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ERGONOMIC AND SAFETY IMPROVEMENTS OF POWER TOOLS

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Abstract This study presents technical solutions whose implementation on the grinder and electro-pneumatic hammers may improve safety and handling comfort of operators. Working conditions to which are exposed workers who are handling with power tools in workshops and construction sites are very often inconvenient and inadequate (low light, dust, noise and vibrations), which as a consequence may have the reduction of visual and motoric capability. Inadequate working conditions cause workers to get tired fast and lose concentration, that may bring to injuries during handling the machines. When it comes to the angle grinders, the improvements that are suggested refer to better visibility of the power cord, the grinding/cutting disc, and on/of state of the power switch. The presented solution for electro-pneumatic hammer drills makes possible to place the machine in vertical position, without deformation and bending of the power cord. Also, there is an improvement of the comfort of handling, with a new switch position for speed regulation, which allows easier speed adjustment when the hammer drill is in use. While working on specific improvements, attention has been paid that the solutions be practical and simple for the tool operators, as well as not to be too demanding for the manufacturers in the sense of the implementation in a manufacturing process.

Keywords: Power tools; ergonomic design; safety at work.

1. INTRODUCTION

Intensive usage of power tools starts in early XX century by mass electrification in industry and households. Power tools are machines used for processing different materials (wood, metal, plastic, concrete, brick, ceramic) and they can be used for drilling, cutting, milling, sanding, planning, trimming, polishing, grinding… The benefit of using power tools is that the finish quality and speed of producing the workpieces and surfaces is on a much higher level compared to the hand tools. Power tools include a large number of different machines, and some of them are: drills, angle grinders, belt sanders, jigsaws, routers, electro-pneumatic hammers and chisels, miter saws, circular saws, sabre saws, polishing machines, planers…
Power tools can be handheld or stationary and be depending on the mechanism type. They can be:

- electrical tools powered by electrical motors
- battery tools powered by battery units
- pneumatic tools powered by compressed air
- gasoline tools powered by internal combustion engines.

Compared to hand tools, engine-driven machines significantly reduce the frequency of motion of the worker during processing the workpiece, which results in a minimal fatigue. The processes involved in design and manufacturing of power tools are complex, and thorough approach is required in order to obtain a well-balanced final product.

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Factors that influence the design of power tools are:

- simplicity of the construction
- ergonomic design of body housing
- quality of the material of the individual parts
- reliability of the machines
- safe usage of a machine
- the possibility of recycling material from which the machine is made of
- accurate production of final products.

Hereinafter, the importance of some of the aforementioned factors especially in terms of ergonomics and safety will be briefly indicated. Specific examples will show how the aforementioned factors can affect the quality of work. A simple construction of machine parts provides economical production, as well as reliability during exploitation that contributes to easier maintenance and servicing of machines. Ergonomics essentially aims to adapt and optimize work space, machines and tools for the human physiognomy and working needs. Adequately ergonomically designed tools result in a more comfortable handling, which in the long term will not lead to fatigue and injury [1]. Led by ergonomic principles in power tool design, fatigue can be reduced and permanent damage to the nervous, muscular and skeleton system avoided [2]. The choice of materials from which certain parts are made plays an important role when it comes to reliability and quality of work. The poor quality material leads to premature failure or breakage of parts, which results in bad operating performance. Usage of highest quality materials, that are not crucial for production, significantly increase the cost of final product. The reliability of machine depends on construction solutions and quality of materials as well as the expertise of an operator, who has to use the machine in a proper way. Intensive monitoring and machine testing, while operating in a longer period of time (simulated working conditions/laboratory or in a real working environment/workshop) may show omissions made in the design or production. Omissions are manifested in premature failure or irregular work caused by intensive wear of highly loaded parts. The safety of use of power tools is a top priority during the design process. It is crucial that all parts of the machine that may be in contact with the hands or body of an operator are ergonomically designed and safe to operate. Accidental human contact with the cutting/grinding disc during the operation can be dangerous or even fatal. Standard protective working equipment [3] which is recommended by the tool and accessory producer, consists of:

- protective glasses
- ear protectors
- safety gloves
- face mask.

An ecological approach to the design and manufacture of tools is important in terms of preserving renewable energy sources. Metal and non-metal alloys, plastics and batteries are reusable by recycling [4] which preserves the ecosystem. The precision of the final processing of elements, which make a machine, must be at a high level. Final processing on the external parts of the tool housing should be flawless, especially in the parts that are intensively used or gripped (handles, power switch, mode selector switch, power tool housing...). Power tool housing that has sharp edges, as a result of

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the poor casting of plastics in molds (Figure1) or increased space of housing assemblies (Figure 2), may cause discomfort during handling of the machine.

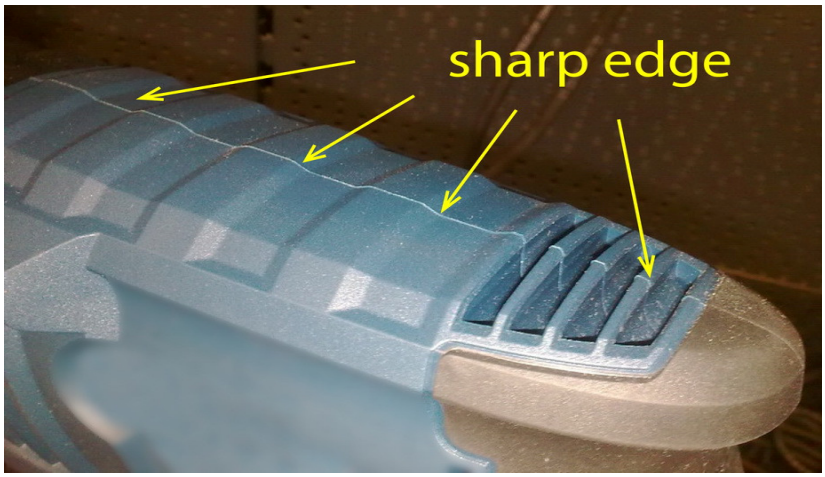

Figure 1. The ergonomically uncomfortable use due to the imprecise processing of power tool housings.

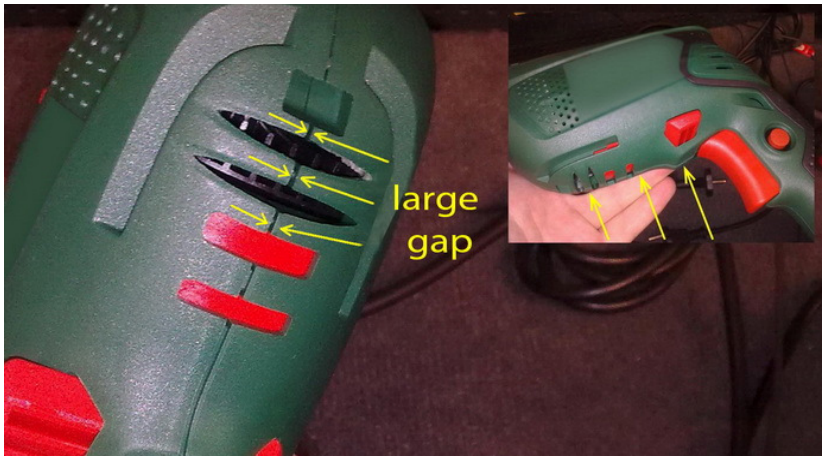

Figure 2. Marked details show imprecision in assembling.

In the following, some individual and original ergonomic and safety improvements for certain types of power tools will be presented.

2. AN ERGONOMIC SOLUTION FOR ANGLE GRINDERS

Angle grinders are power tools driven by engines, which can perform the processing of different materials with adequate auxiliary equipment (grinding, polishing and cutting discs). Depending on the design of angle grinder, engine power and number of revolutions by which the disc rotates, it is possible to:

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- cut and grind metal, stone, brick and ceramic
- polish metal and plastic
- process wood.

Electrical angle grinders are driven by an electric motor whose power ranges from 500-2600 W and number of disc rotations when processing the material is in the range from 500 to 12,000 rpm. Common disc diameters range from 100 to 230 mm, and the diameter depends on the size of an angle grinder. When handling the grinder, special attention is required in order to avoid serious injuries. In addition to protective equipment, that the operator should use (glasses, gloves, and ear protectors), use of the wheel guard is highly recommended [5]. Before using the grinder, it is necessary to check the socket on the wall (whether it is physically damaged or overloaded by other attachable devices), and if there is physical damage to the power cord. The surface, on which power cord relies on, should be dry and without the presence of sharp objects [6]. Usual design solutions of angle grinders that are powered by electricity have black colored power cords. The black color is not the best solution, because of the poor visibility, which ultimately may result in stripping or damaging the cable during the work process. It is very often in practice that after finishing the task, the angle grinder is turned off and stored to the work surface, while the grinder disc is still rotating by inertia. If the work surface is dark (desktop, floor, roof...) and if the operator is not paying attention, it is possible to put angle grinder on the power cord and damage it with the cutting disc. Inadequate lighting of workspace and fatigue that occurs after several hours of work often leads to a weakening of attention and concentration which favors the development of the situation described above. Figure 3 shows the reduced visibility of the cord during the work with the angle grinder in different environments. Inadequate fastening of the workpiece, a lot of sparks during the work as well as cutting of porous materials, makes the angle grinder power cord poorly visible, that may result in an accidental cutting. Power cords in Figure 3 have been marked with red pointers.

Figure 3. Poor visibility during operation can lead to damage of the power cord.

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The presented technical solutions (Figure 4) improves safety and ergonomics of angle grinders as well as visibility of grinding/cutting disc.

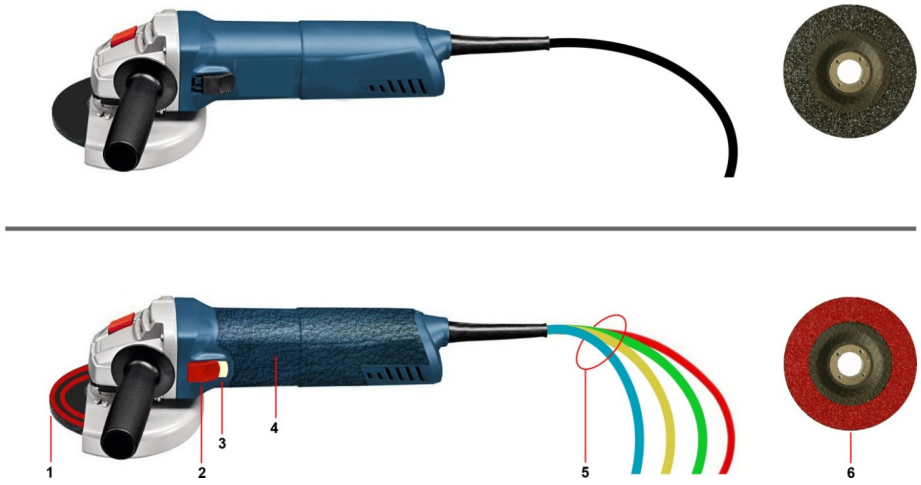

Figure 4. The upper part of the figure shows a conventional design of angle grinder and grinding/cutting disc, the lower part of the figure shows ergonomic and safety improvements.

In Figure 4 upper part shows the grinding disc that usually does not have marked areas, which would highlight the dangerous contact zone. Detail 1 presents the backside of a disc, marked with red circles that show where the disc edge is during material processing. The red color helps the operator to clearly see a marginal part of the disc that represents a dangerous contact zone. Detail 6, shows the face of the grinding disc, which is colored in red for a clear visibility of grinding surface used for processing materials. A visible marking of switch positions on grinders (detail 2), helps to indicate work state, whether it is turned on or off. An example of marking with a fluorescent label that shows up when the switch is turned on is presented with detail 3. The fluorescent label helps better visibility of the work state of the switch, even in the conditions of poor lighting. It is also recommended to coat the grinder housing, the part that is held by hand, with non-skid relief rubber whose function is to obtain less slip in hand during work time (detail 4). Use of a light color for cords helps a user to see the position of cords better during the work with the angle grinder (detail 5).

3. AN ERGONOMIC SOLUTION FOR ROTARY HAMMERS

Rotary hammers are handheld machines driven by the engine, where the electro-pneumatic mechanism and impact-rotational movement of drills, can perform operations of drilling or chiseling. There are used for processing concrete, stone and brick. With a weight of 3 to over 25 kg, engine power of 600 to 3000W, rotary hammers are massive machines where the comfort of handling is very important. While operating these machines generates a significant amount of vibration, noise and dust, so the use of protective equipment is necessary.

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In Figure 5 we can see the most common solution of vertical mounting of the power cord, used by the majority of rotary hammers manufacturers. Displayed solution prevents positioning of drills in the vertical position. Taking into account that the larger models of rotary hammers have a weight of 10 kg or more, deformation of the power cable is inevitable, which in extreme cases can lead to the break of wires.

Figure 5. Vertical mounting of power cords makes disposal of the machine difficult.

Due to the inability of machine disposal on the floor into vertical position due to the position of power cord, leaning to housing sides causes physical damages on the plastic body (Figure 6).

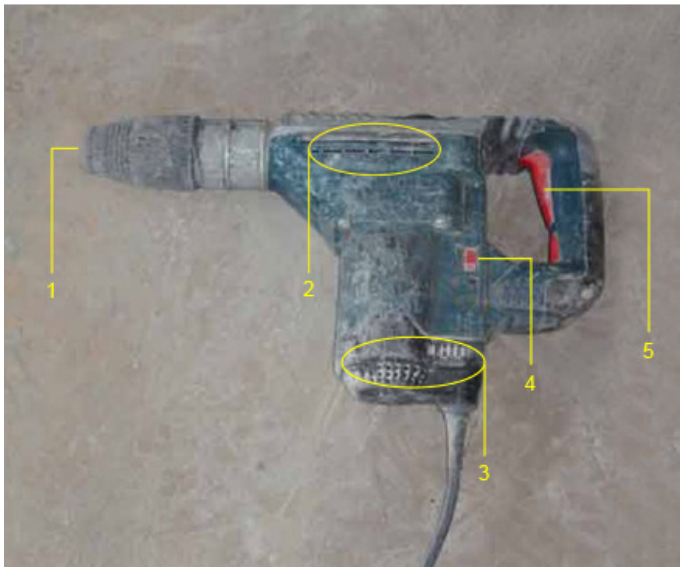

Figure 6. Marked positions are highly exposed to dust entry.

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Besides, intake of dust is increased in the SDS chuck (detail 1), into the engine compartment through the ventilation holes (detail 2 and 3) and in the set of power switches (detail 4 and 5). Taking into account that the dust from concrete and brick in contact with mechanical parts acts abrasive, unexpected malfunction of individual components is possible. Advantages of power cord horizontal mounting are:

- easier disposal of the machine without deformation of power cord
- ventholes, entrance to the chuck and switches are not in direct contact with dust from the floor
- fewer cracks and scratches of the machine's housing.

Graphic illustration (Figure 7) shows a rotary hammer drill, where the speed control switch is set to a more reachable position (detail 1). The output of the power cable from the hammer drill housing, according to the proposed solution is shown in a horizontal position, which enables vertical disposal of the machine on the desktop or floor (detail 2).

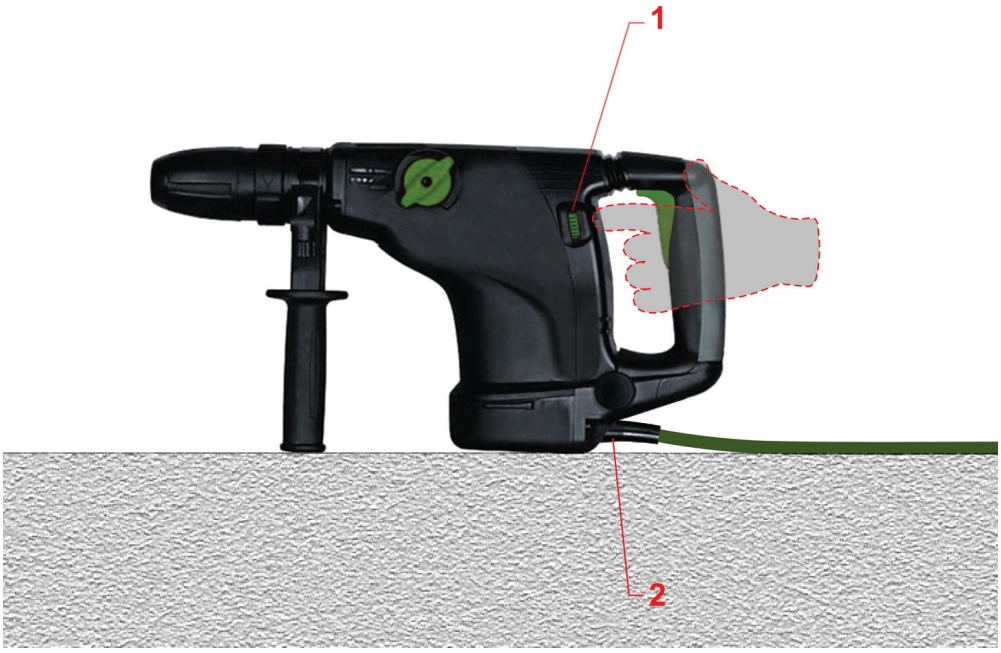

Figure 7. The ergonomic position of the power cord and switch for speed control.

4. CONCLUSION

The ergonomic approach in the design of power tools gains a special significance when the machines are used in demanding conditions, where workers and equipment are under the increased workload. If working conditions are not optimal and power tools are not well designed, in a short period of time fatigue may occur that may result in injury at work. Also, as a result of careless handling, there may occur physical damage on the machine as well as damage to the workpiece.Taking the foregoing into account, the main intention of this publication is to present technical solutions that will help operators

of power tools to have better control over the machines, despite the difficult working conditions and the loss of concentration.

The design of angle grinders and rotary hammers in this publication is adapted to operators, in order to provide safe and more adequate performng of working operations, taking into consideration that those implementations do not affect the work function and technical performances of power tools. Considering that the proposed technical solutions are related to the surface of power tools housing, without affecting the internal structure of the mechanism, implementation in the production process shouldn't be too demanding.

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