) defines non negativity and type of decision variables (integer or binary).

Basic Assumptions of the Model

Employee assignment is assumed to be determined for 36 quarter –hours(4*9 hours) for planning periods, t = {1,... , 36}. For each employee one 30-minute of lunch break and two 15-minute relief breaks (one before and one after the lunch break) are given. The ideal break start time for the first relief break is usually specified as two hours after the start of the shift, the ideal start time for the lunch break is set as four hours of the break after first break length and the ideal start time for the third break is set as six hours of the break after first break length and middle break length. We assume that all break windows are 1.5 hours long and it start half an hour before the ideal break start times. The Break window for the first 15-minute relief break is from 7.30 to 9:00, for the second break from 10:45 to 12:15, and for the second 15-minute relief break from 12:50 to 14:20. Thus, the lunch break for an employee may be scheduled in five different ways and each 15-minute relief break may be scheduled in six different ways.

5.1 Data Table for Model Formulation

Table 4: Data for Model Formulation

Serial No.	Inputs	Units
01	Total number of stations	5
02	number of operators in each workstation	2person/per station
03	Number of permanent employees in station j	20
04	Number of senior worker assigned to station j	15
05	Number of junior worker assigned to station j	10
06	cost of assigning one senior contingent worker to each station in period t	200 tk/per day
07	cost of assigning one junior contingent worker to a station in period t	100tk/per day
08	Capacity of the relief room	12
09	Relative output rate for each senior operator in processing model m in station j	1
10	Relative output rate for each senior operator in processing model m in station j	0.5

6. Result Analysis

- For conventional rest break it has seen total number of rejection for one week was 1309 pcs lamp.
- For fragmented second rest break it became 1224 pcs.
- For chosen rest break criteria , rejection reduces and becomes 901
- Material cost for a bulb is 25 Tk. So, this rest break saves(1309-1224) = 408 bulbs material cost, that means 10,200 Tk.

After providing three different rest breaks, it has seen that productivity improve for third rest break criteria. In this rest break schedule number of rejection reduces. As prolonged work hour has impact on worker mind and work activity, provided rest break create relief for worker, helps to encourage them for further work.

The Result of The Mode

The cost of assigning contingent workers for both senior and junior employees is 5800.00 tk, which is the minimum cost of allocating manpower.

Table 5: Scheduling of Manpower

Number of senior workers assigned to break i, station j for period t; Y_{ijt}	values
Y111	1
Y136	2
Y144	2
Y156	2
Y217	2
Y227	2
Y237	2
Y247	2
Y257	2
Y3112	2
Y3212	2
Y3312	2
Y3412	2

Table 6: Number of Junior Worker Assigned to Break i

Number of junior worker assigned to break i, station j for period t; Z_{ijt}	values
Z126	4

Table 7: Numbers of Employees of Station J Starting Their First Relief Break

Numbers of employees of station j starting their first relief break in period t; V_{jt}	Values
V11	1
V26	2
V36	2
V44	2
V56	2

Table 8: Numbers of Employees of Station Starting Their Second Relief Break

Numbers of employees of station j starting their second relief break in period t; U_{jt}	Values
U17	2
U27	2
U37	2
U47	2
U57	2

Table 9: Numbers of employees of station starting their third relief break

Numbers of employees of station j starting their third relief break in period t; W_{jt}	values
W112	2
W1212	1
W2212	1
W212	2
W1312	1
W2312	1
W312	2
W412	2
W512	2

7. Conclusions and Future Work

This research is done to check the impact of rest break on productivity and defects reduction. Three types of rest break are provided for a lighting industry. Fragmented breaks give more mental relief than continuous break. Optimal rest break increases production rate and decreases defects rate. A model is formulated for scheduling manpower in rest break time as machines become idle during this time. The model is valid for industry with less workstation and where machines are not stopped when rest break is provided because it takes long time to start or stop a machine. After solving the model, it has found that during rest break time what number of senior or junior contingent workers will work in which stations. Overall, this research work is helpful for finding optimal rest break and scheduling manpower during rest break. For any type of industry it is useful to check practical impact of fragmented rest break on productivity and defects reduction. This research is done for bulb industry. There were limited workstations. This is applicable for any kind of garments industry or Process industries to increase productivity and reduce defects. There will be more workstation and substation .So model formulation will be according to regarding constraints. In Future the large size of problem can be solved by any other meta-heuristics such as GA, PSO, SA, etc to get the greater convergence rate of the solution.

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