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Ergonomic modernization in a selected automotive company

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Abstract

The article sets out on presenting the macroergonomic modernization of a manufacturing system employed at an automotive company specializing in repairing and refurbishing Peugeot vehicles. The paper outlines features of auto mechanics' workstations, which constitute the weakest part of the system. Based on observations, interviews with mechanics, the company's performance statistics and the activities carried out before, during and after work, the author identified common hazards encountered during the work process. The identified factors were assessed by risk evaluation methods. These were employed to estimate the probabilities of the occurrence of risk, the durations of risk exposures, as well as the nature and severity of their consequences. Based on the combined risk assessment, the article presents ways to minimize risk and precautionary measures designed to achieve a macroergonomic upgrade of auto mechanics' workstations in technical and organizational terms.

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Keywords: Manufacturing system; Risk analysis methods

1. Introduction

Ergonomic modernization of auto repair shops is a crucial issue. Its significance results from the fact that, in 2013 alone, Peugeot posted the sales of 18 155 vehicles Poland-wide and 1 553 000 vehicles world-wide, all of which are going to require repairs and maintenance in repair shops.

From the macroergonomic viewpoint, modernizing a company means modifying working conditions to ensure that human resources are utilized as best as possible in terms of work effectiveness and efficiency without imposing excessive workloads on workers.

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Technology should contribute to creating a friendly working environment not only in objective terms but also in the subjective assessment of the workers. Therefore, using interdisciplinary macroergonomic knowledge, the author estimated the cost of the proposed modifications and realistically assessed the capacity to put them into practice.

As a sector, the automotive industry faces complex demands. Not only does it need to manage highly complex production systems in which the ergonomics of the workplace play a crucial role but also needs to copy with stringent quality requirements [10].

2. The manufacturing system

Analyses of manufacturing systems are among the most fundamental sources of data on the work design and corporate governance in place in corporate organizations, particularly with respect to human resources, occupational safety, work economics, industrial psychology, occupational physiology and medicine and the broad field of ergonomics.

Macroergonomic analyses of manufacturing systems are used by human labor experts specializing in technical sciences, psychology, sociology, economics, medicine, natural sciences as well as business management and marketing [5]. All of them rely on data relevant for their particular fields of specialization, which they procure by analyzing individual workstations. For that reason, each such designer needs to know the methodologies of workstation analysis, the theoretical underpinnings of such methodologies and various ways to utilize the raw data sets they obtain. The need for a macroergonomic analysis of work systems in business organizations results not only from the humanistic drive to safeguard the dignity of fellow humans employed in specific positions, ensure their psychological development at work and empower workers in their performance. The workstation analyses carried out in business organizations are also driven by social, ethical and economic considerations [6].

Macroergonomic analyses of work systems seek to acquire data on the occupational performance of workers in specific working environments employed in designated positions within the organizational structures of companies. The focus of such analyses is therefore on the operation of people in specific working environments and the tasks they have been entrusted to complete, which follow from the work design in their companies and specifically from the technologies, IT systems and organization employed in given enterprises.

The work system analyses produce empirical data derived predominantly from observations. Information for system analyses comes mainly from:

- company records the tasks and responsibilities of workers, as defined by company management for their specific positions, primary and secondary legislation as well as internal organization rules,
- monitoring the performance of persons employed in given posts (continuously and on a spot basis, with the use of cameras, through participative observation and observation focused on selected aspects of interest),
- workstation measurements (of psychological and physical capabilities of the workers, physical parameters of the working environment such as air pressure, temperature, humidity, air composition, as well as any physical, chemical and biological hazards),
- interviews with employees and their supervisors concerning tasks, working conditions and the operation of people in a given post [14].

Manufacturing system analyses rely on methods for identifying specific tasks performed at a given workstation, assessing occupational risks, recording hazards and on-the-job accidents and determining the requirements put to workers employed in the relevant posts.

One such method is laid down in the Polish risk assessment standard PN-N-18002 which corresponds to the European standard BS OHSAS 18002. The method makes use of two risk parameters: the severity of outcomes (effects) produced by the hazards occurring at the workstation and the likelihood of the occurrence of such outcomes (injuries, diseases). The severity of the outcomes and the probability of their occurrence is rated on a triple point scale describing each hazard as mild, medium and severe. Risk assessments rely on a similar scale from low to medium to high [11].

The preliminary analysis of risks occurring in manufacturing systems are carried out by the PHA method. The method allows for qualitative assessments of risks on the basis of two parameters: E – extent of damage and P – the probability of the occurrence of such damage. The E parameter of damage extent and the probability of damage occurrence are rated on a scale from 1 to 6. Once the extent and probability has been determined, risk is rated (evaluated) as acceptable (1 – 3); acceptable following an assessment (4 – 9) or unacceptable (above 10) [13].

Another method used to analyze risk in complex multiple structure systems is the “risk score” method which assesses risk as a function of three factors: O – possible outcomes of hazards; E – exposure to risks; P – the probability of an event occurring. Once the “risk score” has been determined as a quotient of the above factors O, E and P, the risk is evaluated (always for a specific workstation hazard) as acceptable, low, significant, high or very high [8, 13].

Another notable method is risk assessment on the basis of job safety analysis. The method identifies risk as a function of two factors: event outcomes (consequences) and the probability of such consequences taking place. The probability of the consequences of an event occurring is measured as the sum total of the three factors of F – frequency of hazard occurrence; P – the probability of event occurrence, and A – the ability to avoid or reduce the event consequences. Once the probability of occurrence of the consequences of an event has been assessed as the sum of the F, P and A factors for specific hazards in a given workstation and once the consequences of the event have been classified, one may begin to evaluate the risk as 1-2 (negligible risk), 3-5 (acceptable risk) or 6-8 (unacceptable risk) [13, 15].

A number of ways are available for assessing workstation ergonomics. These include the suitability of jobs in terms of physical exertion, physical activity, the adoption of unforced and comfortable body postures, suitability in terms of physical effort, elimination of repetitive work, the technical working environment, elimination of negative working environment factors, proper work organization systems, elimination or mitigation of stress and interpersonal interactions with peers and superiors [1]. For the purposes of this article, the macroergonomic analysis of the weakest part of a manufacturing system, which is the auto mechanic’s workstation, relies on the “risk score” method.

3. Macroergonomic analysis of automotive company

A macroergonomic analysis of a social and technical system was conducted in an automotive company. The company employs 5 auto mechanics specializing in the repair and refurbishing of Peugeot vehicles, who are particularly exposed to harmful and hazardous risks by virtue of the sheer complexity, the accountability and the quality requirements associated with their work.

The workers are employed in two shifts (working from 8am to 4pm and from 9am to 5pm). During this time, they repair and maintain cars and other motor vehicles. As specified in their job descriptions, the employees:

- check vehicles and discuss damage type and extent with the customer,
- plan their work using charts, technical manuals and personal experience,
- elevate the vehicles with hydraulic lifts to access mechanical assemblies,
- remove assemblies and components such as the engines using power wrenches and jacks,
- take components apart and check them for wear by means of diagnostics devices,
- repair and replace parts such as pistons and levers using manual tools,
- overhaul and replace carburetors, distributors, pumps, etc.,
- modify parts using cutting and welding equipment,
- replace wiring in electrical circuits,
- replace brake pads and adjust brakes, adjust (center), repair and replace shocks and struts, weld up radiator leaks,
- repair damaged body and fenders,
- replace and adjust lights, install and repair accessories such as radios, heatings and anti-theft alarms
- replace disposable materials and parts (oil, filters, etc.).

Fig. 1. Auto mechanics at work (source: http://opel.dixi-car.pl/uzywane-przypadki.htm).

The author used her own observations, interviews with mechanics, company records and information on activities performed before, during and after work at a given workstation to determine the "risk score" and identify the hazards commonly expected to arise during such work.

For the purposes of this article, the "risk score" method was used to assess the risk of harm to humans and tangible property which may occur in the case of performing specific tasks over a specified time interval. This is an indicator-based method in which the level of reliability and the level of risk, both of which are factored into the overall risk calculation, are expressed against arbitrary numerical scales. Ultimately, therefore, risk is arrived at by multiplying the indicators.

$R = C \bullet E \bullet P$

where:

R – risk

C – potential consequences of hazards

E – exposure to hazards

P – probability of hazard occurrence

The estimated risk level is then assessed against an adopted arbitrary risk scale.

Table 1. Risk assessment / evaluation (source: Kinnley G.F., Wiruth A.D.: Practical Risk Analysis for Safety Management 1976).

Evaluation of risk R	Risk category	Preventive measures
R < 20	Acceptable	Inspection recommended
20 < R < 70	Low	Inspection needed (risk mitigation or maintenance at present level recommended)
70 < R < 200	Significant	Improvement required (risk mitigation measures are in order)
200 < R < 400	High	Immediate improvement required (immediate action needed to mitigate risk, workstation not to be used until risk has been reduced)
R > 400	Very high	Work discontinuation recommended (work may not be resumed / continued until risk has been reduced)

The complexity of the assembly work carried out in the company in question exposes the personnel to multiple physical, chemical, biological, psychological and social factors. Twelve of these have been evaluated by the "risk score" method.

Table 2. "Risk score" evaluation of auto mechanic jobs (source: own research based on observations and documentation).

No.	Hazard	Probability (P)	Exposure (E)	Consequences (C)	Risk (R)	Rating
1.	Noise and vibrations	10	6	3	180	medium
2.	Electric shock	3	6	15	270	high
3.	Tripping and fall on flat surface	6	6	3	108	medium
4.	Tripping and fall to lower level	6	6	7	252	high
5.	Burns	6	6	7	252	high
6.	Cuts	10	6	1	60	low
7.	Overstraining of motor system/organs	10	6	7	420	unacceptable
8.	Impact from objects and moving items	6	6	7	252	high
9.	Being crushed	6	6	15	540	unacceptable
10.	Exposure to deleterious chemicals	6	6	15	540	unacceptable
11.	Overstrained eyesight	6	6	3	108	medium
12.	Explosions and fire	6	6	7	252	high

Three of the hazards identified by the "risk score" method in auto mechanics' jobs in question were judged to be unacceptable. These included being crushed, having one's motor system and organs overstrained and being exposed to chemicals.

To rectify the safety level in these positions, the author proposed to adopt technical and organizational adjustments at the net cost estimated at PLN 22,250 per year for the five workers. The proposed adjustments included:

- purchases of personal protective items (hearing protection, anti-vibration gloves, enhanced-grip protective footwear, etc.),
- improvements in repair shop design,
- employee training,
- periodic occupational health and safety of compressors and lifts,
- overhauls of electrical and fire safety installations.

In the case of some of the hazards, all that was needed to restore safety was to ensure that the workers abide by applicable standards and exercise caution.

To verify the advisability and suitability of the proposed ergonomic adjustments in the company in question, the author used the "risk score" method to reassess the industrial risk after such preventive measures have been put in place.

Table 3. Proposed preventive measures for auto mechanics and an assessment of their effectiveness (source: author's research based on observations and documentation).

No.	Hazard	Preventive measures	Probability (P)	Exposure (E)	Consequences (C)	Risk (R)	Rating
1.	Noise and vibrations	Use hearing protection, ear caps, ear plugs and anti-vibration gloves. Use machinery and equipment as per technical documentation and operating manuals. Use only those machines, power and other tools that are fully operational.	3	6	3	54	low
2.	Electric shock	Carry out ongoing checks and periodic overhauls of electrical installations. Use only those machines, power and other tools that are fully operational. Use circuit-breakers.	0.5	6	3	9	acceptable
3.	Tripping and fall on flat surface	Use proper footwear, maintain order in the workstation area and in shop.	3	6	3	54	low
4.	Tripping and fall to lower level	Ensure proper security of the work process, ensure safe access to shop pit. Use proper lighting. Maintain order. Cover pits when not in use.	3	6	3	54	low
5.	Burns	Use protective items when welding. Take precautions when performing work.	3	6	3	54	low
6.	Cuts	Exercise caution during work. Wear personal protective items.	6	6	1	36	low
7.	Overstraining of motor system/organs	Abide by allowable limits during manual handling of objects. Adhere to ergonomic principles. Use safe methods of lifting and moving objects. Use lifting equipment. Take breaks, rotate tasks for diversity, take scheduled physicals.	6	6	3	180	medium
8.	Impact from objects and moving items	Take particular caution. Limit the speed of vehicles moving on shop floor. Mount repaired items accurately and securely. Use personal protection items and tools in proper technical condition.	3	6	3	54	low
9.	Being crushed	Take particular caution. Properly secure lifted vehicles and vehicles over pit. Carefully elevate and lower vehicles by means of lift. Use fully operational lifts only. Enlist the help of co-workers.	1	6	7	42	low
10.	Exposure to deleterious chemicals	Avoid inhaling dust and exhaust and other fumes. Avoid running engines in enclosed space. Vent fumes out. Use personal protection items.	3	6	3	54	low
11.	Overstrained eyesight	Properly select spot lighting.	3	6	3	54	low
12.	Explosions and fire	Ensure shop is fitted with proper fire equipment. Learn the rules for responding to fire or explosions.	1	6	7	42	low

Once preventive measures were in place for all 12 hazards identified in the auto mechanics' workstations, the level of risk in the manufacturing system in question was reduced to low and acceptable.

4. Conclusions

A holistic multidisciplinary approach helped resolve a great deal of quality, safety and environmental issues [2] in the auto repair system. Macroergonomic modernizations of workstations can eliminate or at least mitigate the majority of the identified hazards. As shown by reference to the proposed preventive measures, an ergonomic equilibrium for repair shop workers can be achieved at a relatively low cost by focusing on the worker, raising employee awareness and making the personnel act more responsibly.

The actual macroergonomic quality of the working environment depends on the degree to which the above modernization postulates are actually deployed creating a foundation for high quality and safe performance of work in the investigated automotive company.

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