Stress optimization for performance improvement of direct workers from the automotive industry in Bulgaria

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Abstract: The automotive industry is one of the most dynamic among the industries. Every day the direct workers in this industry have to produce certain number of vehicles or components and this production has to be in required quantity and quality. These two preconditions are common cause of high stress levels in the workers. The high stress levels have impact on their performance and as a result low quantity and/or low quality. The purpose of the article is to investigate the performance improvement of direct workers from the automotive industry in Bulgaria when it is applied stress optimization. The investigation uses human resources and variety of methods in order to accomplish the purpose. The human resources represent 3 work teams with a total of 14 direct workers from several companies from the automotive industry in Bulgaria. Different methods are applied to the individual teams in order to assess the performance more accurately – 1st team was chosen for control team, 2nd team – stress management, 3rd team – stress and time management. Initial and final surveys were conducted to assess worker's stress levels before the beginning and after the end of the investigation. The performance is monitored by OEE. The results for the performance show that the OEE for the 1st team is almost the same, the OEE for the 2nd team raises with 16% and the OEE for the 3rd team raises with 23%. The results for the stress levels shows that 1st team remain almost the same levels (high stress levels), 2nd team – reduction from high to moderate levels, 3rd team – reduction from high to low/moderate stress levels.

Key-Words: automotive industry, stress management, time management, performance, stress levels, Overall Equipment Effectiveness (OEE).

1 Introduction

The automotive industry is one of the most dynamic among the industries. Every day the direct workers in this industry have to produce certain number of vehicles or components and this production has to be in required quantity and quality. These two preconditions are common cause of high stress levels in the workers. The high stress levels have impact on their performance and as a result low quantity and/or low quality. This happen regardless of the country where it is located the production plant.

The performance – arousal law is known in the literature for a long time. It is found by Yerkes and Dodson in 1908. The law shows the relation between performance and arousal when have to be performed simple or difficult tasks [1]. The law is reworked by Hebb in 1955. The author assumes that the hyper arousal does not influence on the performance of simple tasks and because of this he is only analyzing the difficult tasks [2]. For difficult tasks the optimal performance is at optimal arousal levels according to the above mentioned authors. Lower or higher arousal results in lower performance [1][2]. Taking Hebb's work as basis, Welford rework the law in 1977 by referring the performance of difficult tasks to the stress levels [4]. According to Welford, the stress levels are divided in 4 sectors – too little stress, optimum stress, too much stress and burn-out. The performance raises until the moment of fatigue and then decreases. The moment of fatigue is the boundary between optimal stress and too much stress. This means the workers should be in the optimal stress sector in order to have maximal performance. There is exhaustion in the workers in the too much stress sector. The author divides the burn-out sector in 2 parts depending from the raise of the stress – firstly anxiety, panic, anger and then breakdown. Comparison between Hebb's and Welford's curves could be found in fig. 1.
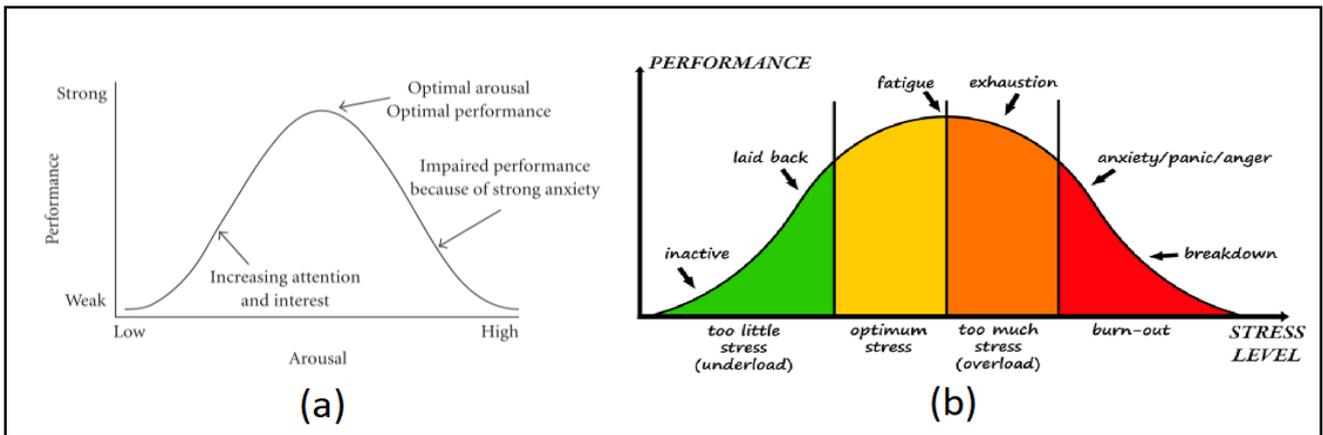
Fig. 1. Comparison between Hebb's curve (a) and Welford's curve (b) [3][4].

The negative effect of the stress has been studied in details in the literature and it is not subject of this paper. The same refers also for the stress reduction methods. Although there are some articles for human resources management in the automotive industry [5][6], stress effect in the automotive industry [7][8][9] and stress management in the automotive industry [10][11], there are not investigations of the performance of the workers in the automotive industry after applying stress reduction methods. The purpose of the article is to investigate the performance improvement of direct workers from the automotive industry in Bulgaria when it is applied stress optimization.

2 Resources and Methods

The investigation uses human resources and variety of methods in order to accomplish the purpose.

The human resources represent 3 work teams with a total of 14 direct workers from several companies from the automotive industry in Bulgaria. The teams were selected after analysis of their performance from the last 3 months before beginning of the investigation. All teams worked at normal shift (8 to 17 worktime). A confidential agreement was signed with the companies and the direct workers in relation to the protection of personal data. Table 1 shows the number of workers in each team.

Team 1	Team 2	Team 3
4	5	5

Table 1. Number of workers in the teams.

Different methods are applied to the individual teams in order to assess the performance more accurately. The first team was chosen for control team. It was not applied any stress optimization

methods to this team. Stress management is the method which is applied to the second team. Stress and time management are the methods which are applied to the third team. The stress optimization methods for each team were chosen at the initial analysis before the beginning of the investigation. Table 2 shows the stress optimization methods applied to the teams.

Team №	Stress Management	Time Management
Team 1	-	-
Team 2	+	-
Team 3	+	+

Table 2. Stress optimization methods applied to the teams.

An initial survey was conducted to assess worker's stress levels. The survey is specially designed for the investigation and it is based on the Perceived Stress Scale (PSS) [12][13]. The survey consists of 10 questions. Each question have answers with points from 0 to 4. The sum of the points of all questions gives the result of the survey. The score scale of the survey is shown in table 3.

0 - 10	Low stress level
11 - 20	Moderate stress level
21 - 30	High stress level
31 - 40	Very high stress level

Table 3. The survey score scale.

The initial survey showed that all workers have high stress levels with scores between 21 and 30. As a result of this for the stress management was chosen stress reduction techniques for teams 2 and 3. The survey was conducted again after the end of

investigation in order to assess the stress optimization together with the performance evaluation.

There are many techniques for stress reduction in the literature [14]. 10 techniques were selected for this investigation, divided in two groups – 5 mandatory and 5 optional. Every worker had to do the 5 mandatory and at least 2 of the optional techniques every week during the period of the investigation. It was spoken with all workers that it is not planned any therapy in the investigation. All conflicts between the team members and with the foreman/bosses were solved before starting the investigation. By this ways the conflicts were not factor in the stress levels. The chosen stress reduction techniques are shown in table 4.

Mandatory	1	Sport/ Exercise
	2	Healthy food and water
	3	Get enough sleep
	4	Reduction of alcohol, coffee and sugar
	5	Less usage of electronic devices
Optional	1	Creativity activities (writing, painting, get a hobby, making artwork)
	2	Take a walk (alone or with family, friends, pet), in the nature
	3	Go to weekend trip, go to massage, go to spa, etc.
	4	Watching comedies and listening music
	5	Talk with good friends

Table 4. Stress reduction techniques.

Time management was chosen to be applied to the third team after the initial analysis (based on the historical OEE). The time management that was used is norm reduction. In order to do this it had to be reviewed the contracted weekly production with the customer. It was seen that the norm inside the contract was the maximum which could be produced on the assembly line. In addition to this, the customer call-offs for the last 3 months before the investigation were much lower than the norm. Because of these two reasons the norm was reduced with 11% for this team after discussions with the customer.

The performance is monitored by the parameter "Overall Equipment Effectiveness" (OEE) [15]. The Overall Equipment Effectiveness could be expressed as the following equations:

$$OEE = Availability \times Performance \times Quality \quad (1)$$

$$Availability = \frac{Ran\ time}{Planned\ time} \quad (2)$$

$$Performance = \frac{Produced\ parts}{Norm} \quad (3)$$

$$Quality = \frac{OK\ parts}{Produced\ parts} \quad (4)$$

After applied equations (2), (3) and (4) into equation (1) is obtained the following:

$$OEE = \frac{Ran\ time}{Planned\ time} \times \frac{Produced\ parts}{Norm} \times \frac{OK\ parts}{Produced\ parts} \quad (5)$$

The maintenance engineers were required to provide working assembly lines without any stops during the investigation. By this way the availability could be excluded from the equation. As a result it can be followed the purpose of the investigation.

The duration of the investigation is 14 weeks. During this period it is recorded all components of the overall equipment effectiveness for every work day. OEE is calculated for every day, for every week and in total for the whole period.

3 Results and Discussion

The first thing that had to be done before starting the investigation was the team selection together with representatives of every company. The selection was based firstly on the historical OEE and secondly with feasibility check to the investigation. The time period for the historical OEE was 14 weeks, the same as the investigation. The average historical OEE was chosen to be around 70%. Figures 2, 3 and 4 show the historical average OEE of each of the selected teams.

The average historical OEE of the 1st team was 70,82% where the average values of the elements – 100% availability, 71% performance and 100% quality. The 2nd team was with 69,87% average historical OEE where the average values of the elements – 99% availability, 72% performance and 97% quality. The average historical OEE of the 3rd team was 69,11% where the average values of the

elements – 99% availability, 73% performance and 95% quality. The norms were 584, 702 and 809 parts per shift for 1st, 2nd and 3rd team respectively. The first team was chosen for control team due to the lowest norm and highest quality compared to the other teams. The second team was selected for only for stress management. The third team was selected for both stress and time management due to the highest norm and lowest quality compared to the other teams.
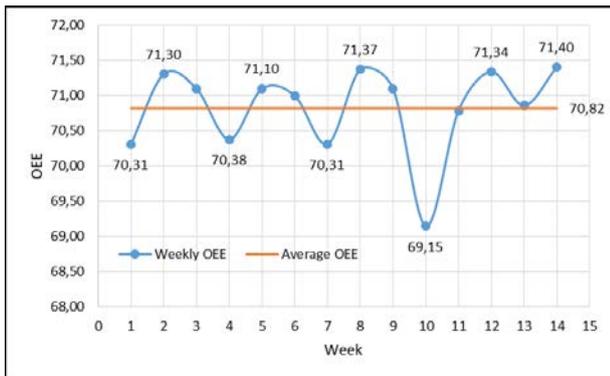
Fig. 2. Historical OEE of the 1st team.
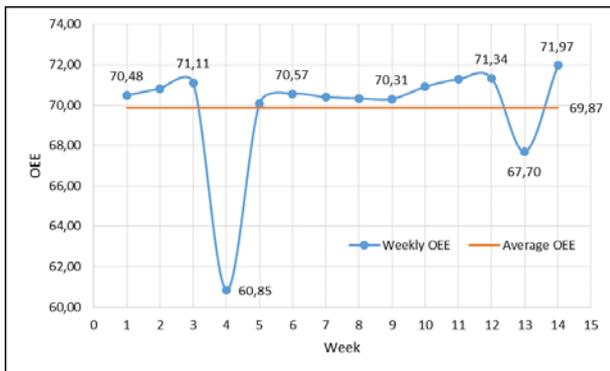
Fig. 3. Historical OEE of the 2nd team.
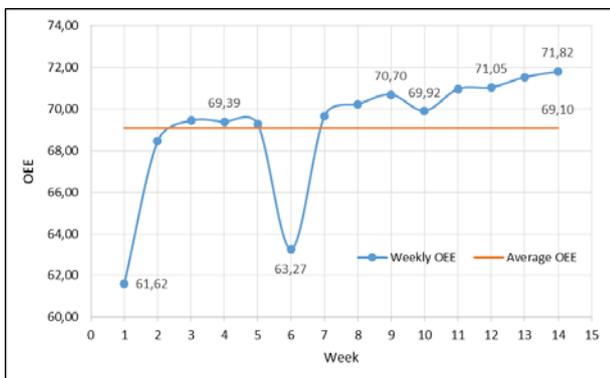
Fig. 4. Historical OEE of the 3rd team.

An initial survey was conducted before the start of the survey in order to show the current stress levels of the workers from every team. The results are shown in table 5. It can be seen from the table that all workers are in the high stress levels with results between 21 and 28 points (average point for the 1st team – 25,5; average point for 2nd team – 23,8; average point for 3rd team – 25,2).

Team	Worker	Score	Average score
1	1	27	25,5
	2	25	
	3	22	
	4	28	
2	1	25	23,8
	2	24	
	3	27	
	4	21	
	5	22	
3	1	27	25,2
	2	25	
	3	24	
	4	25	
	5	25	

Table 5. Initial stress levels of the workers.

The stress reduction techniques carried out by the workers were monitored every day for each worker by the foremans and the team leaders during the investigation. Also the foremans and the team leaders were instructed not to push, criticize and/or motivate the workers. Otherwise it would affect the results of the investigation. This was explained to the workers.

The result for the performance improvement are shown in figures 5, 6 and 7.

The average OEE of the first team after the end of investigation remains almost the same as the historical OEE. Due to this the results from the investigation can be considered as reliable. But it is necessity something visible in the results for the 1st team to be explained. It can be seen in fig. 5 that for week 1 and 2 the OEE raises and then continuously decreases till week 7 with 65,31% OEE. These two phenomena were expected. Because the workers knew they are part from investigation, they were more accurate and precise in their work and as result the OEE increases in week 1 and 2. But this also brings high stress levels and as result in the next weeks the workers reduces the quantity of the produced parts and the quality. As a result the OEE decreases to around 65% in week 7. From week 8 to
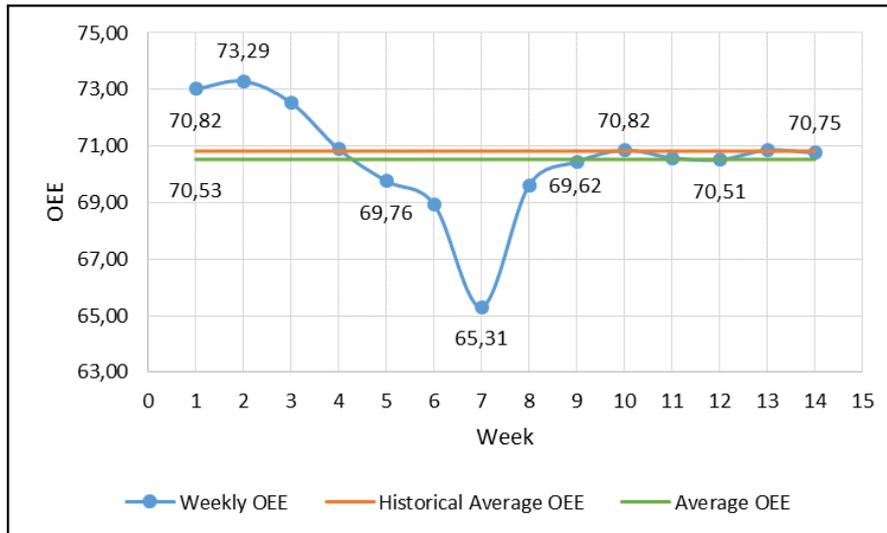
Fig. 5. Performance of 1st team.
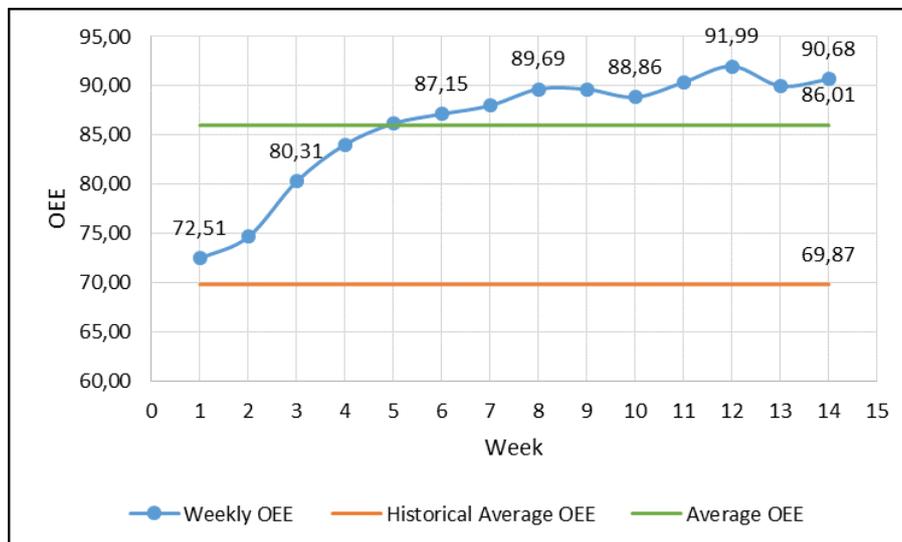
Fig. 6. Performance of the 2nd team.

the end of investigation the OEE varies between 69 and 71%. The average OEE of the first team after the end of investigation was 70,53% where the average values of the elements – 100% available, 71% performance and 100% quality.

Stress reduction techniques were applied to the 2nd team. It can be seen from fig. 6 that the OEE continuously increases till week 8 to around 89% and then from week 8 to the end of the investigation the OEE varies between 89 and 92%. The average OEE has increased with 16,14% (from 69,87 to 86,01). It have to be said that if the period is changed and the investigation starts at week 8 the average OEE would be higher. The average OEE for the 2nd team was 86,01% where the average values of the elements – 100% availability, 87% performance and 99% quality.

Stress reduction techniques together with norm reduction were applied to the 3rd team. The norm was reduced with 11% (from 809 to 720 parts per shift). It can be seen from fig. 7 that the OEE continuously raises from week 1 to the end of investigation and the highest OEE (97,97%) is at week 14. The average OEE has increased with 23,61% (from 69,11 to 92,72). It is visible in the figure that for the last 4 weeks from the investigation the OEE is 96% and above. This phenomenon needs little explanation. The workers knew when the end of investigation is and in the last 4 weeks of it they worked hard in order to achieve better results for their team. After the end they could keep their performance but it could also assumed that the OEE would decrease. The average OEE of the 3rd team was 92,72% where the average values
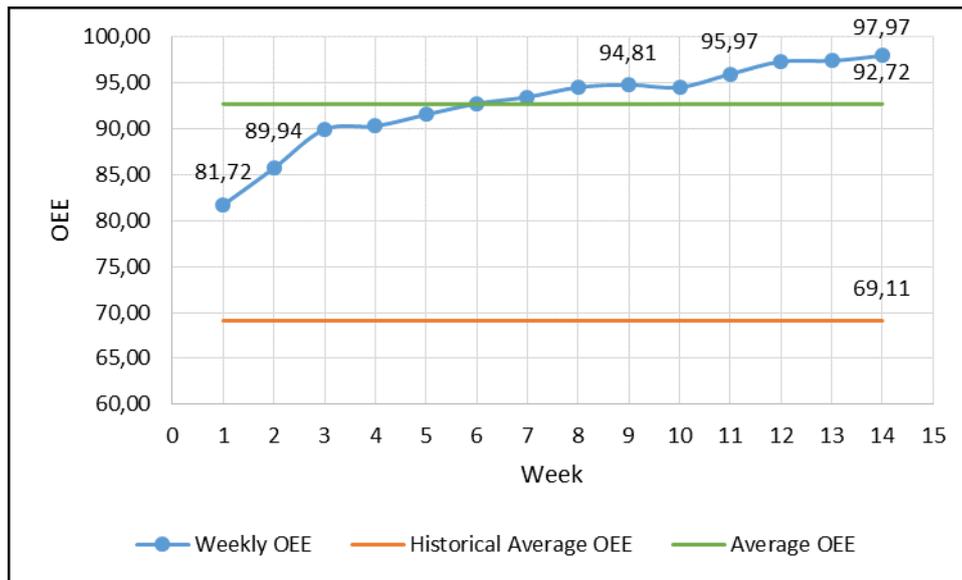
Fig. 7. Performance of the 3rd team.

of the elements – 100% availability, 93% performance and 99% quality.

A question may arise for the increase of the OEE of the third team – what are the parts of stress reduction and norm reduction in the percentage increase of the OEE for this team? In order to clarify this question, it is necessity firstly to be assumed that the availability and quality would be the same as for the 2nd team and to calculate the performance using produced parts from the historical OEE and the reduced norm. Thus would be obtained results only for the stress reduction. For better clarification it will be applied the average and maximum produced parts during the historical OEE (586 and 604 respectively). The new OEE in the both cases is 80,58 and 83,05%. After subtracting the new OEE and the historical OEE is obtained the part of the stress reduction. After subtracting the average OEE and the new OEE is obtained the part of the norm reduction. The parts are shown in table. 6.

Historical OEE	69,11	
Average OEE	92,72	
New OEE	80,58	83,05
Stress reduction	11,46 (48,56%)	13,94 (59,04%)
Norm reduction	12,15 (51,44%)	9,67 (40,96%)

Table 6. Parts of the stress and norm reduction in the percentage increase of the OEE for the 3rd team.

It was conducted the final survey after the end of the investigation. By this way it is assessed the effect of the stress optimization over the workers together with the performance improvement. It is used the same survey as the initial (with the same questions and points). The results are shown in table 7. It is visible that the stress levels remains high for team 1 with slightly increase of the average score. It can be assumed that the worker would have physical problems and/or would leave the company at further increase of the stress levels.

Team	Worker	Initial score	Final score	Average final score
1	1	27	29	27,5
	2	25	27	
	3	22	27	
	4	28	27	
2	1	25	14	14,4
	2	24	19	
	3	27	14	
	4	21	11	
	5	22	14	
3	1	27	8	10
	2	25	10	
	3	24	9	
	4	25	14	
	5	25	9	

Table 7. Final survey results.

The stress levels for the second team decreases from high to moderate. This happens together with performance improvement of 16,14%. The stress levels for the third team decreases from high to low/moderate levels. The performance improvement was 23,61% due to stress and norm reduction. The average score is the lowest among the 3 teams. Although the certain overload level there is low probability workers from the 2nd and 3rd team to leave the company.

It have to be mentioned that if the foreman and team leader use some kind of motivation to the second and third team, the performance and the stress reduction would be higher.

4 Conclusion

Investigation of the performance improvement of direct workers from the automotive industry in Bulgaria was performed when it is applied stress optimization. It used human resources and variety of methods in order to accomplish the purpose. The human resources represented 3 work teams with a total of 14 direct workers from several companies from the automotive industry in Bulgaria. The teams were selected after analysis of their performance for the last 3 months before beginning of the research. Different methods are applied to the individual teams in order to assess the performance more accurately – PSS based survey, stress management, time management, overall equipment effectiveness (OEE). The 1st team was chosen for control team due to the lowest norm and highest quality compared to the other teams. The 2nd was selected for only for stress management. The 3rd was selected for both stress and time management due to the highest norm and lowest quality compared to the other teams. The research took 14 weeks.

The following conclusions can be done from the investigation:

- The historical OEE was around 70%. This OEE percentage could be considered as the lowest limit at which improvement methods is necessary to be implemented.

- High stress levels were reported from the workers at the initial survey. As a result the performance and quality of the work were relatively low. Prolonged exposure or increase above of this level would result in physical problems or company leaving.

- The average OEE of the first team after the end of investigation remains almost the same as the historical OEE (70,53% compared to 70,88% before beginning of the research). Due to this the results from the investigation can be considered as reliable.

- The average OEE of the 2nd team increased with 16,14% (from 69,87 to 86,01%).

- The average OEE of the 3rd team increased with 23,61% (from 69,11 to 92,72%). The stress reduction part in the percentage rise was around 50 – 60%. The norm reduction part in the percentage rise was around 40 – 50%.

- High stress levels remains to the workers from the first team. The average final score showed slightly increase. The probability of company leaving was reported as quite high.

- Stress levels reduction were reported from the workers from 2nd and 3rd team at the final survey. The stress levels of the workers from second team reduced to moderate. The stress levels of the third team reduced to low/moderate. The probability of company leaving was reported as relatively low.

- If the foreman and managers use some kind of motivation to the second and third team, the performance and the stress reduction would be higher.

As general conclusion, the stress reduction techniques are effective way for performance improvement of the direct workers from the automotive industry. The effect of the increase can be raised by applying time management methods. The managers in the automotive industry from Bulgaria need to understand and apply the stress optimization methods in order to achieve better performance of their teams and reduce the company leaving probability of the workers. Although the investigation is done for Bulgaria, the result could be applied for automotive plants in every country in the world.

Acknowledgement

References:

[1] R.M. Yerkes, J.D. Dodson. The relation of the strength of stimulus to rapidly of habit-formation. *Journal of Comparative Neurology and Psychology,* Vol.18, No.5, 1908, pp. 459-482.

[2] D.O. Hebb. Drives and the C.N.S. (conceptual nervous system). *Psychological Review*, Vol.62, No.4, 1955, pp. 243–254.

[3] D.M. Diamond, A.M. Campbell, C.R. Park, J. Halonen, P.R. Zoladz. The Temporal Dynamics Model of Emotional Memory Processing: A Synthesis on the Neurobiological Basis of Stress-Induced Amnesia, Flashbulb and Traumatic Memories, and the Yerkes-Dodson Law. *Neural Plasticity*, 2007.

[4] A.T. Welford. Stress and Performance. *Ergonomics*, Vol.16, No.5, 1973, p. 567 – 580.

[5] E. Hekelova, K. Srdosova. Management of human resources in the automotive industry. *Scientific Proceedings*, Faculty of Mechanical Engineering, STU in Bratislava, 2009.

[6] N. Marquardt, S. Robelski, R. Hoeger. Crew Resource Management Trainings Within the Automotive Industry: Does It Work? *Human Factors: The Journal of Human Factors and Ergonomics Society*, Vol.52, No.2, 2010.

[7] B.A. Edimansyan, B.N. Rusli, L. Naing, B.A. Mohamed Rusli, T. Winn, B.R.H. Tengku Mohamed Ariff. Self-perceived Depression, Anxiety, Stress and Their Relationships with Psychosocial Job Factors in Male Automotive Assembly Workers. *Industrial Health*, Vol.46, 2008, pp. 90 – 100.

[8] B.A. Edimansyan, B.N. Rusli, L. Naing. Effects of short duration stress management training on self-perceived depression, anxiety and stress in male automotive assembly workers: a quasi-experimental study. *Journal of Occupational Medicine and Toxicology*, Vol. 28, No.3, 2008.

[9] M. Spallek, W. Kuhn, S. Uibel, A. Mark, D. Quarcoo. Work-related musculoskeletal disorders in the automotive industry due to repetitive work implications for rehabilitation. *Journal of Occupational Medicine and Toxicology,* Vol.5, No.6, 2010.

[10] R. Ramamoorthy, S. Praveen Kumar. STRESS MANAGEMENT IN AUTOMOTIVE SEGMENT, CHENNAI. *International Journal of Pure and Applied Mathematics*, Vol.116 No.18, 2017, pp. 503-507.

[11] P. Gohila, N.A. Kavitha. A STUDY ON ORGANISATIONAL ROLE STRESS IN AUTOMOTIVE INDUSTRY IN VELLORE. *International Journal of Mechanical Engineering and Technology (IJMET)*, Vol.9, No.3, 2018, pp. 700–705.

[12] S. Cohen. Perceived Stress Scale. *Mind Garden*, 1994.

[13] J. Langan-Fox, M. Sankey, J.M. Canty. Human factors measurement for future air traffic control systems. *Human Factors*, Vol.51, No.5, 2009, pp. 595–637.

[14] L. Varvogli, C. Darvili. Stress Management Techniques: evidence-based procedures that reduce stress and promote health. *Health Science Journal*, Vol.5, No.2, 2011.

[15] P. Muchiri, L. Pintelon. Performance measurement using overall equipment effectiveness (OEE): literature review and practical application discussion. *International Journal of Production Research*, Vol.46, No.13, 2008, pp. 3517 – 3535.