The Structural Design of Industrial Vacuum Cleaner for Dental Laboratories

R. Slanina and P. Sniehotta

Abstract Developed industrial vacuum cleaner, is designed for use in dental laboratories. Primarily is the vacuum cleaner designed for suction of fine dust generated during the manufacture of dental prostheses. In the medical field in general, emphasis is placed on quality workmanship, durability and cleanliness of the environment. This represented a challenge in the design of the device with respect to the required performance and price. Compared with similar vacuum cleaners on the market, with the same power, there is a much better ratio of the basket volume, to the overall dimensions of the vacuum cleaner. The hallmark of the vacuum cleaner is the ability to connect two separate hoses to the vacuum cleaner. Unique about the vacuum cleaner is a triple filtration system and noise, which is lower than competitors. This article describes the development of the vacuum cleaner.

Keywords Vacuum cleaner • Dental laboratories

1 Introduction

Development of industrial vacuum cleaners Applebox DL2013 for dental laboratories, was only one part of the development of equipment for newly established training center YESdent in Jesenik. Part of the development was, apart from vacuum cleaner Applebox, especially the development of laboratory table MIG and suction module EM1. Strong emphasis was laid on design for all devices.

For the vacuum cleaner was essential, besides the required suction power and volume of basket in the design of vacuum cleaner was a crucial point of the resulting noise level. Production of dentures is a challenging work for accuracy. Long-term high noise, reduces concentric and can affect the overall quality of work. For this reason, apart from design of the vacuum cleaner, the noise reduction was a major problem (Fig. 1).

The tables were designed from polished stainless steel and artificial stone. To this was adapted the design of the vacuum cleaner. For hygiene reasons, simpler

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Fig. 1 Training center YESdent – Jesenik

Fig. 2 Table visualization

production and price, a galvanized sheet was chosen, painted with white comaxite color. This contrasts well with the silver color of stainless steel (Fig. 2).

2 Design

The basis on which it was necessary to build, were the dimensions of the box in the table (H×W×D $550 \times 250 \times 530$ mm), where the vacuum cleaner should be placed. The vacuum cleaner should contain a basket with a minimum volume of 15 L, which the space for other components was very small. A specific feature of the vacuum cleaner Applebox is the ability to connect two suction hoses to one

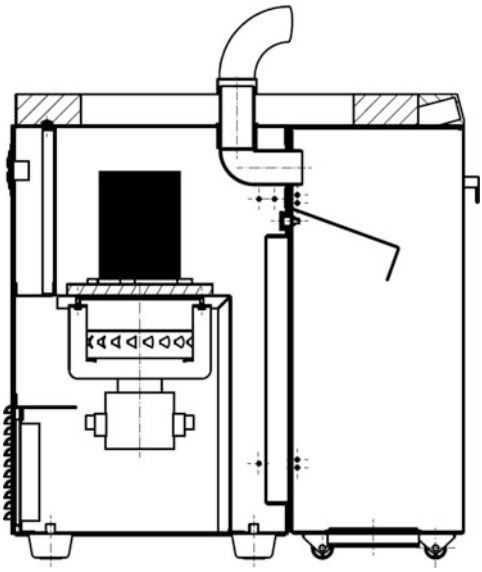

Fig. 3 Cut through the vacuum cleaner

vacuum cleaner. This is very important because the work tables in laboratories are for two laboratory technicians.

The body of the vacuum cleaner and basket was made of 1.5 mm galvanized steel sheet. Galvanized sheet was chosen because of better weldability compared to a stainless steel sheet. Thicker sheet reduced the risk of resonance and increase rigidity vacuum cleaner. Through it came to noise reduction. The disadvantage, however, is the higher weight (Fig. 3).

Basket of the vacuum cleaner was welded to ensure the tightness. The rest of the vacuum cleaner was riveted whit blind rivets, respectively screwed together on parts that should be releasable. A problematic point was the mount of engine bracket, to the cover sheet of the vacuum cleaner. In terms of design it was undesirable to have visible connections on the sides. For this reason, the engine bracket was riveted to cover only the top and bottom. The sides were glued together whit MS polymer (Silyl Modified Polymers terminated) adhesive. This increased rigidity. At the same time using PU adhesive a flexible connection was created, which reduces the transmission of vibrations on a the vacuum cleaner cover and thus contributes to reducing the resulting noise level.

The space in the vacuum cleaner can be divided on the suction and exhaust section. The suction motor, positioned in the exhaust section should have at least 1300 W input power and flow of 3 m^3/min. It was selected motor Hevo SMO.116 127-00, which is also designed for wet suction and has a separate cooling. For reducing noise and vibrations from the motor, it was important to “separate” the motor from rest of the vacuum cleaner, to reduce vibration and noise. Therefore, the engine was placed on the silentblocks and between the motor contact surface and the body of the vacuum cleaner, were inserted rubber rings (Fig. 4).

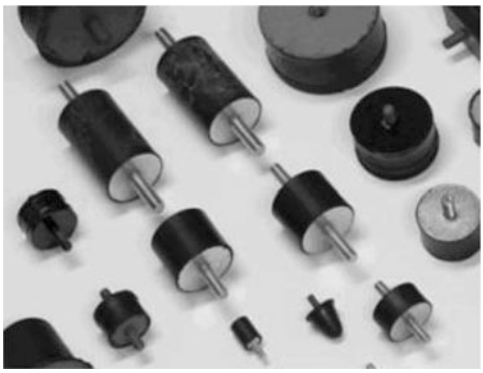

Fig. 4 Sample of the silentblocks

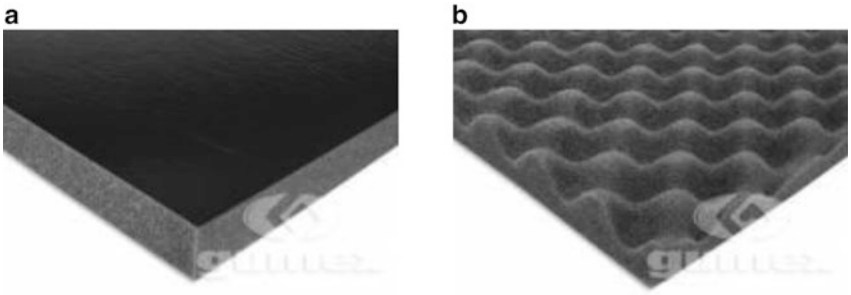

Fig. 5 Noise reduction foam whit PU film (**a**) and wavelet (**b**) – Gumex

Noise reduction has little effect on the function of the vacuum cleaner, but it is essential for the quality work environment. The aim was to achieve a noise level below 60 dB at maximum operation. For this reason, all the sides of the vacuum cleaner body were provided with acoustic foam Gumex type 501 with a thickness of 20 mm. To avoid capturing dust into the foam, a version with black polyurethane film was chosen (Fig. 5).

At the bottom, in the exhaust section and front of the output filter, for better noise absorption, it was used the noise reduction foam Gumex type 505 (in the form of wavelets) with a thickness of 50 mm.

For vacuum cleaner is an important part the filtration of the sucked material. Choosing the right type of filter has a large influence on the resulting noise level. In this case it was a very fine dust which arises in the production of dentures. The dust should not escape from the cleaner space, so we chose a three-stage filtration and quality sealing of the connection between the basket and the body of the cleaner.

The first filter is placed already in the basket vacuum cleaner. We had to make a frame filter (class F5), according to our dimensional requirements, manufactured at the company EWAC (Fig. 6).

Fig. 6 Frame filter for basket – EWAC

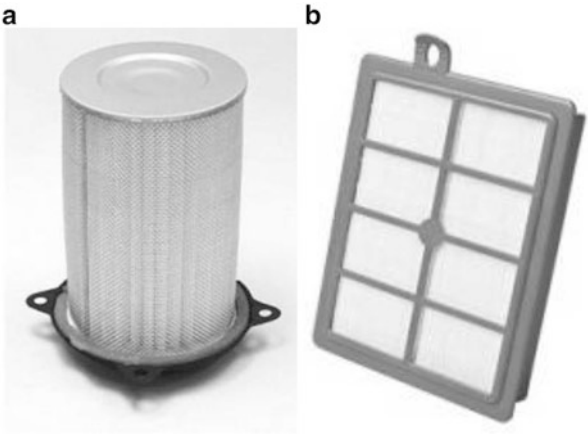

Fig. 7 Motor filter – Hiflofiltro (**a**) and output HEPA filter – Electrolux (**b**)

The second stage consists a cylindrical filter Hiflofiltro HFA 3501. It is in the suction section and protects the motor against the ingress of dust, which the basket filter does not capture.

The third filter is located in the exhaust section, just before the exhausting the air into the room. For absolute filtration has been used Electrolux EFH12N filter, filtration class H13 (HEPA) (Fig. 7).

Noise level of the vacuum cleaner was then measured in an anechoic chamber, using the methodology according to DIN EN ISO 3745 on a hemispherical surface. According to these measurements, at maximum operation the noise level reaches values of the time-averaged sound pressure $Lp = 51.139$ dB, with the index $Vl = 3552$ dB and values of sound power $Lw = 54{,}139$ dB with standard deviation $\sigma tot = 3.587$ dB.

A separate part is the solution of the vacuum cleaner electronics. The vacuum cleaner has an on/off button and a dial to regulate the power of the vacuum cleaner. Solution of electronics has been designed so, that the control system worked (for safety reasons) on the 24 V voltage. Solution of electronics was assign to company MARPOS. The vacuum can have a conventional arrangement controls (the controls

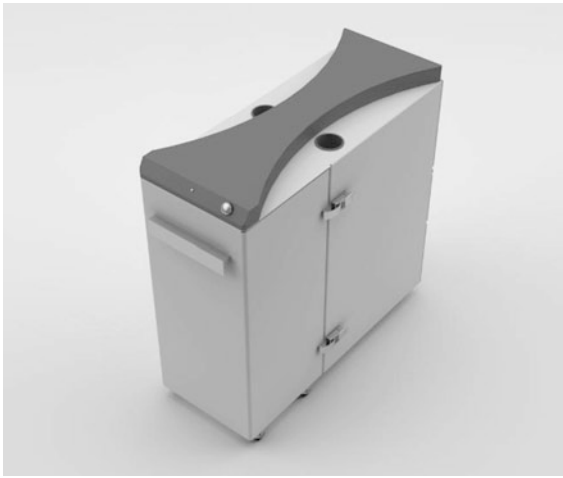

Fig. 8 The final vacuum cleaner Applebox DL2013

are located in the upper part made of artificial stone), or the second option is to lead the controls out of the vacuum cleaner. This allows to integrate the controls into the laboratory table (Fig. 8).

3 Conclusion

The final design solution is functional and several pieces of the vacuum cleaner have been already sold. Despite the development of the vacuum cleaner continues. The main goals for the future is to simplify emptying the basket, which is full very heavy. Another point of development is to expand options in the electrical part. Specifically preparation electronics for engine whit higher performance and system for starting the vacuum cleaner when you turn on another device.

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