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FUME EXTRACTION SYSTEMS FOR TEXTILE LASER CUTTING MACHINES

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Abstract: Lasers are used to cut different materials also textiles. Laser cutting is highly accurate and can easily and precisely create complex shapes, it can also ensure very high productivity. The laser cutting process creates unwanted by–products – a variety of dust, smoke, and aerosols which are generated melting and evaporating cut textile materials. The by–products have to be extracted, filtered and discharged into the ambient air to ensure safe work process and environmental protection. Several parts of a laser cutting machinery are responsible for extraction gases and solid particulates: cutting gas, a cutting surface, an extraction system and filters. Cutting gas drives out the debris and molten material from a cut material kerf. By help of an extraction system the smoke particles and soiling are drawn away above and below the cut material. The filter system separates and removes coarse and fine dust particles and hazardous substances.

Keywords: laser cutting, textile cutting, extraction system, filter system, environmental protection

1. INTRODUCTION

A number of different laser applications are designed for specific industrial use. Lasers are used to cut metals, stones, plastics, rubber, ceramics, leather, textiles and other materials. Laser–cutting systems (see Figure1) are capable of a wide range of cutting and marking tasks, such as, through cutting, kiss cutting, perforating, drilling, engraving, marking, creasing, ablation, structuring, welding etc. [1–7,11].

Comparatively soft materials, such as wood, laminates, sheet metal, plastic films, sheet plastics, foam core, paper, cardboard, leather and textiles use to be cut by carbon dioxide (CO_2) lasers. The laser textile cutting method has several important advantages. As there is no physical contact between the cutting device and the material, very fragile materials and parts can be cut with little or no support and contaminants cannot enter or become embedded in the material. Light–weight fabrics can be cut by laser in high quality and very fast, often much faster than by knife cutting systems [8–13]. Laser cutting is highly accurate and can easily and precisely create complex shapes. Laser power can be accurately controlled to perform different laser treatments on textiles by the same laser source: cutting, kiss cutting, engraving, marking, perforating. Laser cutting is tool–free processing that does not have extra costs related to the purchase and maintenance of cutting tools. There are no delays in the work process because of tool changing and replacement [6,11]. Many software improvements are incorporated into today's optimized laser cutting systems.

Figure 1. CO2 laser cutting machineXL–1600 by company Eurolaser

2. BY–PRODUCTS OF LASER CUTTING PROCESS

Next to great advantages of laser cutting method comparing with a long time used textile knife cutting method, there is also negative sides of it. The laser cutting process produces unwanted by–products – a variety of dust, smoke, and aerosols which are generated due to melting and evaporating cut materials of textile. In the industry these contaminants are known as Laser Generated Air Contaminants (LGACs). They can negatively impact cutting process quality and contaminate or even damage machinery and processed materials. Laser cutting dust impact on cutting efficiency and that is a serious concern. Dust could be so thick that it can diffuse the beam. This reduces the intensity of the beam and can interfere with the process. Also, maintenance costs for these processes can rise if dust is not extracted properly and regularly. By–products also can cause an environmental concern and pose a threat to the health of workers. People can become permanently sensitised to fumes which means that continued exposure, even to very small amounts of fume, may cause asthma attacks or other respiratory diseases.

Dust created by laser cutting is a serious inhalation hazard. The intense heat involved in the process creates particulates in the sub–micron size; the smaller the particulate, the easier it is inhaled and absorbed into the human body [14]. Dusts might include particles of many different elements and molecules. Some of them are dangerous and the Occupational Safety and Health Administration (OSHA) [15] has issued separate worker exposure limits for each one. Fine dusts can be an ignition hazard, as well.

Regulations for laser cutting dust "Permissible exposure limits" (PEL's) are set by OSHA to limit many individual toxic or nuisance dusts as well. These limits are measurements of how much of a substance a worker can be exposed to over an 8–hour shift.

Extraction of gases and solid particulates obtained melting, burning and evaporating cut material is important part of the laser cutting process. In different applications ration in between them use to be different. For example, fume from nylon when treated by laser is roughly 80% particulate to 20% gas, whereas fume from acrylic is 90% gas to 10% particulate [16]. If the contaminants are simple nuisance dust, the filtration would be quite simple and inexpensive. However, if the dust contains one or more dangerous particulates, a filtration system would be capable of filtering that out of the air.

The by–products have to be constantly extracted and, depending on the application, filtered and discharged into the ambient air. Several parts of advanced laser cutting machinery are responsible for extraction of both gases and solid particulates, they are: cutting gas, a cutting surface and an extraction system of a laser cutter [6,11].

3. AUTOMATED LASER CUTTING SYSTEMS AND THEIR MAIN PARTS

A laser system for textile cutting consists of: a laser source, an optical system to guide the laser beam, a laser cutting tool, computer–controlled machine axes to guide the laser tool, operational software, a work surface to support processed material and the extraction system to take away fumes and dust [3].

Laser cutting tool

The laser beam is a column of very high intensity light of a single wavelength, or colour. In the case of a CO_2laser it is infrared light at 10.6 microns. The most part of textile materials may be processed with 60–100 W lasers. However, there are some textiles, e.g., Aramid (Kevlar), which is processed with 400 W lasers. During the cutting process, the light from a laser source is transferred by mirrors and delivered at the cut surface. As the intense beam of light strikes the material, it's temperature rises, portions of it melts, burns, evaporates and by–products (fumes and dust) create [6,11,12].

Cutting head (processing head)

The main parts of the cutting head are a focusing lens and a cutting nozzle. By help of the lens the laser beam is focused onto the material surface precisely for cutting or engraving. A cutting nozzle guides the stream of compressed air into the cutting gap to keep clean cut material edges and take away dust and fumes generated in laser cutting process (see. Figure 2).

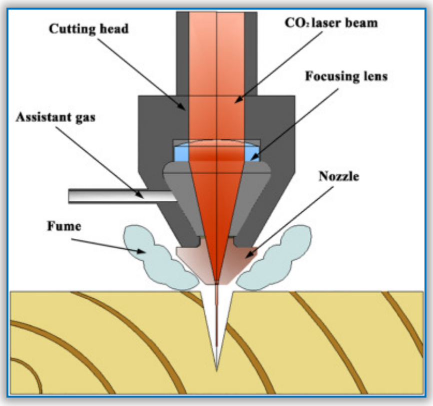


Figure 2. Laser cutting head

Cutting surface

Both gantry and galvo laser systems perform laser treatment of the material on a specifically designed static or conveyorized work surface [11]. Processing flexible materials, such as textiles, a cutting surface has several functions: it has to keep the textile material flat and fixed during the work process, it has to minimize "reflection burns", as well as, it has to support the extraction system of the cutter to lead away the cutting emissions. Taking into account described functions of the cutting surface and the type of job to be performed, metal plates, perforated or not, and grid kind of working surfaces are used for processing textiles [6].

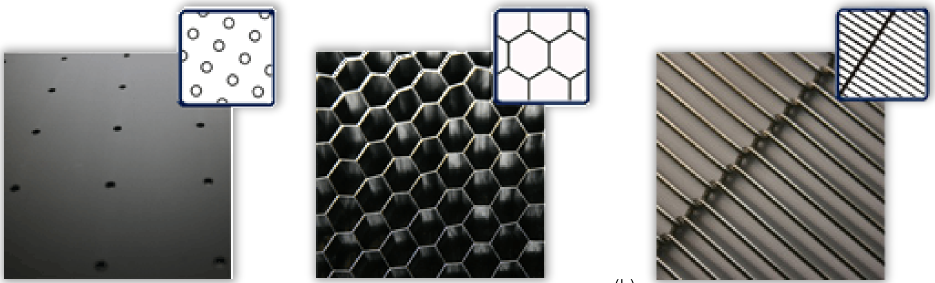
Metal plate

Metal plate (perforated or not) is used on static tables to perform material engraving and marking when the laser beam effects only the top surface of the textile material and not going fully through it (see Figure 2). Very thin fabrics also can be cut on the metal plate because they require very low laser power.

By use of surface perforation, vacuum/extraction system can keep the material fixed and evacuates the cutting emissions.

- Metal grid

Using metal grid (in a shape of web, honeycombs, lamella, or other) the laser beam can pass cleanly through the cut material reducing underside reflections (which are the reason of burning of the back side of material). The grid kind of surface also provides free airflow under the cut material to exhaust cutting fumes easily from the work area avoiding deposition of debris on the reverse side of the cut material. Combined with an air suction system, the grid surface is ideal for cutting light, thin and unstable materials such as textiles.



(a) (b) (c)

Figure 3. Cutting surfaces: perforated metal plate (a), honeycombs (b) and lamella (c)

4. CUTTING GAS (SHIELD GAS, ASSIST GAS, PROCESS GAS)

During the work process, the laser beam heats, melts and partially or completely vaporizes the cut material. The stream of compressed gas (air or nitrogen) is led to the material through a cutting nozzle to drive out the dust and molten material from the cut kerf – the groove made while cutting (see Figure 4). Together with the compressed gas the dust it is vacuumed off downwards through the cutting gap and surface of the vacuum table. The gas also cools the heat–affected material zone and thus reduce cutting width, ensure uniform cut edges, minimize material oxidisation marks on cut edges. Clean air is mostly used as the cutting gas for processing textiles [6].

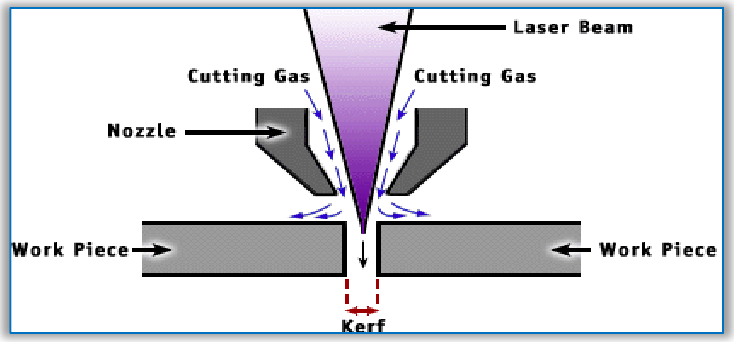


Figure 4. Cut material kerf

The cutting quality and extraction of dust and fumes are very much dependent on the pressure of the cutting gas. If the pressure is too low, the fluid slag can remain adhered to the cut material, forming a permanent burr or closing the kerf again. If the pressure is too high, the lower edges of the cut can be burnt out and often make the cut unusable. Cutting gas pressure has to be increased with the material thickness rise.

5. EXTRACTION SYSTEMS

By help of special extraction system, the smoke particles and soiling created in the laser cutting process are drawn away above and below the material (see Figure 5). Properly positioned fume extraction also prevent or minimize underside marks caused by cutting structure of the table.

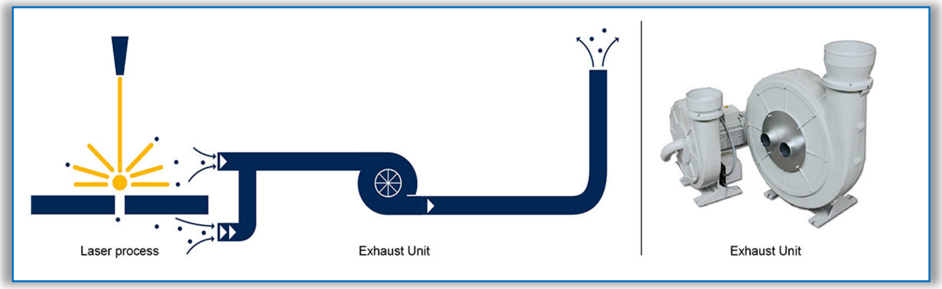


Figure 5. Exhaust unit by company Eurolaser

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Lower extraction

A special air suction system located beneath the cutting surface collects cutting emissions and leads them away (Figure 6). Under the processed material ply it lowers pressure and ensures that thin, flexible materials lay on the cutting surface evenly, prevents cut materials from slipping and small cut parts from lifting. The level of the vacuum as well as the sections of the table that are exhausted can be adjusted individually depending on the treatment, material properties and size of the treated material ply. Lower extraction is proper mainly for gantry systems where the cutting tool is relocated over the significant processing area. Energy costs can be reduced by switching off segments that are not needed.

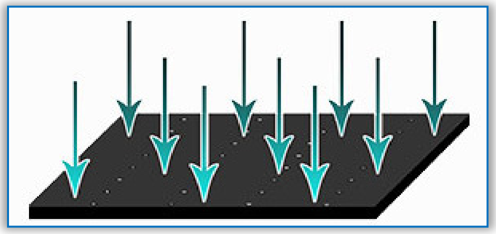
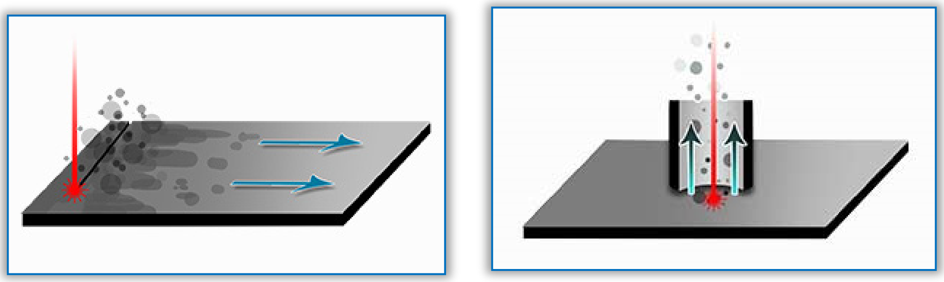


Figure 6. Lower extraction system

Upper and lateral extraction

Above the cut material the cutting emissions can be collected in two different ways: laterally or upwards. In the case of lateral extraction (see Figure7a) ambient air with emissions is evacuated via lateral exhaust slots that are usually located at the rear. This extraction method has one disadvantage – the fumes which are dragged over the material surface can soil it causing marks. Using upper extraction (see Figure7b) cutting emissions are collected around the laser beam directly upwards. Upper/lateral extractions very important when the functioning of the lower extraction unit is restricted or impossible, for example, performing through cutting on the metal plate, performing engraving and kiss cutting, when material is not completely cut through and performing denim finishing on mannequins.



(a) (b)

Figure 7. Lateral extraction (a) and upper extraction (b)

Emissions filtering

To ensure reliable and safe work process and environmental protection, emissions arising from the thermal cutting process need to be extracted safely and if necessary filtered. The filter system separates and removes coarse and fine dust particles and hazardous substances. Hazardous substances, even from the gas phase, are removed using specially designed multistage filters (see Figures 8,9) [16,17]. The advantages of exhaust technology have an impact on cutting quality, cutting speed, material positioning, safety at work, environmental protection and particle filtering.

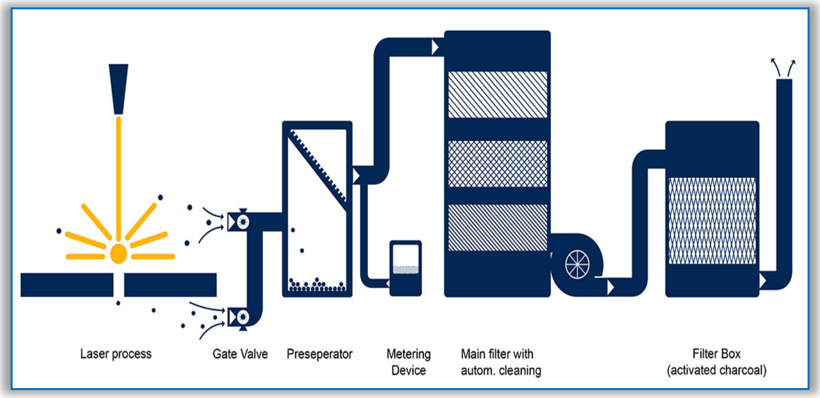


Figure 8. Air extraction concept EFC by company Eurolaser

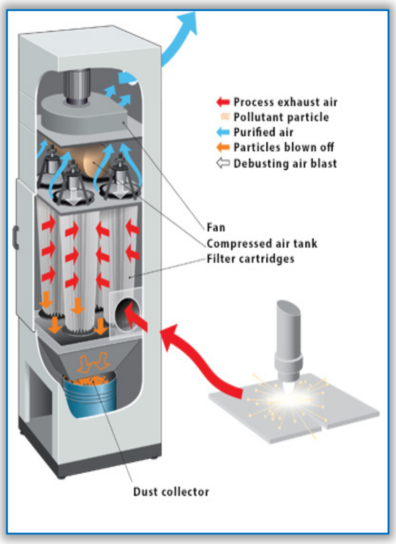


Figure 9. Filtering system by Eurolaser

6. CONCLUSIONS

Currently because of changes in the market and fast fashion dominance, ordered garment styles are manufactured in smaller quantities switching textile material cutting from automated multi–ply to single–ply cutting methods. Comparing with traditionally used knife cutting, the laser single–ply cutting can ensure higher productivity, cutting accuracy and other important advantages mentioned in the article. Producers of the automated laser cutting systems are constantly improving their equipment to ensure higher cutting quality and reduce by–product impact to cutting process, human health and environment.

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