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Research Article

Performance Analysis and Optimization of Ergonomics Posture for Lathe Machine Operators

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Abstract

This paper focus on lathe machine operators who work in environment condition. Practical concern of this work is to improve worker's safe manipulation of tools and equipment and control of machinery, critical posture, and so on. However, the ultimate improvement will depend on the attitude of the people involved at all levels of an interactive system, while health and safety measures are introduced in organization with local systems and/or existing environments. Creating suitable environment an understanding of employers' attitudes and operator's involvement is essential. Taguchi L27 orthogonal array (OA) was applied to evaluate the effect of these parameters' and signal-to-noise and analysis of variance (ANOVA) used for work out the importance and their effect on the response parameter in summer environmental days. For suitable posture condition are optimize by Grey relation analysis.

Keywords: Ergonomics application, Lathe Machine Operator, Ergonomics Posture, Optimization.

1. INTRODUCTION

Industrial and social development is rarely feasible without considering health, hygiene, safety issues and ergonomics applications. Health and safety at the workplace are maintained only with a conscious awareness of work regulation and labor legislation, implementation of work regulation. Labor will be hard without a sincere commitment of the local government authority (LGA) or regulatory agency [1]. Ergonomics is defined as an adaptation to a job or workplace by the design of tasks, workstations, tools, and equipment that are within a worker's physical capabilities and limitations [2,3]. Ergonomics is the systematic process designed for human use through the application of our knowledge of human beings to the equipment they use, the environment in which they operate, the tasks they perform, and the management systems. It is primarily noticeable for the guidance of the safety and efficiency of the operations in refineries, chemical plants, upstream operations and distribution terminals. Additionally, ergonomics refers to the science of dealing with interactions among humans and their activities, equipment, environment, and systems.

There are a number of guidelines for operating the lathe safely; they should be reviewed in detail before beginning [2]. For example, dust production is a common issue during woodworking, particularly during sanding, so a dust mask is also recommended. Dust from exotic woods and splatted woods may be particularly toxic, in which case a face shield that features an air filtration system is the best method of protection. Finally, maintaining a safe work environment helps to reduce the risk of accidents. Sound volume and frequency can be high during lathing; users should consider wearing appropriate hearing protection for these frequencies. However, this may not be appropriate when working with others in the vicinity, when verbal communication is vital to everyone's safety. Job satisfaction may not be possible without an awareness of labor welfare facilities. Workplace intervention is not possible without considering OHS/

ergonomics. Transparency of regulatory agency cannot be achieved without formation of a neutral watch dog body, like the National Health and Safety Council (NHSC).

2. LITERATURE REVIEW

Probst [4] have proposed that safety performance constitutes factors such as safety climate, management support, risk management, safety communication, employee's safety competency and safety training through a broad-based questionnaire survey in manufacturing firms. Dejoy et al. [5] have stated that employees' attitudes play a vital role in safety issues. They have also pointed out that industrial accidents not only affect human capital but also generate financial losses due to disruptions in industrial processes, damages to production machinery and harm the firm's reputation.

Huang et al. [6] present paper on physical risk factors as important first-line risk factors, and other plausible factors such as organizational and psychosocial factors that can provoke a disorder or indirectly influence the effect of physical risk factors. Three categories of risk factors are identified which are biomechanical exposures, psychosocial stressors and individual risk factors. Biomechanical exposures include factors such as poorly designed workplaces and biomechanical exposures such as repetitive motion, high forces and deviations from neutral body alignments. Khan et al. [7] presenting a basic understanding of ergonomic evaluation using the Energy Expenditure Prediction Program (EEPP) software designed by University of Michigan in order to bring about maximum efficiency, productivity and safety of a worker in a production environment. Lifu et al. [8] approach for better machining accuracy and effect of parts, there is a direct relationship between the structural configuration of the CNC lathe, the input and output mode of the machining information, the arrangement of the operating mechanism, the difficulty of the operation of the equipment, and the accuracy of the operator's operation. Mohsin et al. [9] investigated the energy expenditure by using Energy Expenditure Prediction Program Software. The energy expenditure was determined by observing and recording the activities during the operations on a lathe machine. In this work, the average metabolic energy rate is predicted by knowing the energy expenditure and task duration. Increasing the productivity and the quality of the product are the main challenges of manufacturing industries. Prepare the factors and their which is affecting the working condition in machining operation. L27 experiment based orthogonal array design was used to study operator ergonomics in machining. Based on L27 orthogonal array design performs the experiment by operator and note responses from operator. Output responses are optimizing by grey relation method which gives minimum pain in posture at machining. Significant effects of all responses are found to show that these parameters are more critical in posture in machining.

3. PROCESS PARAMETER

This research study is conducted at machining workshop with different temperature condition. Different operators were selected which is convenient for study of average height 165 cm to 175 cm, with three different age factor that is 22years, 35 years and 48 years.

Table 1 Factors and Level

Sl. No.	Age (Yrs)	Working time (Hr)	Standing Position	Working Temperature (ºC)
Level 1	22	3	Straight	28
Level 2	35	3.5	Slightly Bend	32
Level 3	48	4	Down	36

The responses recording of their pain showing movements of the workers during working was recorded. During the experiment, the pain obtained in leg hands and back pain was ask to employer with marking between 0 to 9 categories. The three input parameters are taken for design the experiment are age factor, working time, standing position and working temperature. In this experiment similar type of machine are used to perform the experiment and having 3 levels of each factor was taken as input parameter as shown in Table 1.

For design the performance standing position are converting in numeric number are shown in below:

- **Straight** **1**
- **Slightly bend** **2**
- **Down** **3**

Some factors affect the operator which are shown in fig 1, these factors are age, continious working time, working temperature standing position etc.

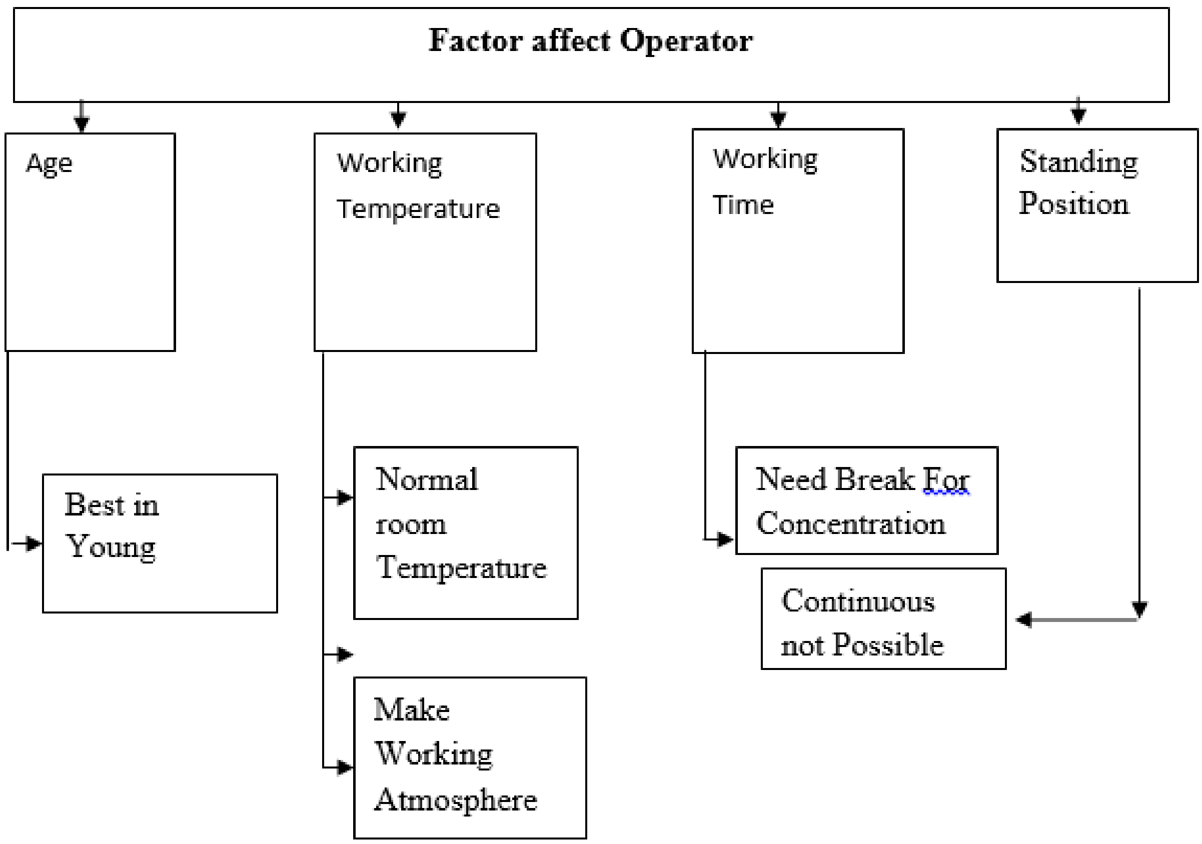

Fig 1 Factor Affect Operator

Losing the expertise of these workers could have a drastic and negative impact on your company's operations. As workers age, their physical, physiological, and psychosocial capabilities and limitations change. Continuous working time is also most dangerous to health which increase the stress in body cause casualty or others harms to operator. Standing for long periods of time to perform a job should be avoided whenever possible. Long periods of standing work can cause back pain, leg swelling and problems with blood circulation, sore feet and tired muscles.

2. Method Flow Process

The conceptual framework of ergonomics optimization is shown in fig 2 gives an outline of possible causes of safety against and relief against heavy pain and accident or presents a preferred approach to occupational safety and health management system to safeguard workers from work related hazards.

Mathematical models were deduced by software design Expert in order to express the influence degree of the main cutting variables such as feed, cutting speed, and mixture of coolant and water experiments with combination of different cutting parameters were randomly repeated. Orthogonal arrays are special standard experimental design that requires only a small number of experimental trials to find the main factors effects on output. On the basis of factors and their level L27 orthogonal array has to be design in Minitab software as shown in table 2, Where 1, 2 & 3 indicating the standing position of working which is depict in table 1. Taguchi experimental design of experiments suggests L27 orthogonal array, where 27 experiments are sufficient to optimize the parameters. Based on main factor, the variables are assigned at columns, as stipulated by orthogonal array.

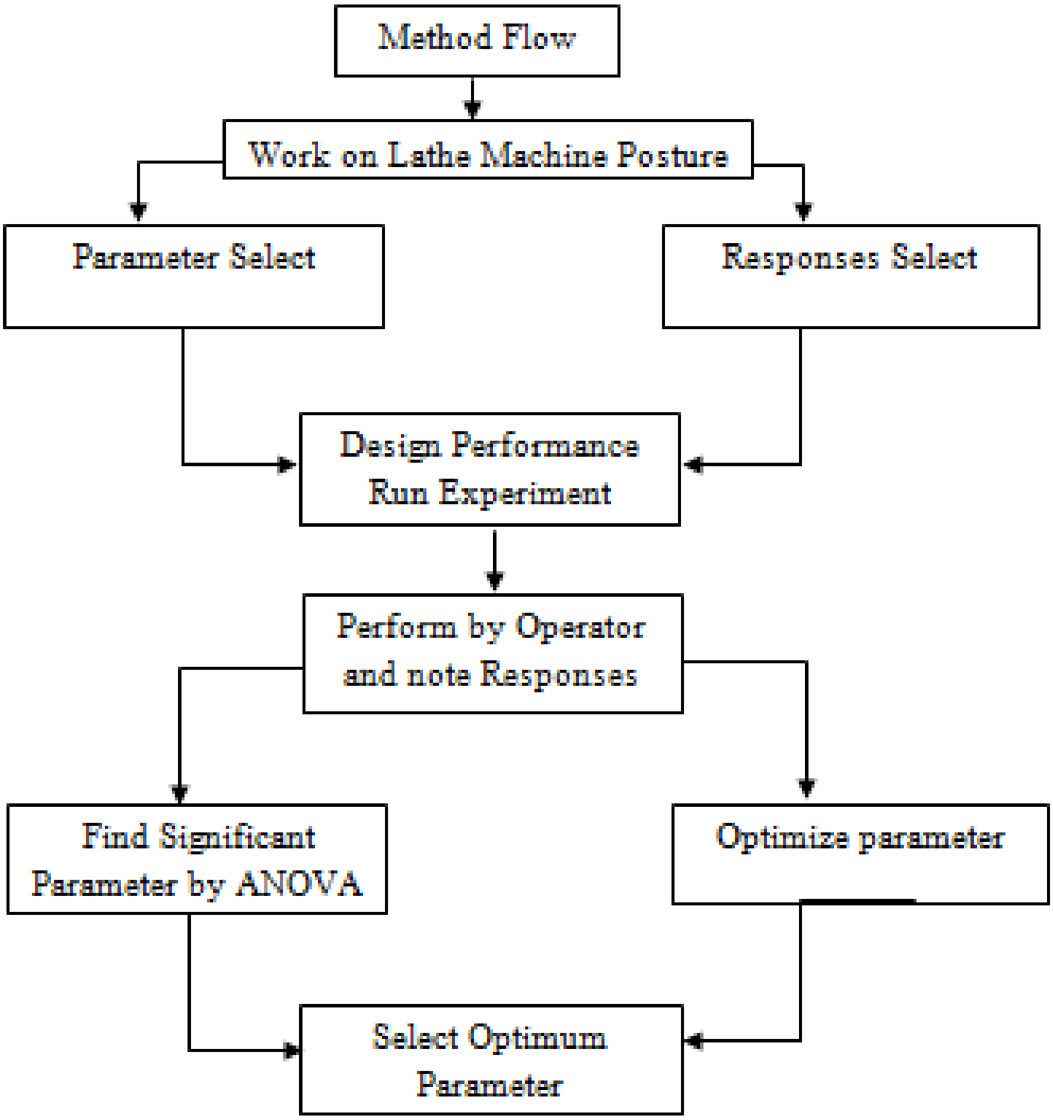

Fig 2 Method Flow

3. RESULT OBTAINED

As per the design performance are obtained where seen that increase in working temperature fact that increase in stress of operator. On the base of DOE parameter, the performance chart is followed by operator and give their responses are shown in table 3.

Table 2 Performance Parameter

S No.	Age (Years)	Working time (Hr)	Standing Position	Working Temperature (^oC)
1	22	3	1	28
2	22	3	1	28
3	22	3	1	28
4	22	3.5	2	32
5	22	3.5	2	32
6	22	3.5	2	32
7	22	4	3	36
8	22	4	3	36
9	22	4	3	36
10	35	3	2	36
11	35	3	2	36
12	35	3	2	36
13	35	3.5	3	28
14	35	3.5	3	28
15	35	3.5	3	28
16	35	4	1	32
17	35	4	1	32
18	35	4	1	32
19	48	3	3	32
20	48	3	3	32
21	48	3	3	32
22	48	3.5	1	36
23	48	3.5	1	36
24	48	3.5	1	36
25	48	4	2	28
26	48	4	2	28
27	48	4	2	28

Table 3 Responses by Operator

S No.	**A**	**Wt**	**Sp**	**T**	**Leg Pain (L)**	**Hand Pain (H)**	**Back Pain (B)**
1	22	3	1	28	3	4	2
2	22	3	2	28	1	3	4
3	22	3	3	28	2	4	6
4	22	3.5	1	32	4	5	2
5	22	3.5	2	32	2	5	3
6	22	3.5	3	32	3	5	5
7	22	4	1	36	6	8	4
8	22	4	2	36	4	7	6
9	22	4	3	36	5	9	8

10	35	3	1	36	6	9	4
11	35	3	2	36	6	7	5
12	35	3	3	36	8	6	8
13	35	3.5	1	28	5	6	6
14	35	3.5	2	28	3	2	5
15	35	3.5	3	28	6	5	6
16	35	4	1	32	4	7	3
17	35	4	2	32	3	6	5
18	35	4	3	32	5	7	4
19	48	3	1	32	6	8	5
20	48	3	2	32	5	5	6
21	48	3	3	32	7	8	8
22	48	3.5	1	36	8	8	5
23	48	3.5	2	36	7	9	6
24	48	3.5	3	36	8	3	8
25	48	4	1	28	7	5	4
26	48	4	2	28	6	4	8
27	48	4	3	28	5	6	6

Table 4 Normalization of responses

S No.	A	Wt	Sp	T	Xi (L)	Xi (H)	Xi (B)
1	22	3	1	28	0.714286	0.714286	1
2	22	3	2	28	1	0.857143	0.666667
3	22	3	3	28	0.857143	0.714286	0.333333
4	22	3.5	1	32	0.571429	0.571429	1
5	22	3.5	2	32	0.857143	0.571429	0.833333
6	22	3.5	3	32	0.714286	0.571429	0.5
7	22	4	1	36	0.285714	0.142857	0.666667
8	22	4	2	36	0.571429	0.285714	0.333333
9	22	4	3	36	0.428571	0	0
10	35	3	1	36	0.285714	0	0.666667
11	35	3	2	36	0.285714	0.285714	0.5
12	35	3	3	36	0	0.428571	0
13	35	3.5	1	28	0.428571	0.428571	0.333333
14	35	3.5	2	28	0.714286	1	0.5
15	35	3.5	3	28	0.285714	0.571429	0.333333
16	35	4	1	32	0.571429	0.285714	0.833333
17	35	4	2	32	0.714286	0.428571	0.5
18	35	4	3	32	0.428571	0.285714	0.666667
19	48	3	1	32	0.285714	0.142857	0.5
20	48	3	2	32	0.428571	0.571429	0.333333

21	48	3	3	32	0.142857	0.142857	0
22	48	3.5	1	36	0	0.142857	0.5
23	48	3.5	2	36	0.142857	0	0.333333
24	48	3.5	3	36	0	0.857143	0
25	48	4	1	28	0.142857	0.571429	0.666667
26	48	4	2	28	0.285714	0.714286	0
27	48	4	3	28	0.428571	0.428571	0.333333

3.1 OPTIMIZATION OF PARAMETERS

In the grey relational analysis, experimental were first normalized and then the grey relational coefficient was calculated from the normalized experimental data to express the relationship between the desired and actual experimental data as shown in table 4 and 5 respectively.

Table 5 Grey relation coefficient

S No.	A	Wt	Sp	T	Gi (L)	Gi (H)	Gi (B)
1	22	3	1	28	0.636364	0.636364	1
2	22	3	2	28	1	0.777778	0.6
3	22	3	3	28	0.777778	0.636364	0.428571
4	22	3.5	1	32	0.538462	0.538462	1
5	22	3.5	2	32	0.777778	0.538462	0.75
6	22	3.5	3	32	0.636364	0.538462	0.5
7	22	4	1	36	0.411765	0.368421	0.6
8	22	4	2	36	0.538462	0.411765	0.428571
9	22	4	3	36	0.466667	0.333333	0.333333
10	35	3	1	36	0.411765	0.333333	0.6
11	35	3	2	36	0.411765	0.411765	0.5
12	35	3	3	36	0.333333	0.466667	0.333333
13	35	3.5	1	28	0.466667	0.466667	0.428571
14	35	3.5	2	28	0.636364	1	0.5
15	35	3.5	3	28	0.411765	0.538462	0.428571
16	35	4	1	32	0.538462	0.411765	0.75
17	35	4	2	32	0.636364	0.466667	0.5
18	35	4	3	32	0.466667	0.411765	0.6
19	48	3	1	32	0.411765	0.368421	0.5
20	48	3	2	32	0.466667	0.538462	0.428571
21	48	3	3	32	0.368421	0.368421	0.333333
22	48	3.5	1	36	0.333333	0.368421	0.5
23	48	3.5	2	36	0.368421	0.333333	0.428571
24	48	3.5	3	36	0.333333	0.777778	0.333333
25	48	4	1	28	0.368421	0.538462	0.6
26	48	4	2	28	0.411765	0.636364	0.333333
27	48	4	3	28	0.466667	0.466667	0.428571

Table 6 Grey Relation Grade

S No.	A	Wt	Sp	T	Γ	S No.	A	Wt	Sp	T	Γ
1	22	3	1	28	0.757576	15	35	3.5	3	28	0.459599
2	**22**	**3**	**2**	**28**	**0.792593**	16	35	4	1	32	0.566742
3	22	3	3	28	0.614238	17	35	4	2	32	0.534343
4	22	3.5	1	32	0.692308	18	35	4	3	32	0.49281
5	22	3.5	2	32	0.688746	19	48	3	1	32	0.426729
6	22	3.5	3	32	0.558275	20	48	3	2	32	0.4779
7	22	4	1	36	0.460062	21	48	3	3	32	0.356725
8	22	4	2	36	0.459599	22	48	3.5	1	36	0.400585
9	22	4	3	36	0.377778	23	48	3.5	2	36	0.376775
10	35	3	1	36	0.448366	24	48	3.5	3	36	0.481481
11	35	3	2	36	0.441176	25	48	4	1	28	0.502294
12	35	3	3	36	0.377778	26	48	4	2	28	0.460487
13	35	3.5	1	28	0.453968	27	48	4	3	28	0.453968
14	35	3.5	2	28	0.712121						

Then, the grey relational grade was computed by averaging the grey relational coefficient corresponding to each process response as shown in Table 6. The overall evaluation of the multiple process responses is based on the grey relational grade. As a result, optimization of the complicated multiple objective responses can be converted into optimization of a single grey relational grade. In other words, the grey relational grade can be treated as the overall evaluation of experimental data for the multi response process. Optimization of a factor is the level with the highest grey relational grade. The greatest value of grey relation grade has optimum parameters for experimented responses as shown in Table 6.

The purpose of the ANOVA is to investigate which factors significantly affect the performance of responses. This is accomplished by separating the total variability of the grey relational grades, which is measured by the sum of the squared deviations from the total mean of the grey relational grade, into contributions by each machining parameter and the error.

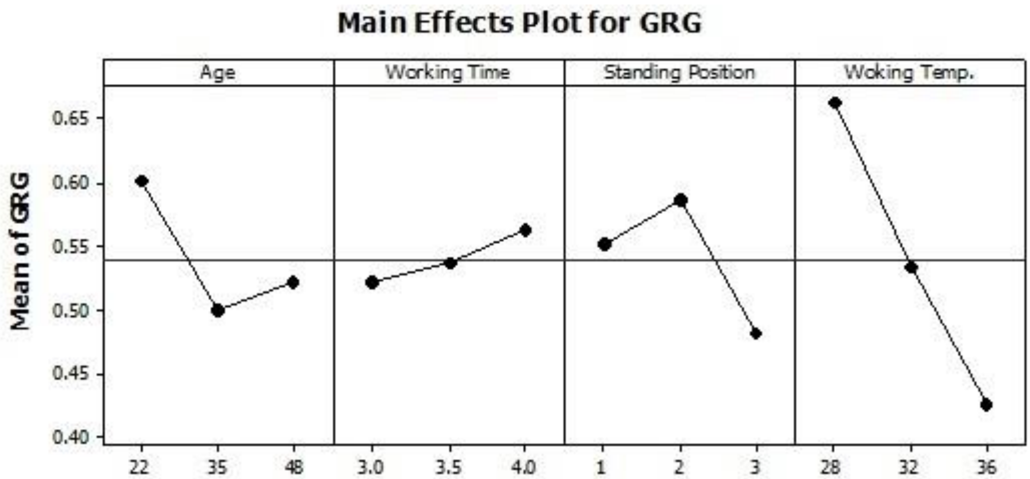

Fig 3 Main effect plot for GRG

In addition, the F test can also be used to determine which factor has a significant effect on the performance characteristic. Usually, the change of a determined factor has a significant effect on the performance characteristic when the F value is large. Results of the ANOVA Table 7 indicate that cutting speed is the most significant factor for affecting the multiple performance characteristics.

For ANOVA test the S/N ratio of the optimum responses are shown in fig 3.

Table 7 Analysis of Variance for GRG

Source	DF	Seq SS	Adj SS	Adj MS	F	P
A	2	0.12157	0.12157	0.060784	8.22	0.008
Wt	2	0.01598	0.01598	0.007988	1.08	0.376
Sp	2	0.03471	0.03471	0.017354	2.35	0.146
T	2	0.11208	0.11208	0.056039	7.58	0.010
Wt*Sp	4	0.01149	0.01149	0.002873	0.39	0.812
Sp*T	4	0.01644	0.01644	0.004111	0.56	0.700
Residual Error	10	0.07397	0.07397	0.007397		
Total	26	0.38624				

Table 8 Response Table for GRG

Level	A	Wt	Sp	T
1	0.6001	0.5215	0.5232	0.5785
2	0.4985	0.5360	0.5493	0.5327
3	0.4374	0.4787	0.4636	0.4248
Delta	0.1627	0.0573	0.0857	0.1537
Rank	1	4	3	2

For GRG age and temperature has lowest P value which is significant. Out of two significant age is most efficient factor is shown in table 8.

CONCLUSIONS

The assessment of body posture has been carried out for this particular lathe machine operator by ANOVA to found significant posture of the workers are working in uncomfortable and painful postures as found by analysis. Based on the observation results presented the following conclusions can be drawn on the effect of operator perform machining operation and give their individual responses in terms of leg pain hand pain and back pain. From the optimization the most possible parameter of ergonomics for less pain are operator age is 22 years, working time is 3 hours, standing position is slightly bend and working temperature is 28^{o}C. Main effect plot of GRG ergonomics posture parameter for lathe operator proposed less pain condition is age 22 years, working time is 3.5 hour, standing position is slightly bend and working temperature is 28^{o}C.

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