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Discovering Thoughts, Inventing Future

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A Mathematical Formulation for Mixed Model Two Sided Assembly Line Balancing Problem to Consider Boundary Conditions

By Ashish Yadav, Pawan Verma & Sunil Agrawal
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Abstract- *Purpose:* The main aim of this paper is to develop a new mathematical model for the mixed model two-sided assembly line balancing problem (MTALBP) generally occurs in plants producing large-sized high-volume products such as buses or trucks.

Methodology: In this paper, the proposed mathematical model is applied to solve two-sided mixed-model assembly line balancing problem with lower and upper bound. The proposed mathematical model is solved using a branch and bound algorithm on LINGO 17.0 solver.

Findings: Based on the computational result, line efficiency that is obtained by reducing single and mated stations of the assembly line is good as compare to the theoretical minimum number of stations and reduces computational time by applying boundary conditions.

Keywords: *two-sided assembly line balancing, mixed model, mathematical model. lingo-17 solver.*

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Ashish Yadav [α], Pawan Verma [σ] & Sunil Agrawal [ρ]

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Practical implications: Since the problem is well known as an NP-hard problem a benchmark study problem is solved, and the result of the study can be beneficial for assembly of the mixed model products in term of minimizing mated stations as well as computational time.

Originality: By literature review, this paper is first to address mixed-model two-sided assembly line balancing problem with bounds using the exact solution approach.

Keywords: two-sided assembly line balancing, mixed model, mathematical model. lingo-17 solver.

I. Introduction

An assembly line is a flow-oriented production system, which consists of some workstations that are connected by material handling systems like a conveyor or moving belt. Assembly line balancing problem is determining the optimal assignment of tasks to workstations by considering some constraints to obtain an efficient assembly line to satisfy the customer demands on time.

Assembly lines can divide into two different groups based on product characteristics and some technical requirements: (i) one-sided assembly lines, and (ii) two-sided assembly lines. While only one restricted side (either left (L) or right (R) side) is used in one-sided assembly lines, both left and right sides are used in two-sided assembly lines. Two-sided assembly lines are usually constructed to produce large-sized high volume products such as buses, trucks, automobiles, and some domestic products.

Regarding the various numbers of product models assembled on the line, assembly lines can also be classified as single-model assembly lines and mixed-model assembly lines. Assembly lines in which more than one product model is assembled on the same line without any setup requirement between models are called as a mixed model assembly line. Mixed-model assembly lines offer several advantages over single-model assembly lines, including avoidance of constructing several lines, satisfied different customer demands, and minimized workforce need. Mixed-model assembly lines provide more flexibility toresponding to consumer demands on time and to reach global markets in a highly competitive scenario. With the solution of assembling more than one model on each adjacent line of two-sided assembly lines, we can obtain a new line system called Mixed-model two-sided assembly lines.

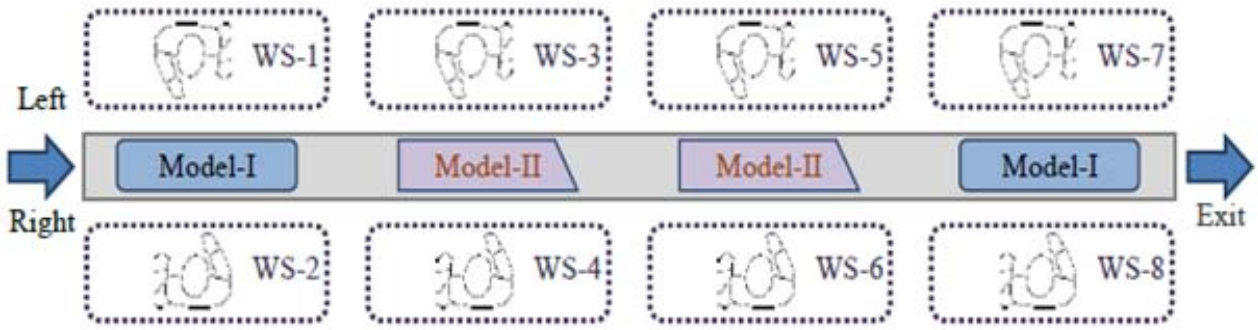

Fig. 1: The structural illustration of MTALBP (Zhang et al. 2016)

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II. Literature Review

(Simaria et al., 2009) presented mathematical programming model with ant colony optimization algorithm for solving two-sided mixed-model assembly line balancing problem with an objective of minimize the number of workstations of the line. (Ozcan et al., 2009) addressed TALBP with the objective of minimizes the number of mated-stations as the first objective and minimizes the number of stations as the second one for a given cycle time They presented a formal mathematical formulation for the problem and developed simulated annealing algorithm for maximizing the weighted line efficiency and minimizing the weighted smoothness index.

(Chutima et al., 2012) Presents a Particle Swarm Optimization with negative knowledge (PSONK) to solve multi-objective two-sided mixed-model assembly line balancing problem with the objective of minimizing the number of mated-stations for given cycle time. PSONK employs the knowledge of the relative positions of different particles in generating new solutions. (Aghajani et al., 2014) AddressedTALBP with the objective to minimize the cycle time for a given number of mated stations. They presented a mixed-integer programming model for robotic mixed-model two-sided assembly line balancing and developed simulated annealing (SA) algorithm as Meta heuristic method is proposed to solve the problem.

(Rabbani et al., 2014) In this paper author presents a novel multiple U-shaped layouts is proposed to deal with the mixed-model two-sided assembly line balancing (MTALB) problems with the the mathematical formulation of two conflicting objectives including minimizing the cycle time and minimizing the number of workstations are considered under precedence, zoning, capacity, side, and synchronism constraints and developed genetic algorithms to solve it optimally.

(Kucukkoc et al., 2014) Presented a new assembly line system configuration for companies that need intelligent solutions to satisfy customized demands on time with existing resources. An agent-based ant colony optimization algorithm is proposed to solve the problem. They presented a mathematical formulation for simultaneous balancing and sequencing and developed an agent-based ant colony optimization algorithm to solve it optimally. (Yuan et al.,2015) Addressed TALBP with the objective of minimizing the number of mated-stations and a total number of stations for given cycle time. A Honey bee mating optimization (HBMO) algorithm is proposed to solve this problem.

(Zhang et al., 2016) In this paper, author introduces mixed-model two-sided assembly line balancing Type-II problem benefiting from the real data gathered through an industrial case study. This paper also contributes to knowledge by incorporating incompatible task groups, different from negative zoning constraints. (Kucukkoc., 2016) Addressed mixed-model two-sided lines with the objective for minimizing the cycle time of the line as well as the number of workstations. A real-world problem is solved using the proposed approach, and the efficiency of the line is improved. They presented a real-world problem and developed ant colony optimization algorithm to solve it optimally.

(Deliceet al., 2017) presented a new modified particle swarm optimization algorithm with negative knowledge is proposed to solve the mixed-model two-sided assembly line balancing problem with minimizing the number of mated stations as the first objective and minimizing the number of stations as the second one for given cycle time. (Liet al., 2018) Addressed TALBP with two objectives those are simultaneous to be optimized; one is to minimize the combination of the weighted line efficiency and the weighted smoothness index. A novel multi-objective hybrid imperialist competitive algorithm (MOHICA) is to solve this problem.

Although researchers have focused on Two-sided ALB problems and, the literature review suggests that a very limited number of researchers focus on the mixed model two-sided assembly line balancing problem (MTALB). MTALB problems with the objective of minimizing mated stations along with lower and upper bound are very crucial objective in some industries. Hence, the main focus of this article is to reduce mated stations and computational time of an MTALB problem.

This article mainly presents the following contributions to the research field:

1) A Mathematical Model of mixed model two-sided assembly line balancing problem is proposed with Station oriented objective with lower and upper bound.
2) The proposed mathematical model is tested on a benchmark problem and is solved using Lingo -17 solvers to obtain the optimal solutions.
3) The results of station oriented objectives with lower and upper bound are compared with the results of the theoretical minimum number of workstations. From this study, it is observed that the proposed station oriented objective with bounds provides better solutions in term of reducing mated stations and computational time.

The rest of the paper is organized as follows: MTALBP definition is given in section 3 with objectives, assumptions, and constraints. Section 4 illustrates a mixed model two-sided assembly balancing problem example which is taken from the literature. Conclusions and future work are presented in section 5.

III. Mathematical Formulation

a) Overview

The main objective of the proposed model is to assign the set of tasks in mixed model two-sided

assembly line balancing problem in such a systematic way so that mated station and single stations are reduced.

In this model reduces the computational time of the solver by adding boundary condition. Here the boundary conditions eliminate some variable which increases the computational time. Since assembly line balancing is an NP-Hard problem that's why increase a single variable or constraint puts a lot of increment in time. So the reduction of these variables reduces the time rapidly.

Here lower and upper bounds for the assignment of a task basically depends on precedence relationship, cycle time and processing time of tasks. Here lower and upper bound are calculated by the formula mentioned below:

Lower bound

If a task does not have any predecessor then $LB_i = 1$

$$LB_i = \left[\frac{\text{sum of task time of all predecessor task of task i and task i}}{cycle\ time}\right]^+$$

Here $[x]^+$ represents the lowest integer greater than or equal to x.

Upper bound

If a task does not have a successor then $UB_i = \max\,[LB_i]$

$$UB_i = \max[LB_i] - \left[\frac{\text{sum of task time of all successor task of task i and task i}}{cycle\ time}\right]^+ + 1.$$

Here $[x]^+$ represents the lowest integer greater than or equal to x.
If for any task i $LB_i > UB_i$ then increment all $UB_i\ by\ 1$.

b) Assumptions

The MTALB problem in this study includes the following assumptions: [2]

- Models with similar production characteristics are produced on the same two-sided assembly line.
- Workers perform tasks in parallel at both sides of the line.
- Some tasks may be required to be performed at oneside of the line, while others may be performed at either side of the line.
- The precedence diagrams of different models are known.
- Task times are deterministic and independent of the assigned station.
- Parallel tasks and parallel stations are not allowed.
- The travel times of operators are ignored.
- No work-in-process inventory is allowed.

Decision Variables	
Symbol	Description
x_{mijk}	Binary variable indicating assignment of task $\begin{cases}1 \text{ if task i of model m is assigned to station j on side k}\\ 0, \text{otherwise}\end{cases}$
st_{mi}	The start time of task i for model m
Z_{ih}	Binary variable indicating precedence relationships among the tasks in the same station $\begin{cases}1 \text{if task i is assigned before task h in the same station}\\ 0, \text{if task h is assignedbefore taski in the same station}\end{cases}$
ms_j	$\begin{cases}1 \text{if mated} - \text{station j is utilized}\\ 0, \text{otherwise}\end{cases}$
ss_{jk}	$\begin{cases}1 \text{ if station (j, k) is utilized}\\ 0, \text{otherwise}\end{cases}$

Notations	
Symbol	Description
I	Set of all assembly tasks
N	Total no. of tasks
J	Set of all mated-stations
M	Set of all models
i	Index of assembly task; $i = 1, 2, \ldots I$
j	Index of station; $j = 1, 2, \ldots J$
m	Index of model; $m = 1, 2, \ldots M$
k	Index of mated-station direction; $\begin{cases} 1 \text{ indicates a left direction} \\ 2 \text{ indicates a right direction} \end{cases}$
(j, k)	Index of station j and the associated mated-station direction k
$P(i)$	Set of immediate predecessors of task i
$S(i)$	Set of immediate successors of task i
t_{mi}	Completion time of task i for model m
μ	Large positive number
CT	Cycle time
$\mathrm{d1_i}$	$\begin{cases} 0 \text{ if task } i \text{ is a right} - \text{side} \\ 1 \text{ otherwise} \end{cases}$
$\mathrm{d2_i}$	$\begin{cases} 0 \text{ if task } i \text{ is a left} - \text{side} \\ 1 \text{ otherwise} \end{cases}$
R^+ LB_i UB_i	Positive real number Lower bound for assignment of task i Upper bound for assignment of task i

Objective Function

$$Max\ Z = \sum_{j=1}^{J} \left(t_{mi} * x_{mijk}\ (J - j + 1)\right)^2 \tag{1}$$

This non-linear objective function in equation (1) represents the sum of the square of each workstation's workload to maximize the workload on each workstation. $(J - j + 1)$ is higher for initial stations and lower for ending stations.

Constraints

$$\sum_{j=LB_i}^{UB_i} \sum_{k=1}^{2} x_{mijk} = 1 \qquad \forall\ m \in M,\ \forall\ i \in I \tag{2}$$

$$\sum_{j=LB_i}^{UB_i} (d1 * x_{mij\,1} + d2 * x_{mij\,2}) = 1 \qquad \forall\ m \in M,\ \forall\ i \in I \tag{3}$$

$$\sum_{k=1}^{2} x_{mijk} * (st_{mi} + t_{mi}) \leq j * ct \qquad \forall\ m \in M,\ \forall\ i \in I,\ j \in [LB_i, UB_i] \tag{4}$$

$$\sum_{k=1}^{2} (x_{mijk} * (j-1) * ct) \leq st_{mi} \qquad \forall\ m \in M,\ \forall i \in I,\ j \in [LB_i, UB_i] \tag{5}$$

$$\sum_{j=LB_i}^{UB_i} \sum_{k=1}^{2} j * x_{mhjk} - \sum_{j=LB_i}^{UB_i} \sum_{k=1}^{2} j * x_{mijk} \leq 0 \qquad \forall\ m \in M,\ \forall\ i,h \in I,\ h \in p(i) \tag{6}$$

$$st_{mh} - st_{mi} + \mu\left(1 - \sum_{k=1}^{2} x_{mijk}\right) + \mu\left(1 - \sum_{k=1}^{2} x_{mhjk}\right) \geq t_{mi}$$

$$\forall\ m \in M,\ \forall\ i,h \in I,\ i \in p(h), \forall\ j \in [LB_i, UB_i] \tag{7}$$

$$st_{mh} - st_{mi} + \mu(1 - x_{mijk}) + \mu(1 - x_{mhjk}) + \mu(1 - \mu(1 - z_{i,h}) \geq t_{mi}$$

$$\forall\ m \in M,\ \forall\ i,h \in I,\ i \notin p(h), h \notin p(i), \forall\ j \in [LB_i, UB_i], \forall\ k \in K \tag{8}$$

$$st_{mi} - st_{mh} + \mu(1 - x_{mijk}) + \mu(1 - x_{mhjk}) + \mu * z_{i,h} \geq t_{mh}$$

$$\forall\, m \in M,\ \forall\, i,h \in I,\ i \notin p(h), h \notin p(i), \forall\, j \in [LB_i, UB_i],\ \forall\, k \in K \quad (9)$$

$$x_{m_1ijk} = x_{m_2ijk} \qquad \forall\, m_1, m_2 \in M,\ \forall\, i \in I,\ j \in [LB_i, UB_i],\ \forall\, k \in K \quad (10)$$

$$\mathrm{x_{mijk}} \in \{0,1\} \forall\, \mathrm{i} \in \mathrm{I}, \forall\, \mathrm{m} \in \mathrm{M}, \forall\, \mathrm{j} \in [LB_i, UB_i],\ \forall\, \mathrm{k} \in \mathrm{K} \quad (11)$$

$$\mathrm{ss_{jk}} \in \{0,1\} \forall\, \mathrm{j} \in [LB_i, UB_i],\quad \forall\, \mathrm{k} \in \mathrm{K} \quad (12)$$

$$\mathrm{ms_j} \in \{0,1\} \forall\, \mathrm{j} \in [LB_i, UB_i] \quad (13)$$

$$\mathrm{z_{ih}} \in \{0,1\} \forall\, \mathrm{i,h} \in \mathrm{I},\ \mathrm{i} \notin \mathrm{p(h)}, \mathrm{h} \notin \mathrm{p(i)} \quad (14)$$

$$\mathrm{st_{mi}} \in R^{+} \forall\, \mathrm{i} \in \mathrm{I},\ \forall\, \mathrm{m} \in \mathrm{M} \quad (15)$$

Constraints (2) and (3) ensure that all the tasks are assigned to the workstation and each task is assigned only once. Constraint (4) and (5) ensures that the start time of every task is in the time range of the station on which it is assigned. Constraint (6) ensures that the starting time of any task is equal to or greater than the completion time of immediate predecessor of that task in the precedence diagram. Constraint (7) to (9) is specially designed for a TALBP. Constraint (7) will be active when task $h$is precedence of task i and are assigned at the same mated station on opposite side otherwise the constraint will not be active. When this holds, the constraint is applied to $\mathrm{st_{mi}} - \mathrm{st_{mh}} \geq \mathrm{t_{mh}}$ which ensures that task h is assigned before task i. Constraints (8) and (9) become active when tasks $h$and i do not have any precedence relationship and are assigned on the same station (j,k). If $i$is assigned earlier than p, then constraint (8) become $\mathrm{st_{mh}} - \mathrm{st_{mi}} \geq \mathrm{t_{mi}}$; if not, then constraint (9) becomes $\mathrm{st_{mi}} - \mathrm{st_{mh}} \geq \mathrm{t_{mh}}$.Constraint (10) ensures the assignment of a task on same station for all the models. Constraints (11) to (14) are the binary constraints constraint (15) ensures that the starting time of any task is a positive integer.

IV. Solution Approach and Results

a) Benchmark Problem

In this section benchmark problem data [2] is used to solve the mixed model two-sided assembly line balancing problem (MTALB) problem as depicted in the appendix. Table (A,B,C) in appendix represents data of problem P(9), P(12), P(16) with their preferred side (Left, Right and Either). Further, it shows task processing time for both the models A and B and immediate predecessors of a task.

b) Computational Results

In this paper, MTALBP is solved by LINGO 17 solver. Calculate theoretical minimum number of stations by the formula mentioned below:

$$Theoretical\ minimum\ number\ of\ station = [\frac{Total\ task\ time}{cycle\ time}]^{+}$$

where $[X]^{+}$ denotes the smallest integer greater than or equals to X.

Here we are taking the maximum value of task for model A and model B in the calculation of total task time and cycle time is 3 for problem P(9) and P(12) and cycle time is 10 for problem P(16).

$$Theoretical\ minimum\ number\ of\ station\ P(9) Problem = [\frac{19}{3}]^{+} = 7$$

$$Theoretical\ minimum\ number\ of\ station\ P(12) Problem = [\frac{28}{3}]^{+} = 10$$

$$Theoretical\ minimum\ number\ of\ station\ P(16) Problem = [\frac{98}{10}]^{+} = 10$$

In figure 2, there are four mated stations in the optimal solution. In P(9) problem tasks, 1 are assigned to left side mated-station for model 1 and model 2 on the other hand task 2,3 are assigned to the right side of mated-station for model 1 and model 2.

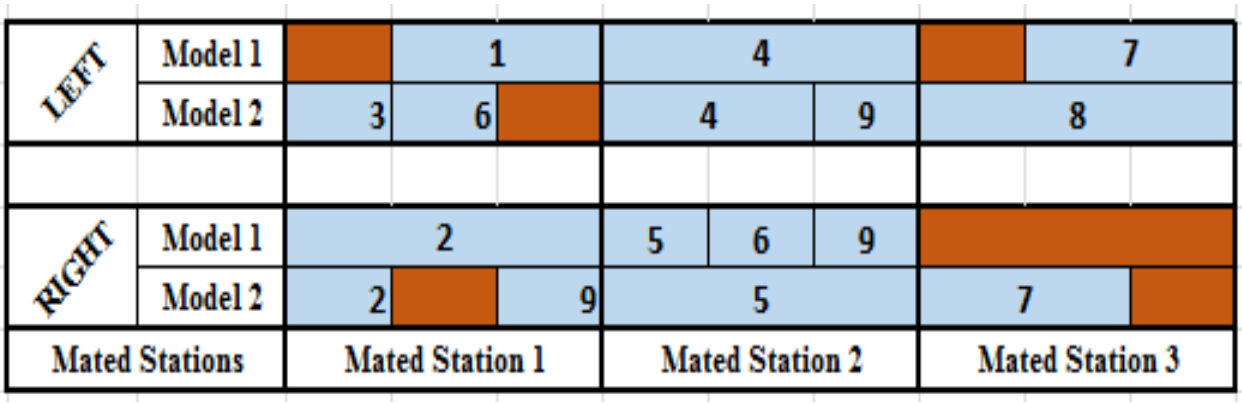

Fig. 2: Optimal task assignment of station oriented P(9) problem

Figure 3 indicates that in P(12) problem there are five mated stations in the optimal solution and idle time for the left side and right side mated-station is very less. Idle time is rearranging at the end of the process without violating precedence relationship.

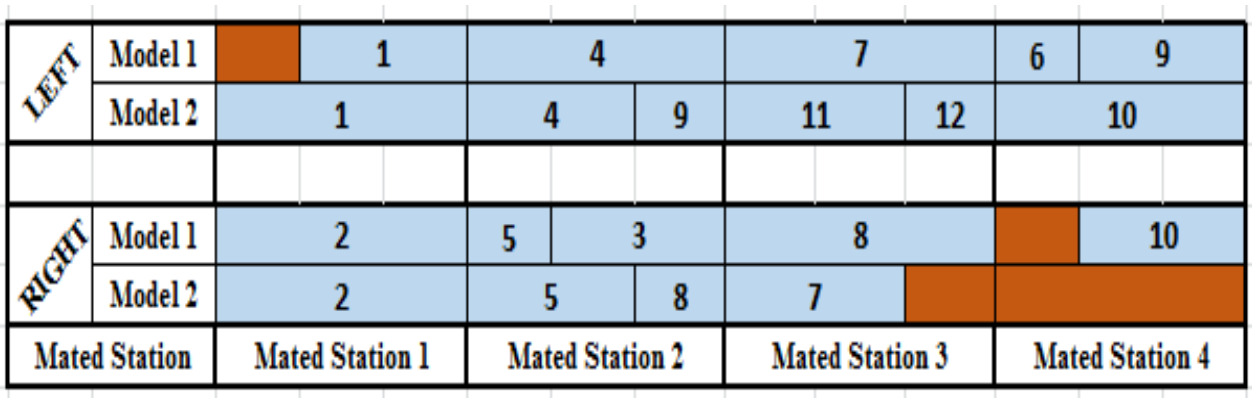

Fig. 3: Optimal task assignment of station oriented P(12) problem

Similarly, figure 4 indicate that in P(16) problem there are five mated stations in the optimal solution.

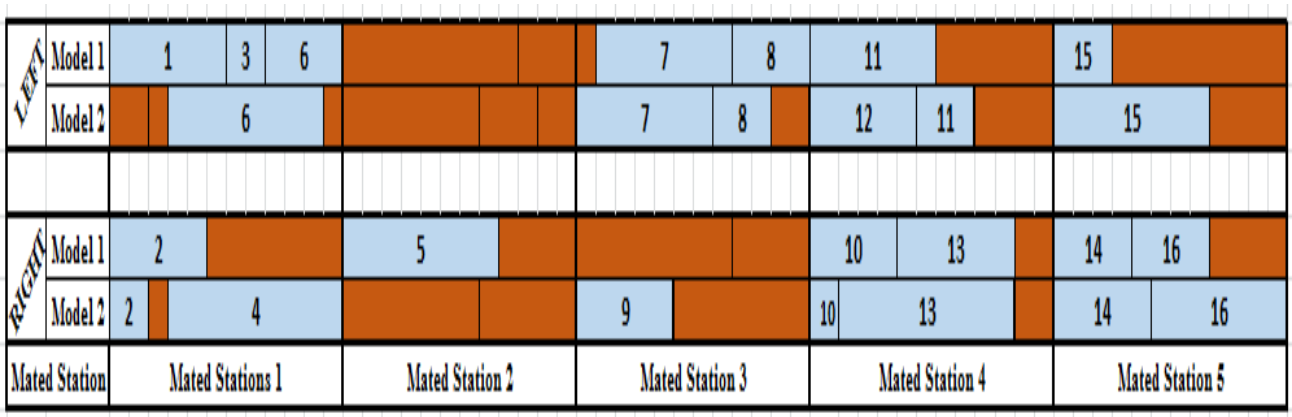

Fig. 4: Optimal task assignment of station oriented P(16) problem

Table 1: Computational result of problems

S. N.	Mated Station	Single Station	P(9)	P(12)	P(16)
			Task Assigned	Task Assigned	Task Assigned
1	1	1 2	1,3,6 2,9	1 2	1,2,3,6 2,4
2	2	1 2	4 5,6,9	4,9 5,3,8	8 5,7,9
3	3	1 2	7,8 7	7,11,12 8,7	7,8,11,12 10,13
4	4	1 2	- -	6,9,10 10	13,14,16 11,14,15
5	5	1 2	- -	- -	- 15
Total no. of mated station			3	4	5
Total no. of a single station			6	8	9
Theoretical minimum number of stations			7	10	10
Computational time without boundary conditions Computational time with boundary conditions			00:10:04 00:00:01	00:23:09 00:02:01	22:57:35 00:21:33

Table 1 is the summary result for benchmark problem that indicates task assignment in Problem P(9), P(12), P(16) for mated stations and single stations and indicate computational time are less with boundary conditions. Theoretical minimum number of stations is higher as compared to the total number of a single station for MTALB benchmark problem.

Table 2. Indicate that the efficiency of MTALB for problem P (9) is 61.90 % for model 1and 52.38% for model 2.

Table 2: Efficiency for MTALB problems

Efficiency (%)	Model 1	Model 2
P9	61.90	52.38
P12	81.48	74.07
P16	62.04	62.04

V. Conclusions and Future Research

In this paper, a new mathematical model for solving the mixed model two-sided assembly line balancing station oriented objective approach with lower and upper bound is represented. Here lower and upper bounds for the assignment of a task reduce computational time as compared to without lower and upper bounds.

An illustrative benchmark problem P(9), P(12), P(16) is solved using the proposed approach, and a numerical experiment is conducted to demonstrate the efficiency of the proposed approach. Solutions obtained by LINGO-17 solver for station oriented objective with bounds and theoretical minimum number of stations are evaluated. The experimental results show that the proposed approach obtains good solutions within a short computational time for every test problem.

In future mixed model, two-sided assembly line balancing can be developed for stochastic approach and meta-heuristic, such as tabu search algorithm and simulated annealing algorithm, ant colony optimization algorithm can be applied to solve mixed model two-sided assembly line balancing problem based on station oriented objective with lower and upper bound.

References Références Referencias

1. Simaria A S, Vilarinho P M. 2-ANTBAL: an ant colony optimization algorithm for balancing two-sided assembly lines. Computer & Industrial Engineering, 56 (2) (2009) 489–506.
2. Ozcan U, Toklu B. Balancing of mixed-model two-sided assembly lines. Computer & Industrial Engineering, 57 (2009) 217–27.
3. Chutima P, Chimklai P. Multi-objective two-sided mixed-model assembly line balancing using particle swarm optimization with negative knowledge. Computer & Industrial Engineering, 62 (1) (2012) 39–55.
4. Aghajani M, Ghodsi R, Javadi B. Balancing of robotic mixed-model two-sided assembly line with robot setup times International Journal of Advanced Manufacturing Technology, 74 (5) (2014) 1005–16.

5. Rabbani, M., Moghaddam, M., Manavizadeh N. Balancing of mixed-model two-sided assembly lines with multiple U-shaped layouts. International Journal of Advanced Manufacturing Technology, 59 (12) (2012) 1191–1210.
6. Kucukkoc I, Zhang D Z. Simultaneous balancing and sequencing of mixed-model parallel two-sided assembly lines. International Journal of Production Research, 52 (12) (2014) 3665–87.
7. Kucukkoc I, Zhang D Z. Mathematical model and agent-based solution approach for the simultaneous balancing and sequencing of mixed-model parallel two-sided assembly lines International Journal of Production Economics, 158 (2014) 314–33.
8. Yuan B, Zhang C-Y, Shao X-Y, Jiang Z-B. An effective hybrid honey bee mating optimization algorithm for balancing mixed-model two-sided assembly lines. Computer & Operation Research, 53 (2015) 32–41.
9. Zhang D. Z., KucukkocI., Karaoglan A. D. Rebalancing of mixed-model two-sided assembly lines with incompatible task groups: an industrial case study.46th International Conference on Computers & Industrial Engineering, China, (2016) 29–31.
10. Zhang D., C. Tian, Shao X., Li Z. Multi objective program and hybrid imperialist competitive algorithm for the mixed-model two-sided assembly lines subject to multiple constraints. IEEE Transaction System Manufacturing Cybernetics, 99(2016) 1–11.
11. Kucukkoc I. Multi-objective Optimization of Mixed-model Two-sided Assembly Lines – A Case Study. International Conference on Computer Science and Engineering 58 (2016) 21–27.
12. Kucukkoc I., Zhang D. Z., Mixed-model parallel two-sided assembly line balancing problem: A flexible agent-based ant colony optimization approach. Computer & Industrial Engineering 97 (2016) 58–72.
13. Delice Y, Aydogan E K, Ozcan U, Ilkay M S. A modified particle swarm optimization algorithm to mixed-model two-sided assembly line balancing. Journal of Intelligent Manufacturing, 28 (2017) 23–36
14. Li Zixiang, Kucukkoc Ibrahim, Nilakantan J. Mukund Comprehensive review and evaluation of heuristics and meta-heuristics for two-sided assembly line balancing problem. Computer & Operation Research, 84 (2017)146–161.
15. Roshani Abdolreza, Fattahi Parviz, Roshani Abdolhassan, Salehi Mohsen & Roshani Arezoo Cost oriented two-sided assembly line balancing problem: A simulated annealing approach. International Journal of Computer Integrated Manufacturing, 25 (2012).689-715.

Appendix

Table A : Data of P(9) Problem

Task No.	Side	Processing Time Model A	Processing Time Model B	Immediate Predecessors
1	L	2	0	-
2	R	3	1	-
3	E	0	1	-
4	L	3	0	1
5	R	1	3	2
6	E	1	1	2,3
7	E	2	2	4,5
8	L	0	3	5
9	E	1	1	6

Table B: Data of P(12) Problem

Task No.	Side	Processing Time Model A	Processing Time Model B	Immediate Predecessors
1	L	2	3	-
2	R	3	3	-
3	E	2	0	-
4	L	3	2	1
5	E	1	2	2
6	L	1	0	3
7	E	3	2	4,5
8	E	3	1	5
9	E	2	1	5,6
10	E	2	3	7,8
11	E	0	2	9
12	R	0	1	11

Table C: Data of P(16) Problem

Task No.	Side	Processing Time Model A	Processing Time Model A	Immediate Predecessors
1	E	6	0	-
2	E	5	2	-
3	L	2	0	1
4	E	0	9	1,2
5	R	8	0	2
6	L	4	8	3
7	E	7	7	4,5
8	E	4	3	6,7
9	R	0	5	7
10	R	4	1	7
11	E	6	3	8
12	L	0	5	9
13	E	6	9	9,10
14	E	4	5	11
15	E	3	8	11,12
16	E	4	7	13

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Implementation of Control Chart for Statistical Process Control Considering Temperature and Humidity Effect in Synthetic Staple Fiber Industry

By Abu Md. Saifuddoha & Md. Saiful Islam
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Abstract- The purpose of this paper is to identify various fluctuations of temperature and humidity effecting synthetic staple fibers quality such as strength and tenacity as a final finished product and address these fluctuations effect through implementation of control chart for establishing statistical process control over synthetic fiber production process. Critical observations and test results are analyzed to show that temperature and humidity effect over synthetic staple fiber quality such as strength and tenacity. Establishing statistical process control in the synthetic staple fiber-processing sector is one key to improving the quality of synthetic staple fiber sector considering temperature and humidity effect. The resultant variations and fluctuations are addressed through categorizing various kinds of fiber by implementing control chart. The paper addresses the fluctuations and variations of synthetic fiber quality such as strength and tenacity due to temperature and humidity effect in the production processing of synthetic fiber industry, using control chart as an approach to solve these variations which was hardly attempted before. Strength and tenacity individually prioritized to reduce fluctuations into the entire production process system.

GJRE-G Classification: *FOR Code: 290502*

Implementation of Control Chart for Statistical Process Control Considering Temperature and Humidity Effect in Synthetic Staple Fiber Industry

Abu Md. Saifuddoha [α] & Md. Saiful Islam [σ]

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I. Introduction

The manufacture of synthetic fibers represents a huge industry, both in the Bangladesh and worldwide. In the twenty first century, the dollar value of synthetic fibers was roughly $100 billion in the worldwide. We sometimes forget how much of these fibers we consume, especially since the appeal of "natural" fibers of cotton and wool has grown in recent years. Despite questions of aesthetics and taste, there should continue to be a significant demand for synthetic fibers, in large part because these fibers can be tailor-made to provide specific properties that natural fibers cannot provide.

Statistical methods play a vital role in the quality improvement process in manufacturing and service industries. Control charts are used to check for process stability. In this context, a process is said to be "in statistical control" if the probability distribution representing the quality characteristic is constant over time. If there is some change over time in this distribution, the process is said to be "out of control."

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As students of production engineering, we are interested in implementing control chart to improve synthetic fibers quality because the process involves several fundamental aspects of production and quality control engineering. The goal here to address the fluctuations and variations of synthetic fiber quality such as strength and tenacity due to temperature and humidity effect in the production processing of synthetic fiber industry, using control chart as an approach to solve these variations which was hardly attempted before.

II. Synthetic Fiber Manufacturing

True synthetics are products of the polymerization of smaller chemical units into long-chain molecular polymers. Fibers are formed by forcing a viscous fluid or solution of the polymer through the small orifices of a spinneret and immediately solidifying or precipitating the resulting filaments. Synthetic fibers are produced typically by two easily distinguishable methods, melt spinning and solvent spinning. [1]

For the common spinning of filaments in the finished range of about 0.1 – 2 tex spinnerets of a diameter 0.1-0.7 mm for melt spinning. Melt spinning is done for most polymers (PET, PP) between 240°C and 320°C. [2]

Polyester fiber spinning is done almost exclusively with extruders, which feed the molten polymer under pressure through the spinnerets. Filament solidification is induced by blowing the filaments with cold air at the top of the spin cell. The filaments are then led down the spin cell through a fiber finishing application, from which they are gathered into tow, hauled off, and coiled into spinning cans. Depending on the desired product, post-spinning operations vary but may include lubrication, drawing, crimping, heat setting, and stapling. [1][3]

a) Synthetic Fiber Measurement

Various units are used to refer to the measurement of a fiber, such as: the denier and tex (linear mass density of fibers), super S (fineness of wool fiber), worsted count, woollen count, cotton count (or Number English Ne), Number metric (Nm) and yield (the reciprocal of denier and tex). [4]

Denier /'or den (abbreviated D), a unit of measure for the linear mass density of fibers, is defined as the mass in grams per 9000 meters. The denier is based on a natural reference: a single strand of silk is approximately one denier; a 9000-meter strand of silk weighs about one gram.

Denier = (weight of fiber ×9000) ÷ (number of fiber× length of fiber) (1)

Tex is a unit of measure for the linear mass density of fibers, yarns and thread and is defined as the mass in grams per 1000 meters. The unit code is "tex". When measuring objects that consist of multiple fibers, the term "filament tex" is sometimes used, referring to the mass in grams per 1000 meters of a single filament. Tex is used for measuring fiber size in many products, including cigarette filters, optical cable, yarn and fabric. [5]

$$\text{Tex} = \text{Denier} \div 9 \quad (2)$$

b) Temperature and Humidity Effect during Polypropylene Spinning

The rate of crystallization depends on the molecular weight, the history of the PP melt, and the temperature and humidity. In the Spinneret capillary there is a minor pre orientation. The major portion of the orientation is created from the outside filament portion that solidifies first in the border phase between the liquid inside portion and the solidified filament portion. [2] The temperature effect can described below:

- A hot shroud below the spinneret lengthens the freezing zone, delays the filament thinning and cooling, and increases the yarn tension.
- Cooler quench air and/or higher quench air velocity result in faster filament thinning and higher yarn tension.
- Higher spinneret temperatures result in higher yarn temperatures along the first part of the filament axis, reduce the yarn tension.
- Higher throughputs per spinneret with constant take-up speed increase the cooling time and cooling zone with little influence on the yarn tension.

c) Case Study

The temperature and humidity effect during polypropylene (pp) spinning is studied at a synthetic fiber manufacturing company named Dird Polytex Limited. Here, the tenacity of the PP fiber increases due to lower temperature and humidity during winter from October to March and the tenacity of the PP fiber decreases due to higher temperature and humidity during summer from April to September. The data was taken from July, 2014 to May, 2015 of average monthly temperature, humidity and tenacity.

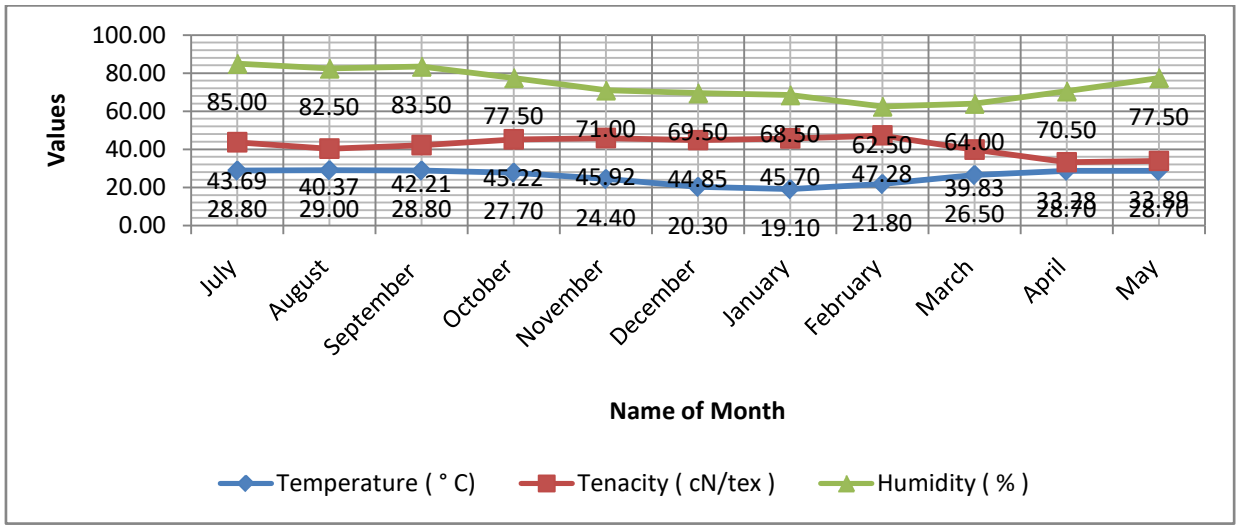

Figure 1: Temperature and humidity effect over PP fiber tenacity.

III. Control Chart

Control chart is graphical representation of the collected information. A control chart indicates whether a process is in control or out of control. It determines processes variability and detects unusual variations taking place in a process. It provides information about the selection of process and setting of tolerance limits. There are two types of control charts. They are variable and attribute chart. Variable charts involve the measurement of the job dimensions whereas an attribute chart only differentiates between a defective item and a non-defective item. [6]

a) X-bar and R chart

X-bar and R chart is one kind of variable chart. X-bar chart shows changes in process and is affected by changes in process variability. R chart secures information in establishing or modifying processes, inspection procedures. X-bar and R-bar chart when

used together form a powerful instrument for diagnosing quality problems. [6]

$\overline{X} = (\sum(\underline{X1}, \underline{X2} \ldots . \underline{Xn}))/n$, n is the number of observations (3)

$\overline{X} = (\sum(\underline{X1}, \underline{X2} \ldots . \underline{Xk}))/k$, k is the number of subgroups (4)

$$UCL_X = \overline{\overline{X}} + A_2 \times R \quad (5)$$

$$LCL_X = \overline{\overline{X}} - A_2 \times \overline{R} \quad (6)$$

$$Range = X_{max} - X_{min} \quad (7)$$

$\overline{R} = (\sum(R1, R2 \ldots . Rk))/k$, k is the number of subgroups (8)

$$UCL_R = D_4 \times R \quad (9)$$

$$LCL_R = D_3 \times R \quad (10)$$

b) Case Study of Control Chart Implementation

i. *Synthetic Fiber Company*

Here, Table 1 shows monthly tenacity value of PP white fiber which has been recorded and among them randomly eight days value have been taken for implementation of x-bar and r chart.

Table 1: PP fiber tenacity result for eight days and calculation of x double bar and r bar through equation 3, 4, 7, 8.

Month	Tenacity (cN/tex)									
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	X Bar	Range
July,14	39.49	47.66	46.91	38.33	45.22	42.71	43.75	45.44	43.69	7.11
August,14	37.73	42.89	35.17	36.62	38.72	42.81	45.41	43.62	40.37	8.79
September ,14	36.1	39.05	43.37	43.93	44.94	37.38	43.27	43.54	41.45	8.84
October,14	42.64	45.29	42.88	46.28	47.61	43.73	48.95	41.79	44.90	5.82
November,14	41.25	48.77	42.86	45.00	43.18	45.98	50.22	45.41	45.33	8.97
December,14	45.77	40.03	43.24	44.96	49.56	44.34	43.49	48.31	44.96	9.53
January,15	45.69	41.41	49.25	45.93	46.51	49.97	45.44	41.41	45.70	8.56
February,15	49.47	46.45	55.17	49.93	48.92	43.46	45.22	41.79	47.55	13.38
March,15	44.38	39.45	37.39	38.62	43.33	38.48	38.02	38.93	39.83	6.99
April,15	35.94	26.69	31.06	29.14	30.4	32.6	39.62	40.78	33.28	14.09
May,15	31.78	34.3	34.3	36.43	34.1	34.23	29.64	36.3	33.89	6.79
									X Double Bar	R Bar
									44.29	8.79

Table 2: Resultant value of x bar and r chart using previous formula of equation 5, 6, 9, 10.

Bar Chart Type	Description	Formula
X bar	Upper Control Limit	46.80
	Upper Warning Limit	45.96
	Lower Warning Limit	42.62
	Lower Control Limit	41.79
Range	Upper Control Limit	10.53
	Lower Control Limit	8.53

[1]Warning limit is the two third portion of the corresponding control limit.

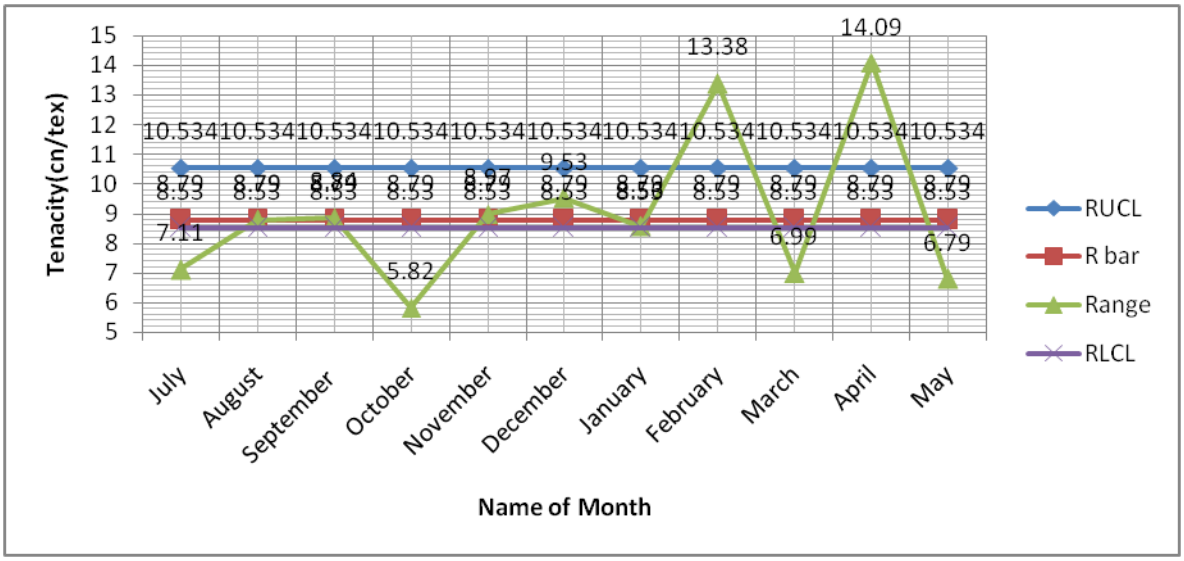

Figure 2: X-bar chart for monthly average PP fiber tenacity.

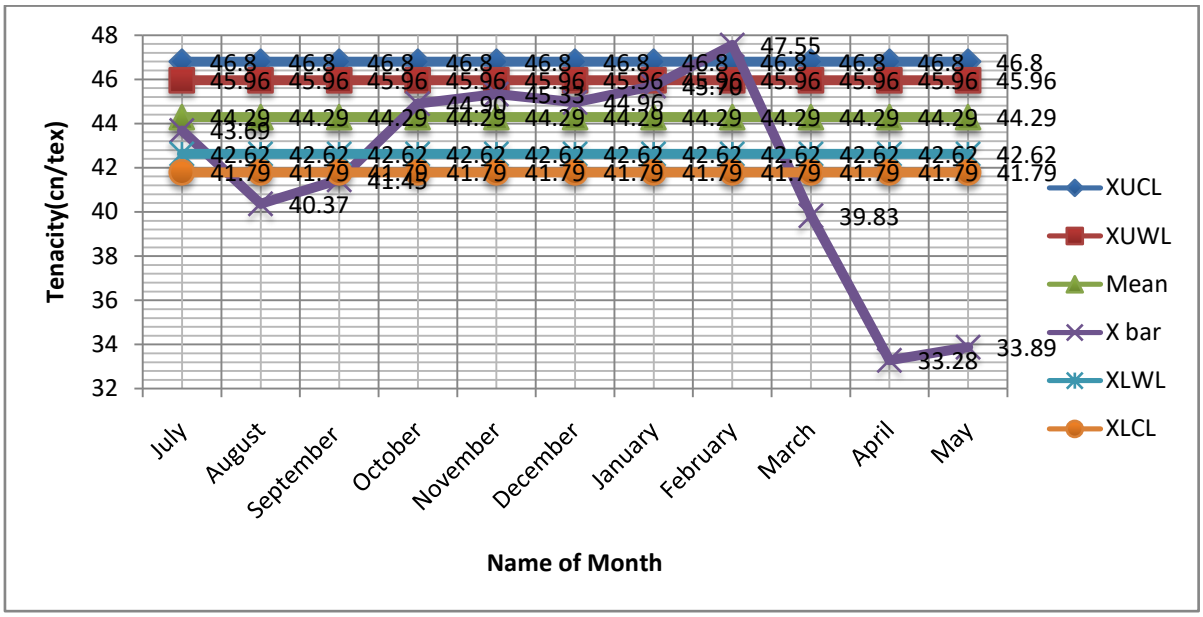

Figure 3: R chart of PP fiber tenacity.

IV. Result Analysis

Here fig. 2 and 3 depict x bar and r chart in which fig. 2 shows 4 points below lower limit and 1 point above upper limit and fig. 3 shows 4 points below lower limit and 2 points above upper limit. That means both x bar and r chart shows the process is out of control.

As the corresponding figure shows the process is out of control, this happens due to variation of temperature and humidity across the year 2014-15. The weather phenomena cannot be controlled so to solve this problem. A proper grading system is developed for different quality fibers in table 3 according to the x bar chart.

Table 3: A grading system of fiber quality.

Fiber Quality Limit	Tenacity(cn/tex)	Fiber Grade	Fiber Quality
Above upper limit	>46.8	A	Very Good
Between upper warning limit to upper limit	45.96-46.8	B	Good
Between upper warning limit and mean	44.29-45.96	C	Average
Between mean to lower warning limit	42.62-44.29	D	Below Average
Between lower warning limit to lower limit	41.79-42.62	E	Bad
Below lower limit	<41.79	F	Very Bad

V. Conclusion

There is significant effect of temperature and humidity over synthetic staple fiber production process. Control chart is applied to categorize various kinds of synthetic staple fiber considering temperature and humidity effect for establishing statistical quality control over synthetic fiber production process. The paper addresses the fluctuations and variations of synthetic fiber quality such as strength and tenacity due to temperature and humidity effect in the production processing of synthetic fiber industry.

APPENDIX.A

Tabular values for X-bar and range charts

Subgroup Size	A_2	d_2	D_3	D_4
2	1.880	1.128	-----	3.268
3	1.023	1.693	-----	2.574
4	0.729	2.059	-----	2.282
5	0.577	2.326	-----	2.114
6	0.483	2.534	-----	2.004
7	0.419	2.704	0.076	1.924
8	0.373	2.847	0.136	1.864
9	0.337	2.970	0.184	1.816
10	0.308	3.078	0.223	1.777
11	0.285	3.173	0.256	1.744
12	0.266	3.258	0.283	1.717
13	0.249	3.336	0.307	1.693
14	0.235	3.407	0.328	1.672
15	0.223	3.472	0.347	1.653
16	0.212	3.532	0.363	1.637
17	0.203	3.588	0.378	1.622
18	0.194	3.640	0.391	1.608
19	0.187	3.689	0.403	1.597
20	0.180	3.735	0.415	1.585
21	0.173	3.778	0.425	1.575
22	0.167	3.819	0.434	1.566
23	0.162	3.858	0.443	1.557
24	0.157	3.895	0.451	1.548
25	0.153	3.931	0.459	1.541

References Références Referencias

1. "Fibers 540.000", Chemical Economics Handbook, Menlo Park, C A, March 1978.
2. Franz Fourne, Synthetic fibers, Munich: Hanser; Cincinnati : Hanser/Gardner, 1998.
3. Industrial Process Profiles For Environmental Use - Chapter 11 - The Synthetic Fiber Industry, EPA Contract No. 68-02-1310, Aeronautical Research Associates of Princeton, Princeton, N J, November 1976.
4. Haynes, Williams (1946). "XVII: New Fibres: New Fabrics". This Chemical Age. London: Secker and Warburg. p. 217.
5. Collier, Ann M (1970), A Handbook of Textiles, Pergamon Press, p. 258, ISBN 0-08-018057-4, ISBN 0-08-018056-6, retrieved January 2009.
6. Foster, S. Thomas. Managing Quality. Upper Saddle River: Prentice Hall, Inc. 2001.

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Application of Mineral Admixture in High Performance Concrete

By Shan Wu
Southeast University

Abstract- Mineral admixture is a key material component in high performance concrete. With the low water cement ratio, mineral admixture is of advantages: Increase later strength of concrete, reduce the hydration heat, enhance the compactness of concrete internal structure, improve the corrosion resistance and wear resistance, and decrease carbon dioxide emissions, so as to achieve rational utilization of resource and energy conservation and emission reduction under the new situation, and meet the economic and environmental requirement. In recent years, high performance concrete has been applied and popularized in practical engineering, which shows the superiority of using mineral admixtures to replace cement, and summarizes the practical engineering experience.

Keywords: mineral admixture; high performance concrete; compressive strength; durability.

GJRE-G Classification: FOR Code: 290502p, 090599

Strictly as per the compliance and regulations of:

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Keywords: mineral admixture; high performance concrete; compressive strength; durability.

I. Introduction

At present, the total consumption of commercial concrete in our country has reached 2.5 billion m^3 per year, and the output of cement has reached 2.6 billion tons, ranking first in the world for 20 consecutive years. So, china is a country with great cement production and concrete consumption. A large amount of CO_2 greenhouse gases (about 1.8 billion tons) are emitted in the cement production process, and industrial residues and wastes from iron and steel, electric power and geological and mineral industries in China amount to 1.05 billion tons annually, while the average utilization rate in concrete is less than 10%. Concrete industry has entered a new stage to reduce the consumption of energy and natural resources, improve the service life of concrete structures and reduce maintenance and repair costs. The energy conservation and emission reduction of concrete should first be reflected in the reduction of cement consumption, which needs to use all kinds of waste residue discharged every year to replace the cement with high energy consumption and high discharge in the production process. Rational application of mineral admixtures not only has achieved direct results in energy conservation and emission reduction, but has played an important role in promoting the development of high strength and performance concrete. Mineral admixtures can improve the micro-porous structure of concrete and the interface conditions between binder conditions between binder and aggregate. Thus, under the same water-binder ratio, the fluidity and late strength of concrete can be improved, the hydration temperature can be reduced, the shrinkage can be increased, and the volume stability of concrete can be enhanced. The concrete strength, impermeability, corrosion resistance and other durability indicators have been significantly improved, which plays a fundamental role in changing the conventional concrete performance. [1]

a) *High performance concrete and high strength and performance concrete*

High performance is a new requirement for concrete at an international conference in 1990. High performance concrete is also a basic direction of concrete technology development in the future. There are different definitions of high performance concrete at home and abroad, but they can be summarized as the following five aspects: (1) High durability. It is of long service life and small maintenance cost under normal service condition. Under special service conditions, it can meet the special requirements of anti-erosion, anti-freeze and thaw resistance in harsh environment. (2) High construction performance. It can smoothly complete the transportation and pouring of concrete under specific construction conditions, so that the concrete structure with superior compactness and uniformity can be obtained; (3) Higher strength. It is able to satisfy the strength requirement of design bearing capacity, and has enough capacity to increase strength in the later period to ensure that the strength of structural concrete does not shrink under normal conditions; (4) High volume stability. Concrete is not stratified and segregated before condensation, and its volume changes little after hardening, with good crack resistance; [2] (5) It can meet the requirements of environmental protection and sustainable development.

Of the above requirements, many are related to the compactness of concrete. Therefore, many materials take the relative index of measuring concrete compactness - chloride ion penetration resistance as an index to classify and test high performance concrete. High strength and performance concrete refers to high performance concrete whose strength grade is greater than or equal to C60.

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b) Main technical approach of preparing high performance concrete

1) Using high-quality mineral admixtures with large amount is the technical core of preparing high performance concrete. Because high performance concrete requires high compactness, and it is difficult to meet such requirements with a single cement as binding material. High-quality mineral admixtures must be used to repair and fill various micro-cracks in concrete by secondary hydration in the later stage. Practice in many units in our country shows that to prepare qualified high performance concrete, the mineral admixture content should reach at least 30%, and it is better to use it in combination. A large amount of concrete mixed with mineral admixtures also meets the requirements of environmental protection and sustainable development, as well as the basic condition for the preparation of green concrete. If the durability requirement of concrete is very high, a small amount of silica fume (3-5%) can also be added into concrete. For the silica fume's particles are very fine, it can infiltrate into the capillary pore of cement paste, and then carry out secondary hydration. In addition, its densification effect is very significant.
2) Low water-binder ratio is adopted. The high durability formed by high content of mineral admixtures can only be shown when concrete adopts low water-binder ratio, otherwise it may be counterproductive. For the limitation of low water-binder ratio, the current standards are different and generally less than or equal to 0.35-0.45, which may be related to the different scope of application for the standards. High content of mineral admixtures and low water-binder ratio should be two matching technical approaches.
3) To achieve high content of mineral admixtures and low water-binder ratio, water reducing agent with high quality and high efficiency is certainly required. Polycarboxylic water reducing agent developed and popularized in recent years is an ideal material, which not only has high water reducing rate and good plasticity retention, but the shrinkage of the concrete made by it is significantly lower than that of the concrete prepared with other types of water reducing agents, which can significantly improve the crack resistance of concrete.
4) In addition to the above special requirements, the selection of raw materials, mix design and production control of concrete should be strictly carried out in accordance with the requirements of the standards.

c) Effect of mineral admixture in high performance concrete

i. *Enhancement effect*

When mineral admixtures are added, the composition of cement paste's gelatinous substance can be improved; especially the free lime ($Ca(OH)_2$) can be reduced and removed. For SiO_2 in the active mineral admixture, $Ca(OH)_2$ and tobermorite with high alkaline can react pozzolanic reaction, which can produce tobermorite with low alkaline, higher strength and better stability.

ii. *Filling effect*

The average particle size of cement is 20-30 microns, while the average particle size of fly ash is 3-6 microns, and the silica fume is smaller than both of them, which is between 0.1-0.26 microns. It can fully fill the gap between the cement particles, so that the compressive strength and permeability performance are significantly improved. Close concrete prevents moisture from entering the interior of concrete. Freezing water in concrete is very scarce. Therefore, under the condition of freeze-thaw alternation, the frost resistance of concrete is greatly improved.

iii. *Reduction of hydration temperature peak effect*

After adding mineral admixtures, the amount of cement in concrete is reduced, so the calorific value of cement hydration in concrete is reduced. Although these active mineral admixtures will produce pozzolanic reaction and release hydration heat in concrete, this reaction lags behind the hydration reaction of the main body of cement and lasts a long time. This can restrain the early strength of concrete, but the later strength will not decrease.

iv. *Improvement effect of concrete durability*

1. Improve impermeability: The structure of cement paste and the interface between cement paste and aggregate are more compact, blocking the possible permeability pathway. 2. Reduce the harmfulness of alkali aggregate reaction: Due to the incorporation of mineral admixture, a large amount of calcium silicate gel with low alkalinity is formed in concrete hydrates. They can absorb and maintain large amounts of Na+ and K+ ions, thus greatly reducing the effective alkali content in solution of concrete pore. Therefore, the harmfulness of alkali aggregate reaction is greatly reduced. 3. Improve frost resistance: When water can't enter the concrete, the frozen water in concrete is very scarce. Therefore, under the condition of freeze-thaw alternation, the frost resistance of concrete is greatly improved.

v. *Relation of high fly ash content and reduction of alkalinity*

The possible negative effect of adding active mineral admixtures makes the alkalinity of concrete, the carbonization resistance of concrete, and the ability of protecting steel bar decrease. But the decline rate of

concrete alkalinity is not very fast. The research of Pu Xincheng and his students on the alkalinity of cement with large amount of fly ash shows that the PH values of fly ash are 12.56, 12.50, 12.46, 12.24, 12.15 and 12.06 respectively when the content of fly ash is 0%, 30%, 40%, 50%, 60% and 70%, which indicates that even if the content of fly ash reaches 70%, the PH value of cement mortar is still above 12, which is still higher than the lowest alkalinity value for reinforcement structure: 11.50. [3] When slag and other admixtures with high CaO content are added, their alkalinity is more guaranteed. The addition of active mineral admixtures improves the compactness of high performance concrete. Moisture, even O_2 and CO_2, are difficult to enter concrete, which also increases the ability of concrete to protect steel bar from erosion.

d) Green high performance concrete

1. More clinker cement is saved and environmental pollution is reduced. Because a large number of industrial residues are used for high performance concrete as active mineral admixture to replace a large number of cement, and these fine water-quenched slag and high-quality fly ash, silica fume or their composite materials become the main components of binding materials. Compared with the production of clinker cement, the emission of CO_2 is greatly reduced, and resources and energy are also saved.
2. Adding more active mineral admixtures (mainly industrial waste) is of advantages of improving the environment, saving land and limestone resources and energy, reducing the hydration temperature rise of concrete, and enhancing the volume stability and wear resistance.
3. Give full play to the advantages of high performance and reduce the amount of cement and concrete. By reducing the environmental burden fundamentally, concrete can become a sustainable building material as the largest artificial material in the contemporary era. It is the direction of concrete development and the future perspective of concrete.

Table 1: High strength and performance concretef increases with age

No.	Project Name and Age Limit	The Strength of Concrete Increases with Age				
		mf 28 (MPa)	mf 360 (MPa)	mf 5 years (MPa)	mf 10 years (MPa)	mf 14 years (MPa)
1	(Shenyang) Daxi Electric Industry Park In 1998	100.97	108.64	115.09	123.3	135.6
2	Shenyang Royal Wan Xin Hotel In 2001	116.39	126.5	139.2	157.3	
3	Shanghai Tower In 2012	118.7	131.9			
4	Shenzhen Ping'an Building In 2016	117.0				

Table 2: Concrete strength in each stage

No.	Date	Concrete strength (mpa) in each stage					
		28 Days	60 Days	360 Days	5 Years	10 Years	14 Years
1	2001.5.21	96.8		110.2	115.8	119.7	129.8
2	5.22	113.5	119.1	120.0	129.9	129.1	139.3
3	5.26	100.7		110.9	112.1	122.9	129.9
4	6.7	101.0		109.9	113.0	124.6	135.0
5	6.17	104.2		107.9	109.0	120.6	138.8
6	6.27	100.2		100.8	110.5	120.9	141.1
7	7.6	90.4		100.8	115.3	125.3	135.6
Mean values		101.0	119.1	108.6	115.1	123.3	135.6
Percentage increase in strength			117.92	107.52	113.96	122.08	134.26

Note: The 5-year strength specimens obtained from 3-5 groups of mean values.

Table 3: The long-term strength of C80 concrete in Daxi Electric Industry Park

Huaneng-Xiaoyettian P II 52.5	AdmixtureZ-3	AdditiveJL118	Medium Sand of Hun River	Gravel of Liaoshang 5-25 mm
Water cement ratio0.28 500 kg/m3	70 kg/m3	4 % 22.8	813	954

II. Conclusion

At present, our scientific work should be transformed from maximizing wealth from nature to properly using resources, protecting environment and maintaining ecological balance. The development and application of high performance concrete will be the goal of several generations of workers for concrete. Now, the situation is very favorable, that is, it draws great attention from Standard Quota Department of the Ministry of Housing and Urban-Rural Construction and the Raw Materials Industry Department of the Ministry of Industry and Information Technology. The Building Material Research Institute of China Academy of Building Research has compiled *Technical Guide for the Application of High Performance Concrete*, and approved and issued *Technical Specification for the Application of Mineral Admixture* GB/T51003-2014, which has been "applied for approval for nearly eight years". Although the condition mentioned above is very good for popularization and application of high performance concrete, the measurers can't be taken hastily. At present, the quality of raw materials in various places is very poor, and it is difficult to reduce the water consumption of certain type of concrete. So, it is necessary to carry out popularization and application of high performance concrete steadfastly.

References Références Referencias

1. Xingzu Wu, Sufang Han, Laijun Lu. (Sep 2009) *Competition and development coexist with challenges and opportunities –– Looking back on the development course of concrete industry in China*. China Concrete. pp 20-24.
2. Wenjun Li. (Jul 2015) *The development and application of high performance concrete.* Architectural Engineering Technology and Design. pp 2292-2293.
3. Xincheng Pu, Yongwei Wang. (Feb 2002) *High effective and high performance active mineral admixture concrete.* Concrete. pp 3-6.

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Multivariate Analysis of Risk Factors Applied to the Study of Induced Hearing Loss due to Occupational Noise in the Industry

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Abstract- *Background:* Noise-induced hearing loss (NIHL) impacts on about 20% of inability to hear around the world, becoming an increasingly common occupational disease.

Objectives: Identify and analyze the latent variables that impact on NIHL in the workplace, finding approaches that relate the understanding of the phenomenon in the occupational context.

Methods: Application of questionnaires to 278 workers potentially exposed to occupational noise in an industry in Brazil. After, we used multivariate analysis by Pearson correlation and multiple linear regressions applied on subconstructs identified.

Keywords: *perception; noise; exposure; nihl; risk; hearing loss.*

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Abstract- Background: Noise-induced hearing loss (NIHL) impacts on about 20% of inability to hear around the world, becoming an increasingly common occupational disease.

Objectives: Identify and analyze the latent variables that impact on NIHL in the workplace, finding approaches that relate the understanding of the phenomenon in the occupational context.

Methods: Application of questionnaires to 278 workers potentially exposed to occupational noise in an industry in Brazil. After, we used multivariate analysis by Pearson correlation and multiple linear regressions applied on subconstructs identified.

Results: The dominance of cases suggestive of NIHL and significant associations ($p<0.05$) were identified and suggests risk perception and age variables as a potential factor.

Conclusions: The results contribute to a better understanding of the possible risk factors related to the development of NIHL in the industrial segment.

Keywords: perception; noise; exposure; nihl; risk; hearing loss.

I. Introduction

Approximately 30 million workers are exposed daily to high levels of sound pressure in the United States only, with the potential for real damage to health.[1] Loss hearing induced by high levels of sound pressure is the second cause of occupational disease.[2]

In 2006, only in Norway, of 3392 cases of occupational diseases reported to the government, about 59% were related to noise-induced hearing loss.[3] Checking occupational diseases most incident in Mongolia was observed the predominance of noise-induced hearing loss, a phenomenon associated with the rapid industrialization that occurred in that country.[4]

The magnitude of hearing loss would be a direct result of excessive exposure to noise, thus being dependent on several factors, among them those associated with exposure and related to the characteristics of the individual: sound pressure level (SPL), duration of exposure, type and frequency of the noise, susceptibility to damage by noise, age, history of hearing loss.[5]

Models relating labor hearing loss to the behavioral of workers, named Health Promotion Model, analyze modifying factors (behavioral characteristics) and cognitive-perceptual factors (such as perceived benefits and self-efficacy).[6] The authors indicate that this and other developed models, allow them to infer that workers must be aware of the risk of noise-induced hearing loss (NIHL), and that they can do something to prevent of this disease.

In a survey that took as sample a group of researchers in this area of occupational health and safety, noted that the notion of risk perception is socially constructed variable, being influenced by the nature of labor relations; valuesin society and individual events.[7]

Although there are some publications on occupational noise exposure, the analysis of the individual perception of the worker and its implications on his behavior remains a poorly discussed subject. Moreover, the approaches verified relating the understanding of the behavioral phenomenon to the exposure to occupational noise, need more analysis and the support of quantitative approaches of main humans factors relacteds to NIHL. This paper aims to use the technique of factor analysis as a tool for examining the variable noise-induced hearing loss, to propose actions that may contribute to the prevention and anticipation of mitigating the risk of the exposed worker.

This research started the discussion of two specific contextual proposals: (1) identification of approaches to understanding the exposure to occupational noise; (2) application of statistical to analysis of risk factors such as: perception of effects, age, safety culture, risk index and sex.

II. Methods

Across-sectional study was carried out in an industry in Brazil looking for analyze the prevalence of cases suggestive of noise-induced hearing loss (NIHL) among 278 industrial workers potentially exposed to work noise (more than 80 dB (A)) between 11/2013 and 06/2014. The research procedures verified two perspectives: Theoretical and Applied.

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a) Theoretical Research

For development of the theoretical research, there was conducted a literature search of indexed journals, seeking to identify main studies conducted in the identification of variables related to the development of noise-induced hearing loss.

The research showed that the variables related to the development of NIHL would be influenced by a lot of factors related to the individual, as well as by the social and cultural organizational system, as shown in Table 1.

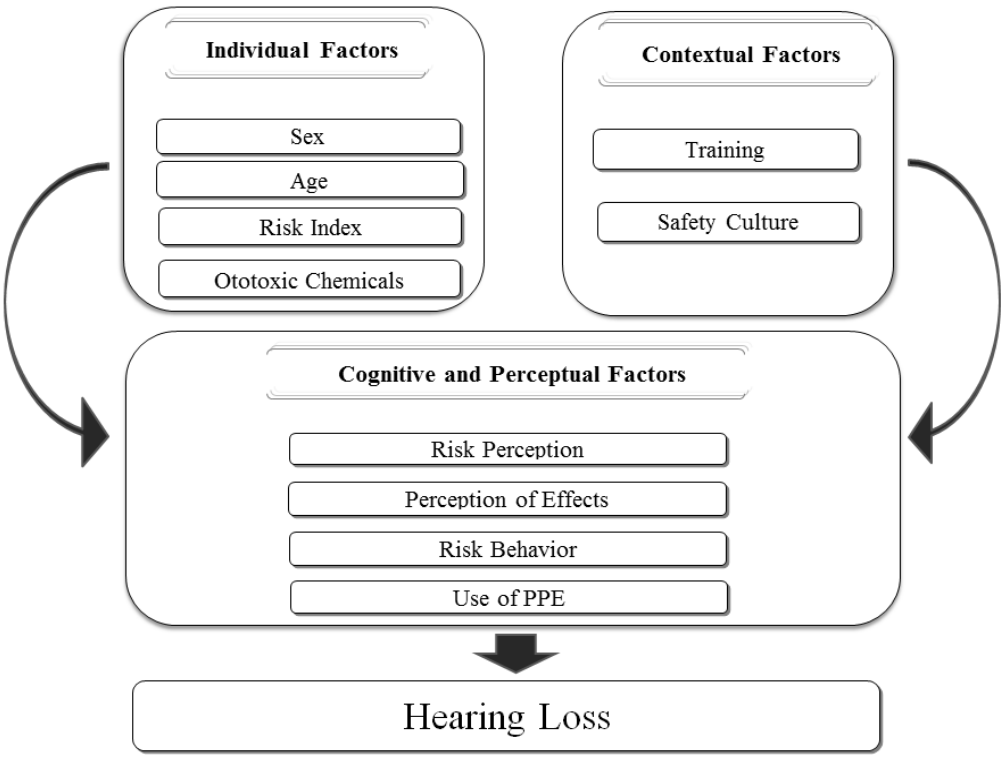
Table 1: Theoretical framework in research–NIHL

	Variables related to hearing loss due to noise exposure - NIHL																								
References	Sex	Age	Race/Ethnicity	RH ffactor	Exercise and nutrition	Fasting glucose / diabetes	Confort of PPE	Daily period in area	Risk of exposure to noise	Leq	Exposure period (years)	Training	Level of education	Safety culture	Risk perception	Perception of effects	Expect. and exploit. of results	Risk behavior	Use of PPE	Hearing loss	Training for use PPE	Discipline / Habit	Ototoxic chemicals	Alcohol use	Auditory symptoms	Extra-auditory symptoms	Occupational group
8		X						X	X	X	X					X		X		X						X	
9		X						X			X									X					X		
10		X						X	X	X		X		X	X	X		X		X							
11		X						X	X	X	X							X									X
12																				X			X				
13		X						X	X	X	X					X				X							
14		X						X	X	X	X					X	X			X			X				
15	X	X	X		X			X	X	X	X	X		X	X			X					X		X		
16		X						X	X	X					X	X		X	X	X					X		X
17	X	X						X	X	X	X	X	X	X		X		X	X	X	X				X		
18		X					X				X					X				X			X				
19	X	X						X	X	X	X				X	X		X	X	X		X			X		
20		X						X	X	X	X									X							
21		X							X	X										X			X				
22				X				X	X	X	X																
23		X							X	X				X					X	X					X		
24		X						X	X	X	X									X			X				X
25		X						X	X	X	X	X		X						X					X		
26							X		X	X		X		X	X	X		X	X	X	X						
27	X	X						X			X									X					X		
28		X						X	X	X	X	X				X				X							
29		X			X	X		X	X	X	X									X			X	X			
30		X			X			X	X	X	X												X		X		
31		X						X	X	X	X							X					X				
32		X						X	X	X	X			X						X							
33		X						X	X	X	X	X															X
34	X	X				X		X	X	X	X													X	X		
35	X	X						X	X																		
36		X																		X			X				
37	X	X						X	X		X									X							
38	X	X				X		X	X	X	X								X	X			X		X	X	
Total	**8**	**28**	**1**	**1**	**3**	**3**	**2**	**25**	**26**	**24**	**23**	**7**	**1**	**7**	**5**	**10**	**1**	**9**	**6**	**21**	**2**	**1**	**12**	**2**	**11**	**2**	**4**

Source: The author.

According to Table 1, the following subconstructs that may influence strongly in the development of NIHL was found in the literature: risk behavior, safety culture, training, sex, age, risk index, risk perception, perception of effects, hearing loss, chemicals ototoxic drugs, use of PPE.

For this research, a sustained quantitative methodology for factor analysis technique was developed, and a statistical model was adjusted to support the conceptual model.The proposed conceptual model, as shown in Figure1, is structured on the adaptation of similar models of other authors who also researched on this topic. [10,39,40]



Source: The author.

Figure 1: Conceptual model proposed

b) Applied Research

In a second stage, for the research development, data collection was performed using questionnaires, in a sample of 278 workers exposed to noise beyond the action level - defined in Brazilian law as 80 dB (A).

The self-administered questionnaires comprise the most frequently indicated version.[41]During filling, someone was available to assist in understanding the instrument, ensuring that no questions were left blank.

In research on the influence of the perception of employees on the effects of occupational health hazards was also used as an instrument of data collection a questionnaire then generating similar analysis, with the objective of further reducing the dimensionality of the data. The analysis was useful for the planning of health promotion campaigns and prioritization of other interventions.[42]

The initial questionnaire aimed to characterize the individual risk perception, consisting of questions divided into the following sections: worker´s identification (name, workplace, age, sex, marital status and education), individual risk perception and perception of noise effects, expectation and appreciation of the results of use of PPE, barriers, safety culture and risk behavior.

The second questionnaire intended to characterize the noise exposure and the use of PPE, having questions grouped into the following sections: risk exposure, exposure to ototoxic chemicals, family history of hearing loss, training in occupational health and safety/hearing loss/use of PPE, comfort, and use of PPE and audiometry.

The evaluation instrument used the Likert five-level scale, from "strongly agree" to "strongly disagree." After filling in all the 278 questionnaires, responses were converted into numbers, according to the scale, and tabulated in a spreadsheet. The answers were coded on scales from 1 (strongly disagree) to 5 (strongly agree). In some cases, the use of inverted scale was necessary, for example, for questions about barriers, physical load, and risk behavior.

In a second stage, through the environmental noise assessment of each work micro-area of all evaluated employees, was possible the characterization of daily personal exposure level. The evaluated employees were still undergoing tonal audiometric examination by ISO 8253.1 standard.

In a third stage, the model was tested and validated through multivariate statistical analysis which took into account, in addition to the construct (the development of NIHL), dependent subconstructs: risk perception; perception of effects; risk behavior and use of PPE.

Because of this study include more than two dependents subconstructs, will be used the technique of multiple regression analysis (MRA), which, using dependent subconstructs whose values are known, allows predicting a single subconstruct independently

selected.[43]Equation 1 presents the MRA adopted in this article, which aimed to:

1) maximize the overall power prediction of a group of independent subconstructs as representatives of a composition;
2) to compare two or more groups of independent subconstructs regarding the predictive power of each factor.

$$Y_1 = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_m X_m + \epsilon \qquad \text{Equation 1}$$

where
Y1: Dependent subconstruct or criterion;
Xi: Independent subconstructs or predictor;
β_i: Regression coefficients;
ϵ: Associated error;

The path analysis is an essential resource of multivariate statistics, allowing correlations between characters are split into direct and indirect effects, measuring the influence of a variable, independent of the other, on the other.

Path analysis was used to proof the conceptual model. Following the results of this analysis, the corresponding path diagram was established, as the summary presented in Figure 3. Statistical analysis was performed using IBM SPSS.

III. Results

Using the alpha (α) of Cronbach, it was possible to test the internal reliability, allowing a decrease up to 37,5% of the items. Thus, from the starting 74 questions, the technique applied in this questionnaire allowed to shorten it down to only 61 questions.

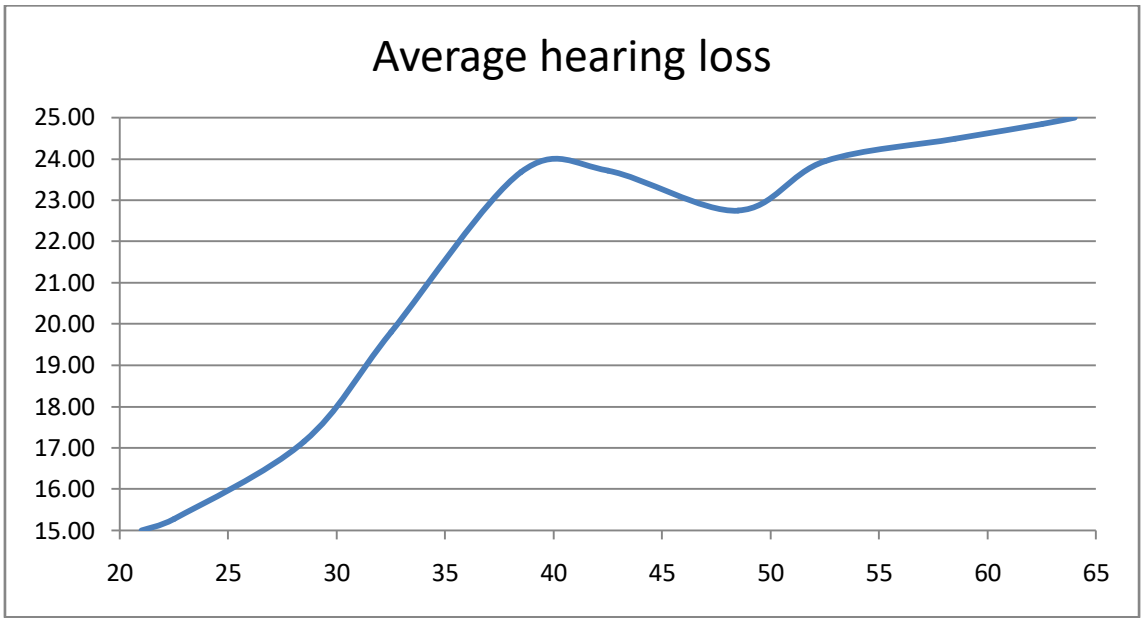
223 of the 278 employees evaluated in the sample were male and 55 were female, 147 had completed high school, 73 had incomplete graduation, and 44 had completed graduation. Table 2 shows the sample distribution between factories.

Table2: Sample distribution between factories

Factory	Total number of workers	Number of workers in the sample (N)	Number of workers in the sample (%)	Age (years)			Period of service (years)	
				Average	Standard Deviation		Average	Standard Deviation
A	689	152	22%	36,2	10,1		15,7	8,6
B	516	63	12%	42,9	9,2		3,3	4,8
C	153	20	13%	48,2	11,1		8,2	11,6
D	225	43	19%	42,6	8,9		7,9	9,5
Total	*1583*	*278*	*18%*	*39,6*	*9,2*		*11,1*	*1,5*

Source: The author.

The estimated average hearing losses versus age, in the sample, may be observed in Figure 2, where the increase of hearing loss due to the aging of the population, by presbycusis, can be evidenced.



source: The author.

Figure 2: Average hearing loss in the sample (age [years] versus loss [dB])

The questionnaire also asked about the period of use and comfort of hearing protection equipment, aiming to quantify the subconstruct *Use of PPE*, in this case particularly the hearing protector was considered - due to the focus of the study on NIHL. As provided in table 5, of 278 evaluated employees, the vast majority - 261 - reported using such equipment, and on average used their hearing protectors around 90% of the journey. The standard deviation was close to 18 points, featuring a small oscillation of the answers.

From 261 people who reported using hearing protection, there was a divergence of habits between the sexes of 4% of usage time and 6% in the proportion. Chi-square test for equality has the value of 0,0976. Threshold for rejecting the hypothesis of equality at the 5% value is 3,84, one cannot drop the hypothesis of no difference between men and women in the PPE use.

a) Statistical Analysis

Through the Pearson correlation coefficient matrix, shown in Table 3, it was possible to analyze the correlation between the subconstructs inspect.

The correlation shows the linear relationship between two variables, where values will always be between -1 and +1. The sign indicates the direction and the size of the variable specify the strength of the correlation. An amount above 0,7 module is a strong correlation. Thus, variables with a rejected hypothesis of null relation at 5% level were considered significantly correlated.

Table 3: Matrix of Pearson correlation coefficients between subconstructs

Correlations

Subconstructs		Sex	Age	Risk Index	Ototoxic Chemicals	Training	Safety Culture	Risk Perception	Perception of Effects	Risk Behavior	Use of PPE	Hearing Loss
Sex	Pearson Correlation	1	-,062	-,142*	,011	,032	,010	-,213**	-,082	-,028	,093	-,126*
	Sig. (2-tailed)		,314	,021	,865	,602	,872	,000	,183	,648	,145	,041
	N	264	264	264	264	264	264	264	264	264	248	264
Age	Pearson Correlation	-,062	1	,428**	,142*	-,012	,251**	-,203**	,165**	-,034	-,116	,330**
	Sig. (2-tailed)	,314		,000	,021	,841	,000	,001	,007	,587	,067	,000
	N	264	264	264	264	264	264	264	264	264	248	264
Risk Index	Pearson Correlation	-,142*	,428**	1	,263**	,108	0,0248	0,0521	0,072	-,071	,018	,195**
	Sig. (2-tailed)	,021	3,4E-13		,000	,080	,688	,399	,245	,251	,775	,001
	N	264	264	264	264	264	264	264	264	264	248	264
Ototoxic Chemicals	Pearson Correlation	,011	,142*	,263**	1	,099	,054	-,069	,014	,007	,040	,068
	Sig. (2-tailed)	,865	,021	,000		,110	,383	,265	,816	,904	,533	,268
	N	264	264	264	264	264	264	264	264	264	248	264
Training	Pearson Correlation	,032	-,012	,108	,099	1	,058	,164**	-,102	-,153*	-,004	-,010
	Sig. (2-tailed)	,602	,841	,080	,110		,344	,007	,098	,013	,956	,877
	N	264	264	264	264	264	264	264	264	264	248	264
Safety Culture	Pearson Correlation	,010	,251**	,025	,054	,058	1	-,091	-,103	,047	-,136*	,154*
	Sig. (2-tailed)	,872	,000	,688	,383	,344		,141	,096	,445	,033	,012
	N	264	264	264	264	264	264	264	264	264	248	264
Risk Perception	Pearson Correlation	-,213**	-,203**	,052	-,069	,164**	-,091	1	-,092	-,129*	,200**	,026
	Sig. (2-tailed)	,000	,001	,399	,265	,007	,141		,134	,036	,002	,669
	N	264	264	264	264	264	264	264	264	264	248	264
Perception of Effects	Pearson Correlation	-,082	,165**	,072	,014	-,102	-,103	-,092	1	,185**	-,125*	,136*
	Sig. (2-tailed)	,183	,007	,245	,816	,098	,096	,134		,003	,050	,027
	N	264	264	264	264	264	264	264	264	264	248	264
Risk Behavior	Pearson Correlation	-,028	-,034	-,071	,007	-,153*	,047	-,129*	,185**	1	-,158*	,015
	Sig. (2-tailed)	,648	,587	,251	,904	,013	,445	,036	,003		,013	,814
	N	264	264	264	264	264	264	264	264	264	248	264
Use of PPE	Pearson Correlation	,093	-,116	,018	,040	-,004	-,136*	,200**	-,125*	-,158*	1	-,049
	Sig. (2-tailed)	,145	,067	,775	,533	,956	,033	,002	,050	,013		,438
	N	248	248	248	248	248	248	248	248	248	248	248
Hearing Loss	Pearson Correlation	-,126*	,330**	,195**	,068	-,010	,154*	,026	,136*	,015	-,049	1
	Sig. (2-tailed)	,041	,000	,001	,268	,877	,012	,669	,027	,814	,438	
	N	264	264	264	264	264	264	264	264	264	248	264

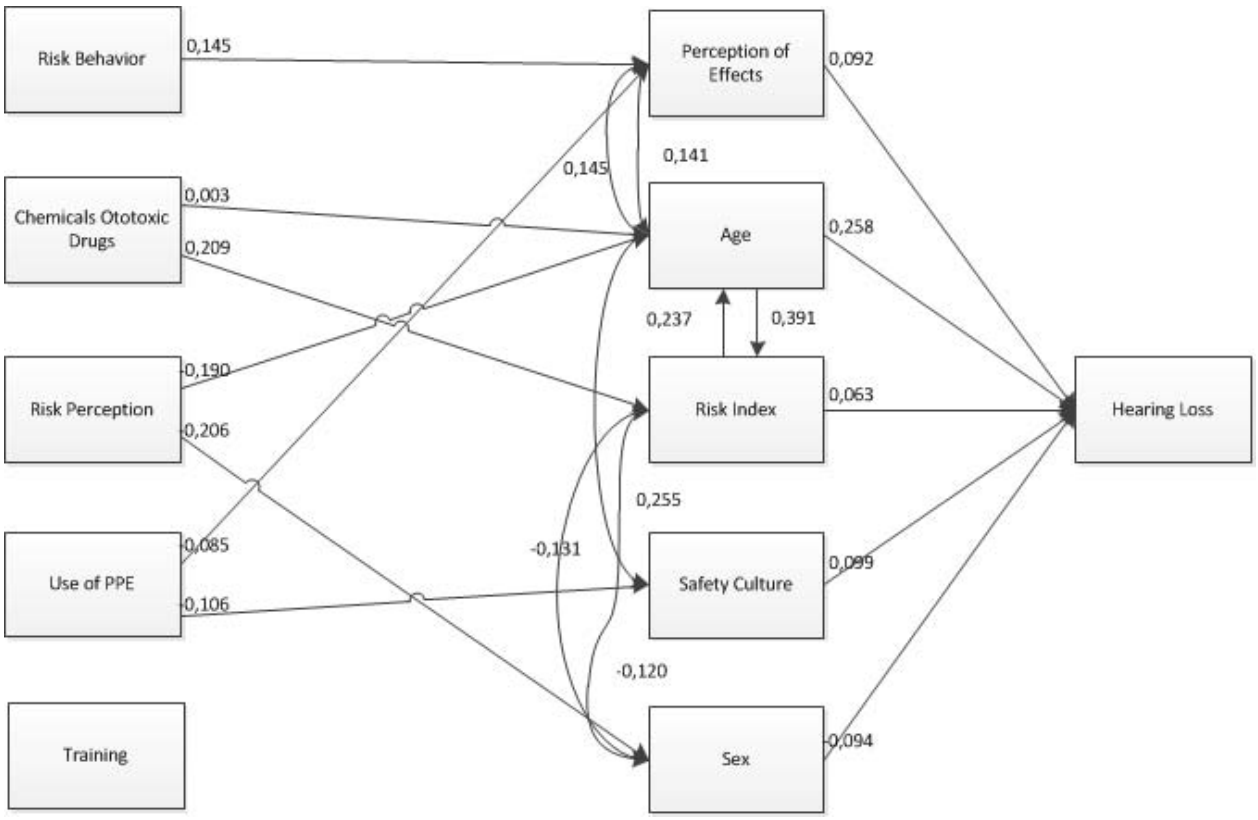
*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Source: The author.

Thus, considering the above, the research screen in this study uses the multivariate analysis of multiple regression analysis (MRA) data, using the data generated by the questionnaires. Five equations of multiple linear regressions were adjusted, with the dependent subconstructs: *Perception of Effects; Age; Risk Index; Safety Culture; and Sex.*

After, the technique of path analysis was used, as the summary presented in Figure 3. This diagram symbolizes paths for subconstructs evaluated.



Source: The author.

Figure 3: Path analysis summary

Table 4 presents the results of all the calculated effects values (direct, indirect, and total) of the subconstructs studied in the proposed model.

Table 4: Direct, indirect, and total effects summary on Hearing Loss construct

Variable	Indirect Effect	Direct Effect	Total Effect
Risk Behavior	0,013	-	*0,013*
Safety Culture	-	0,099	*0,099*
Training	-	-	-
Sex	-0,008	-0,094	*-0,102*
Age	0,063	0.258	*0,321*
Risk Index	0,061	0,063	*0,124*
Risk Perception	-0,030	-	*-0,030*
Perception of Effects	0,036	0,092	*0,128*
Hearing Loss	**-**	**-**	**-**
Chemicals Ototoxic Drugs	0,014	-	*0,014*
Use of PPE	-0,018	-	*-0,018*

Source: The author.

IV. Discussion

Table 4 shows the following results:

a) Risk Behavior

The study of the factor related to *Risk Behavior* of the sample has small effect on the development of hearing loss (0,013), where this parameter totally contemplates the indirect consequence arising from the interaction with the subconstruct *Perception of Effects*. This parameter may be positive, i.e., the higher the irresponsible behavior that puts the employee at risk of acquiring irreversible lesion in his auditory system, more significant these attenuations are.

b) Safety Culture

The *Safety Culture*, which contains only the direct component (0,099), presents a significant contribution to the construct parameter. As a positive value, it oddly reflects that the higher the presence of safe work procedures, the higher the level of hearing loss encountered. Perhaps this positive effect is justified by the conjuncture of the companies evaluated, which hada history of compromising workers' hearing and therefore implemented hearing conservation policies, such as HCP (Hearing Conservation Program).

c) Formation

The study of *formation* did not contribute to the model since it presented no direct or indirect components in this evaluation.

As for the characterization of this factor, we used questions to prior knowledge of the interviewee in areas such as safety and hygiene, as well as any previous training in the prevention of noise-induced hearing loss and about the correct use of earplugs and muffs.

d) Sex

The factor that symbolizes the worker´s *Sex* has presented a significant value (-0,102), with a negative sign and contributed predominantly by the direct effect (-0,094) and the remainder coming from the indirect reaction through subconstruct *Risk Index* (-0,008). Its negative sign indicates that hearing loss tends to be lower in females and higher in the male sex, a fact which goes against table 7 (PPE use by sex).

Regarding the sex distribution in the study sample, the vast majority of workers were male, a common factor in the industrial sector, and that may contribute to explain the results. I am giving a strong tendency for a higher incidence of hearing loss among females, when compared to the same sample of males.

e) Age

The *Age* factor presents the highest of values (0,321), originated mostly by the direct effect (0,258) by the reaction of subconstructs Safety *Culture, Risk Index, and Perception of Effects*. It is of positive module, means that the higher the age of the employee, the greater is his degree of hearing loss. In this subconstruct study, the SPSS software used for the multiple linear regression automatically excluded the subconstruct *Safety Culture*, which seemed initially to collaborate indirectly to the composition of the factor.

f) Risk Index

The *Risk Index* also contributes to the study of the components associated with occupational hearing loss, presenting a significant factor (0,136), with the direct and indirect effects (influenced by factors *Age* and *Sex*) having same values: 0,063. This parameter is related to the sound pressure level at work (dB), with the noise exposure time (years). The higher this indicator, the greater the average hearing loss of the worker.

g) Risk Perception

The *Risk Perception* presents only one discrete factor (-0,030) of indirect effect arising from variables *Age* and *Gender*. As a negative number, it indicates the serious sensitivity of the employee against the risk of hearing loss, the lower will be the harm to the employee´s auditory system. The results collaborate to the trend that, the higher the perceived risk is (specifically through dimensions: Identification of risk sources, Knowledge about the noise, Perception of the efficiency of PPE and Means of protection), the smaller will be the chances of damaging the employee´s hearing.

h) Perception of Effects

Regarding the *Perception of Effects* factor, there is a significant level (0,128) of participation, with a serious part being of direct effect (0,092) and the remainder (0,036) coming from the indirect interaction with the *Age* factor. As a positive number, it indicates that the higher the degree of perception of negative health effects for occupational noise, the higher is the degree of hearing attenuation.

i) Chemicals Ototoxic Drugs

The impact study of *Chemicals Ototoxic Drugs* factor provides one of the lowest factors (0,014) of this model. Derived exclusively from indirect effects, it operates through the variables *Age* and *Risk Index*. As a positive value, it symbolizes the larger presence of these agents that are proven harmful to human hearing, the higher the occurrence of hearing loss of employees.

j) Use of PPE

Finally, the impact study of the *Use of PPE* provides a discrete factor (-0,018) in this model. Coming exclusively from indirect effects, it operates through the variables *Perception of Effects* and *Safety Culture*. Negative value symbolizes the higher use of hearing protection devices – provided by the company to workers, the lower will be the occurrence of hearing loss in employees.

V. Conclusions

Multivariate analysis was adequate and essential in the study of risk factors associated with occupational noise-induced hearing loss in the industry. There is a need for research on risk perception and mitigation strategies in the context of noise-induced hearing loss. Such is found tied to the increased probability of occurrence associated with the risk factors identified in the study. The development of risk management strategies to reduce NIHL requires both knowledge of the physical environment, and the social, psychological and economic processes that can affect

people's responses to environmental conditions of danger.

Noise-induced hearing loss (NIHL) is a cumulative, insidious disease that grows over the years of exposure to noise associated with the workplace - causing damage to organ of Corti, usually bilateral, with progressive and irreversible loss and symptoms such as hearing loss, tinnitus, ear fullness, ear pain, dizziness, transient changes in blood pressure, stress, vision and mood disturbances, directly related to the exposure time, with sound pressure levels (SPL) and individual susceptibility.

NIHL is caused by any exposure to a daily average of 85dB, for several years. Noise is responsible for about 20% of global hearing loss, including being the second leading cause of the occupational disease that affects more American workers.

In an attempt to investigate the variables that impact on noise induced hearing loss, an analysis was developed taking into account the independent variable hearing loss, related to the variables dependent on metrics: *Perceived Effects, Age, Risk Index, Culture of Safety and Sex.*

In order to predict any changes in the dependent variables - due to changes in the independent variable. The statistical analysis was applied to identify the latent dimensions of significant effect on the variable in the analysis of known risk factors, such as: *Risk Behavior, Culture Security, Education, Sex, Age, Risk Index, Risk Perception, Perceived Effects, Chemical Substances, Ototoxic Drugs and Use of PPE*.

To test these associations were used Pearson correlation coefficient and multiple linear regression on the subconstructs identified. Through path analysis, was performed a factor analysis of direct and indirect factors related to NIHL effects.

In this context, the present study examined the possible approaches that relate to understanding the exposure to noise risk in the workplace.

The study enabled us to verify that Hearing Conservation Programs (PCA), and other campaigns, to be developed by companies, particularly in the industrial field, are based on modifiable factors identified. Thus, promoting actions that encourage the expansion of perception of the effects of hearing loss induced by occupational noise, will contribute to the prevention of the risk to workers' health.

The path analysis showed how the exceptional impact variable on hearing loss, both direct and indirect effects aspect, the *Age* variable - demonstrating the effect of natural hearing loss related to aging-presbycusis. At the other extreme, the dependent minor indirect effect were variable *Chemicals Ototoxic drugs*.

According to the results obtained in the present study, the individual perception of the risk of job exposure to noise is an important issue with regard to safe behavior, in particular, to avoid the involvement of occupational hearing loss by noise in the industry. Workers seem to avoid exposure to noise based on their perceptions of the risk. Unfortunately, it appears that they are bad appraisers this risk.

Finally, other investigations may complement the study performed here. As this research was limited to the study of continuous or intermittent noise found in industrial environments surveyed, further research can evaluate the work environment whose employees are subject to impact noise.

References Références Referencias

1. NIOSH- National Institute for Occupational Safety and Health. Available fromhttp://www.cdc.gov/niosh /topics/noise/. 2013.
2. PENNEY, P.J; EARL, C.E. Occupational noise and effects on blood pressure: exploring the relationship of hypertension and noise exposure in workers. AAOHN J. 2004; 52(11):476-80.
3. PARKER, DAVID; SAMANT, YOGINDRA; WANNAG, AXEL; WERGELAND, EBBA. The Norwegian Labour Inspectorate's Registry for Work-Related Diseases: Data from 2006. International Journal of Occupational and Environmental Health, 2014, Volume 14, Issue 4.
4. JAVZMAA, JAMSRANJAV; OYUNBILEG, SHAGDARSUREN; OYUNTOGOS, LKHAASUREN; SUMBERZUL, NYAMJAV; WANG, JUNG-DER. Analysis of Incidence Rates of Occupational Diseases in Mongolia, 1986–2006. International Journal of Occupational and Environmental Health, 2014, Volume 17, Issue 1.
5. COLLEE, A; DE BOODT, F; DEGRAVE, E; GOVAERTS, B; LEGRAND, C; VEKEN, P.V. Occupational exposure to noise and the prevalence of hearing loss in a Belgian military population: A cross-sectional study. Noise Health 2011; 13: 64-70.
6. LUSK, SALLY L; HONG, OISAENG; RONIS, DAVID L. Comparison of the Original and Revised Structures of the Health Promotion Model in Predicting Construction Workers' Use of Hearing Protection. Research in Nursing & Health, 2006, 29, 3–17.
7. HILHORST, THEA J. Appraisal of Risk Perception in Occupational Health and Safety Research in Developing Countries. International Journalof Occupational and Environmental Health, 2014, Volume 2, Issue 4.
8. CORDEIRO, RICARDO; LIMA-FILHO, EUCLYDES C; NASCIMENTO, LILIAN C. R. Associação da Perda Auditiva Induzida pelo Ruído com o Tempo Acumulado de Trabalho entre Motoristas e Cobradores. Cad. Saúde Públ., 1994, 10 (2): 210-221.

9. ALMEIDA, S. I. C. DE. História natural da perda auditiva ocupacional provocada por ruído. Rev. Assoc. Med. Bras., 2000.
10. AREZES, P.M. Percepção do risco de exposição ocupacional ao ruído. Tese submetida à Escola de Engenharia da Universidade do Minho para obtenção do grau de Doutor em Engenharia de Produção. Minho, 2002.
11. PRINCE, MARY M. Distribution of risk factors for hearing loss: Implications for evaluating risk of occupational noise-induced hearing loss. Journal of the Acoustical Society of America, 2002, Volume 112, Issue 2.
12. LACERDA, ADRIANA; LEROUX, TONY; MORATA, THAIS. Efeitos ototóxicos da exposição ao monóxido de carbono: uma revisão. Pró-Fono R. Atual. Cient., 2005,vol.17 no.3.
13. MEDEIROS, MÁRCIA PINHEIRO HORTENCIO DE; TELES, RENATA DE MESQUITA. Perfil audiométrico de trabalhadores do distrito industrial de Maracanaú - CE. Rev. soc. bras. fonoaudiol.,2007, vol.12, n.3, pp. 233-239.
14. MEHRDAD, RAMIN; MOHAMMADI, SABER; POURYAGHOUB, GHOLAMREZA. Interaction of smoking and occupational noise exposure on hearing loss: a cross-sectional study.BMC Public Health, 2007, p137.
15. DANIEL, E. Noise and Hearing Loss: A Review. Journal of School Health, 2007, volume: 77, pages
16. CORDEIRO, RICARDO; DIAS, ADRIANO. Interação entre grau de perda auditiva e o incômodo com zumbidos em trabalhadores com história de exposição ao ruído. Rev. Bras. Otorrinolaringol., 2008, vol.74 no.6.
17. ALVARENGA, KÁTIA DE FREITAS; BASTOS, JOSÉ ROBERTO MAGALHÃES; CALDANA, MAGALI DE LOURDES; FENIMAN, MARIZA RIBEIRO; JORGE, TATIANE MARTINS; *et al*. Alterações auditivas em trabalhadores de indústrias madeireiras do interior de Rondônia. Rev. bras. Saúde ocup. 2009, São Paulo, 34 (119): 88-92.
18. BOTELHO, CARLA TOMAZ; FROTA, SILVANA; GONÇALVES, ANDRÉ MARTINS; PAZ, ANNA PAULLA MAIA LOPES. Estudo comparativo de exames audiométricos de metalúrgicos expostos a ruído e ruído associado a produtos químicos. Revista Brasileira de Otorrinolaringologia, 2009; 75 (1):51-7.
19. GONCALVES, CLÁUDIA GIGLIO DE OLIVEIRA *ET AL*. Percepção e o impacto da música na audição de integrantes de banda militar. Rev. Soc. Bras. Fonoaudiol., 2009, vol.14, n.4, pp. 515-520.
20. GONCALVES, CLÁUDIA GIGLIO DE OLIVEIRA; MARQUES, JAIR MENDES; MOTA, PEDRO HENRIQUE DE MIRANDA. Ruído e idade: análise da influência na audição em indivíduos com 50 - 70 anos. Pró-Fono R. Atual. Cient., 2009, vol.21, n.1, pp. 57-62.
21. ATTARCHI, MIR SAEED; MAZHARI, MOHAMMAD MAHDI, MEHRPARVAR, AMIR HOUSHANG; MOHAMMADI, SABER. Cigarette smoking and occupational noise-induced hearing loss. European Journal of Public Health, 2009, Volume 20, Issue 4, Pp. 452-455.
22. AYÇIÇEK, ABDULLAH; DEREKÖY, F. SEFA; KENAR, FETHULLAH; SARGÂN, RAMAZAN. Can Rh antigens be a risk factor in noise-induced hearing loss? EurArchOtorhinolaryngol, 2009, 266, 363–366.
23. ARAKAWA, AM; CALDANA, ML; SALES-PERES, SHC; SITTA, ÉI. Análise de diferentes estudos epidemiológicos em audiologia realizados no Brasil. Rev. CEFAC, São Paulo, 2010.
24. GAROFANI, VANESSA GREGORCZYK; LACERDA, ADRIANA; MARQUES, JAIR MENDES; RIBEIRO, LEILA. Efeitos auditivos em operadores de empilhadeira. Rev. Soc. Bras. Fonoaudiol., 2010, vol.15, n.4, pp. 514-519.
25. FIGUEIREDO, GISELE; LACERDA, ADRIANA; MASSAROLO NETO, JEANE; MARQUES, JAIR MENDES. Achados audiológicos e queixas relacionadas à audição dos motoristas de ônibus urbano. Rev. Soc. Bras. Fonoaudiol., 2010, vol.15, n.2, pp. 161-166.
26. NEVES, EDUARDO BORBA; SOALHEIRO, MARCIA. A protecao auditiva utilizada pelos militares do Exercito brasileiro: há efetividade? Ciência e Saúde Coletiva, 2010, vol:74, iss:5, pg:889.
27. CHAGAS, PATRÍCIA DA SILVA CARLOS; DINIZ, THIAGO HERNANDES; GUIDA, HERALDO LORENA; KINOSHITA, SÉRGIO KOODI. Perfil audiológico em policiais militares do Estado de São Paulo. Arquivos Int. Otorrinolaringol., 2010, vol.14, no.4.
28. KARIMI, ALI; KAZEROONI, FARSHID; NASIRI, SALEH; OLIAEI, MOHAMMAD. Noise induced hearing loss risk assessment in truck drivers. Noise and Health, 2010, p49.
29. IM HJ; JANG TW; KIM BG; KWON YJ. The association between impaired fasting glucose and noise-induced hearing loss. J. Occup. Health, 2011, 53(4):274-9.
30. KOSKINEN, HELI; TOPPILA, ESKO. Hearing loss among classical-orchestra musicians. Noise and Health, 2011, 13.50, p45.
31. DUBE, KAMALESH; INGALE, LALIT; INGALE, SOPAN. Hearing impairment among workers exposed to excessive levels of noise in ginning industries. Noise and Health, 2011.
32. COLEMAN, MATTHEW. Breaking News: Restaurants Serve Up an Extra Helping of Hearing Loss. The Hearing Journal, 2012, Volume 65(10), p 38.

33. MUTLU, ATAKAN; ONDER, MUSTAFA; ONDER, SEYHAN. Determination of noise induced hearing loss in mining: an application of hierarchical log linear modelling. Environmental Monitoring and Assessment, 2012, Volume 184, Issue4, pp 2443-2451.
34. ATTIAA, JOHN; BOGGESS, MAY; GUEST, MAYA. Relative risk of elevated hearing threshold compared to ISO1999 normative populations for Royal Australian Air Force male personnel. Hearing Research, 2012, Volume 285, Issues 1–2, Pages 65–76.
35. BRUNSKILL, EMMA; FINUCANE, MARIEL; FLAXMAN, SETH; MASCARENHAS, MAYA; MATHERS, COLIN D; STEVENS, GRETCHEN. Global and regional hearing impairment prevalence: an analysis of 42 studies in 29 countries. EuropeanJournalofPublic Health, Feb 2013.
36. OLIVEIRA, CRISTIANE COSTA DA CUNHA; SENA, TEREZA RAQUEL RIBEIRO DE; VARGAS, MARLIZETE MALDONADO. Saúde auditiva e qualidade de vida em trabalhadores expostos a agrotóxicos. Ciência Saúde Coletiva vol.18 no.6 Rio de Janeiro June 2013.
37. ENGDAHL B, JOHNSEN TS, LIE A, SKOGSTAD M, TAMBS K. Hearing status among Norwegian train drivers and train conductors. Occup. Med. (Lond.), 2013.
38. BRAMATTI, LUCIANA; KUNZ, BETINA THOMAS; MENIN, ELIZIANE GAI. Relação da perda auditiva induzida por ruído e o uso de tabaco em trabalhadores de uma indústria alimentícia. Rev. CEFAC vol.16 no.2 São Paulo Mar./Apr. 2014
39. PENDER, N.J. Health Promotion in Nursing Practice. 1982. Norwalk, CT: Appleton-Crofts.
40. BRADY, J. Training to promote worker's use of hearing protection: The influence of work climate factors on training effectiveness, PhD Thesis, Michigan State University, 1999.
41. GUEDES, DARTAGNAN PINTO; GUEDES, JOANA ELISABETE RIBEIRO PINTO; LOPES, CYNTHIA CORREA. Reprodutibilidade e validade do Questionário Internacional de Atividade Física em adolescentes. RevBrasMed Esporte _ Vol. 11, N^{O} 2 – Mar/Abr, 2005.
42. BONET, MARIANO; CAÑIZARES, MAYILÉE; FERNÁNDEZ, NIURYS; MAS, PEDRO; TATE, ROBERT B.; YASSI, ANNALEE.Health-risk Perception in the Inner City Community of Centro Habana, Cuba. International Journal of Occupational and Environmental Health, 2014, Volume 6, Issue 1.
43. HAIR, J.F.JR; ANDERSON, R.E; TATHAM, R.L. E BLACK, W.C. Multivariate Data Analysis (with readings), 4 ed. Prentice Hall, Englewood Cliffs, 1995.

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The Global Journals Incorporation (USA) at its discretion can also refer double blind peer reviewed paper at their end to the board for the verification and to get recommendation for final stage of acceptance of publication.

The IBOARS can organize symposium/seminar/conference in their country on behalf of Global Journals Incorporation (USA)-OARS (USA). The terms and conditions can be discussed separately.

The Board can also play vital role by exploring and giving valuable suggestions regarding the Standards of "Open Association of Research Society, U.S.A (OARS)" so that proper amendment can take place for the benefit of entire research community. We shall provide details of particular standard only on receipt of request from the Board.

The board members can also join us as Individual Fellow with 40% discount on total fees applicable to Individual Fellow. They will be entitled to avail all the benefits as declared. Please visit Individual Fellow-sub menu of GlobalJournals.org to have more relevant details.

We shall provide you intimation regarding launching of e-version of journal of your stream time to time. This may be utilized in your library for the enrichment of knowledge of your students as well as it can also be helpful for the concerned faculty members.

After nomination of your institution as "Institutional Fellow" and constantly functioning successfully for one year, we can consider giving recognition to your institute to function as Regional/Zonal office on our behalf.
The board can also take up the additional allied activities for betterment after our consultation.

The following entitlements are applicable to individual Fellows:

Open Association of Research Society, U.S.A (OARS) By-laws states that an individual Fellow may use the designations as applicable, or the corresponding initials. The Credentials of individual Fellow and Associate designations signify that the individual has gained knowledge of the fundamental concepts. One is magnanimous and proficient in an expertise course covering the professional code of conduct, and follows recognized standards of practice.

Open Association of Research Society (US)/ Global Journals Incorporation (USA), as described in Corporate Statements, are educational, research publishing and professional membership organizations. Achieving our individual Fellow or Associate status is based mainly on meeting stated educational research requirements.

Disbursement of 40% Royalty earned through Global Journals : Researcher = 50%, Peer Reviewer = 37.50%, Institution = 12.50% E.g. Out of 40%, the 20% benefit should be passed on to researcher, 15 % benefit towards remuneration should be given to a reviewer and remaining 5% is to be retained by the institution.

We shall provide print version of 12 issues of any three journals [as per your requirement] out of our 38 journals worth $ 2376 USD.

Other:

The individual Fellow and Associate designations accredited by Open Association of Research Society (US) credentials signify guarantees following achievements:

- The professional accredited with Fellow honor, is entitled to various benefits viz. name, fame, honor, regular flow of income, secured bright future, social status etc.

- In addition to above, if one is single author, then entitled to 40% discount on publishing research paper and can get 10%discount if one is co-author or main author among group of authors.
- The Fellow can organize symposium/seminar/conference on behalf of Global Journals Incorporation (USA) and he/she can also attend the same organized by other institutes on behalf of Global Journals.
- The Fellow can become member of Editorial Board Member after completing 3yrs.
- The Fellow can earn 60% of sales proceeds from the sale of reference/review books/literature/publishing of research paper.
- Fellow can also join as paid peer reviewer and earn 15% remuneration of author charges and can also get an opportunity to join as member of the Editorial Board of Global Journals Incorporation (USA)
- • This individual has learned the basic methods of applying those concepts and techniques to common challenging situations. This individual has further demonstrated an in–depth understanding of the application of suitable techniques to a particular area of research practice.

Note :

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- In future, if the board feels the necessity to change any board member, the same can be done with the consent of the chairperson along with anyone board member without our approval.
- In case, the chairperson needs to be replaced then consent of 2/3rd board members are required and they are also required to jointly pass the resolution copy of which should be sent to us. In such case, it will be compulsory to obtain our approval before replacement.
- In case of "Difference of Opinion [if any]" among the Board members, our decision will be final and binding to everyone.

"

We accept the manuscript submissions in any standard (generic) format.

We typeset manuscripts using advanced typesetting tools like Adobe In Design, CorelDraw, TeXnicCenter, and TeXStudio. We usually recommend authors submit their research using any standard format they are comfortable with, and let Global Journals do the rest.

Alternatively, you can download our basic template from https://globaljournals.org/Template.zip

Authors should submit their complete paper/article, including text illustrations, graphics, conclusions, artwork, and tables. Authors who are not able to submit manuscript using the form above can email the manuscript department at submit@globaljournals.org or get in touch with chiefeditor@globaljournals.org if they wish to send the abstract before submission.

Before and during Submission

Authors must ensure the information provided during the submission of a paper is authentic. Please go through the following checklist before submitting:

1. Authors must go through the complete author guideline and understand and *agree to Global Journals' ethics and code of conduct,* along with author responsibilities.
2. Authors must accept the privacy policy, terms, and conditions of Global Journals.
3. Ensure corresponding author's email address and postal address are accurate and reachable.
4. Manuscript to be submitted must include keywords, an abstract, a paper title, co-author(s') names and details (email address, name, phone number, and institution), figures and illustrations in vector format including appropriate captions, tables, including titles and footnotes, a conclusion, results, acknowledgments and references.
5. Authors should submit paper in a ZIP archive if any supplementary files are required along with the paper.
6. Proper permissions must be acquired for the use of any copyrighted material.
7. Manuscript submitted *must not have been submitted or published elsewhere* and all authors must be aware of the submission.

Declaration of Conflicts of Interest

It is required for authors to declare all financial, institutional, and personal relationships with other individuals and organizations that could influence (bias) their research.

Policy on Plagiarism

Plagiarism is not acceptable in Global Journals submissions at all.

Plagiarized content will not be considered for publication. We reserve the right to inform authors' institutions about plagiarism detected either before or after publication. If plagiarism is identified, we will follow COPE guidelines:

Authors are solely responsible for all the plagiarism that is found. The author must not fabricate, falsify or plagiarize existing research data. The following, if copied, will be considered plagiarism:

- Words (language)
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- Findings
- Writings
- Diagrams
- Graphs
- Illustrations
- Lectures

- Printed material
- Graphic representations
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- Any other original work

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2. Drafting the paper and revising it critically regarding important academic content.
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Changes in Authorship

The corresponding author should mention the name and complete details of all co-authors during submission and in manuscript. We support addition, rearrangement, manipulation, and deletions in authors list till the early view publication of the journal. We expect that corresponding author will notify all co-authors of submission. We follow COPE guidelines for changes in authorship.

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Appealing Decisions

Unless specified in the notification, the Editorial Board's decision on publication of the paper is final and cannot be appealed before making the major change in the manuscript.

Acknowledgments

Contributors to the research other than authors credited should be mentioned in Acknowledgments. The source of funding for the research can be included. Suppliers of resources may be mentioned along with their addresses.

Declaration of funding sources

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Preparing your Manuscript

Authors can submit papers and articles in an acceptable file format: MS Word (doc, docx), LaTeX (.tex, .zip or .rar including all of your files), Adobe PDF (.pdf), rich text format (.rtf), simple text document (.txt), Open Document Text (.odt), and Apple Pages (.pages). Our professional layout editors will format the entire paper according to our official guidelines. This is one of the highlights of publishing with Global Journals—authors should not be concerned about the formatting of their paper. Global Journals accepts articles and manuscripts in every major language, be it Spanish, Chinese, Japanese, Portuguese, Russian, French, German, Dutch, Italian, Greek, or any other national language, but the title, subtitle, and abstract should be in English. This will facilitate indexing and the pre-peer review process.

The following is the official style and template developed for publication of a research paper. Authors are not required to follow this style during the submission of the paper. It is just for reference purposes.

Manuscript Style Instruction (Optional)

- Microsoft Word Document Setting Instructions.
- Font type of all text should be Swis721 Lt BT.
- Page size: 8.27" x 11'", left margin: 0.65, right margin: 0.65, bottom margin: 0.75.
- Paper title should be in one column of font size 24.
- Author name in font size of 11 in one column.
- Abstract: font size 9 with the word "Abstract" in bold italics.
- Main text: font size 10 with two justified columns.
- Two columns with equal column width of 3.38 and spacing of 0.2.
- First character must be three lines drop-capped.
- The paragraph before spacing of 1 pt and after of 0 pt.
- Line spacing of 1 pt.
- Large images must be in one column.
- The names of first main headings (Heading 1) must be in Roman font, capital letters, and font size of 10.
- The names of second main headings (Heading 2) must not include numbers and must be in italics with a font size of 10.

Structure and Format of Manuscript

The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

a) A title which should be relevant to the theme of the paper.
b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
c) Up to 10 keywords that precisely identify the paper's subject, purpose, and focus.
d) An introduction, giving fundamental background objectives.
e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition, sources of information must be given, and numerical methods must be specified by reference.
f) Results which should be presented concisely by well-designed tables and figures.
g) Suitable statistical data should also be given.
h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
j) There should be brief acknowledgments.
k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.

Format Structure

It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

All manuscripts submitted to Global Journals should include:

Title

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

Author details

The full postal address of any related author(s) must be specified.

Abstract

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Keywords

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, “What words would a source have to include to be truly valuable in a research paper?” Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

Numerical Methods

Numerical methods used should be transparent and, where appropriate, supported by references.

Abbreviations

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

Formulas and equations

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

Tables, Figures, and Figure Legends

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.

Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

Preparation of Eletronic Figures for Publication

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

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Tips for Writing a Good Quality Engineering Research Paper

Techniques for writing a good quality engineering research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

4. Use of computer is recommended: As you are doing research in the field of research engineering then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.

6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.

- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

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	A-B	**C-D**	**E-F**
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Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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