

REVIEW AND EVALUATION OF DIFFERENT PAINT BOOTHS DEPENDING ON THEIR AIR FLOW

Paulius Skėrys

Šiauliai University, Department of Engineering

E-mail: skeryspaulius@gmail.com

Introduction

Like everything else in manufacturing, it is possible to find a spray paint booth designed for any particular application. There are models designed for small plastics, furniture, motorcycles, automobiles, aircraft, boats, etc.

Booths are classified into pressurized and non-pressurized. Pressurized booth is an enclosed spray booth that exhausts air outdoors at the same volume at which it draws air in. An air makeup system or heater is used in colder environments, to aid temperature control and air purity. This is a popular style for manufacturing and refinishing automobiles and electronics. Here a clean environment is a vital component to finish quality. Non-Pressurized Booth draws air from, and expels it into, the building through a series of filters. Some environments require a heated air makeup unit. Many industries use non-pressurized spray paint booths, including auto manufacturing and refinishing of metalwork and fiberglass. Both pressurized and non-pressurized spray booths come in a variety of airflow configurations, each with its own advantages and disadvantages. The type of ventilation system the paint booth will use is one of the most important factors to consider. There are three main types of spray booths depending on their air circulation configuration: cross draft, side draft and downdraft.

The aim of the article. To evaluate which of the described types of air flow used in spray booths is the most optimal based on analysis of options.

Research objectives. Identify pros and cons of each painting booth type. Evaluate optimal air flow form in relation to the price, simplicity of construction, paint finish quality, overall spray booth size and energy consumption.

Evaluation of each spray booth type

Cross draft spray booths bring air through the front of the spray booth and exhaust it out at the rear of the booth (see Fig. 1). Used air is put through a filter system. The major benefits to this type of booth is that they are more affordable than downdraft booths and typically easier to install because there is no concreting to be performed. When accompanied with an air make up unit they are often as effective as a downdraft spray booth in providing a clean finish. The downside is that if top priority is finish quality a downdraft will always have a cleaner paint finish because all overspray is pulled down away from the product while in a cross draft spray booth, overspray at the front of the spray booth can potentially land on your product at the back of the booth. Cross draft booth is not particularly adequate when painting multiple vehicles in the same booth, because overspray sits on objects further from air inlet [2].

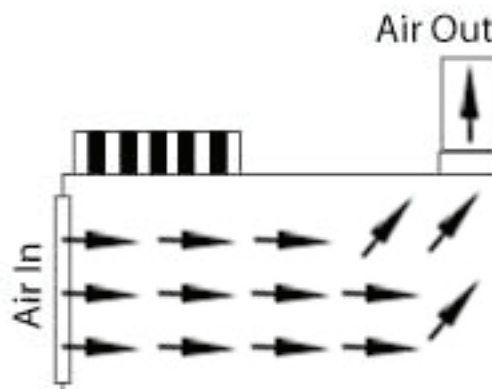


Fig. 1. Cross draft spray booth model [4]

Side draft paint booths bring air in through the roof and exhaust it out the sidewalls of the paint booth (see Fig. 2). The exhaust ducts are placed on the bottom of the booth so it is highly efficient. This allows for a downdraft finish quality but doesn't require a lifted construction of the booth floor. It might seem like a Side draft paint booth has all the benefits of the downdraft without any drawbacks, but there are some negatives to a Side draft paint booth. First of all it will require a lot of ductwork which can often lead to a cost similar or even more expensive than a downdraft paint booth. For example a Side draft paint booth will require at least twice the number of duct runs compared to cross or down draft paint booth that requires longer booths and even more

duct runs. Each duct run also adds an additional risk of weather tightness on the building. An additional downside to Side draft spray booths is that over spray from painting is carried back against the painter which can be annoying for some painters, has greater health risk and can be a threat to the finish quality if a painter is not skilled enough. A final consideration is that a Side draft will exhaust a similar volume of air as a downdraft paint booth. Ultimately, if a downdraft finish is absolutely needed and it is impossible to alter the floor of a building a Side draft can be a good solution. It can also be a great solution for a smaller booth where only two duct runs would be needed and no floor alterations can be made [1].

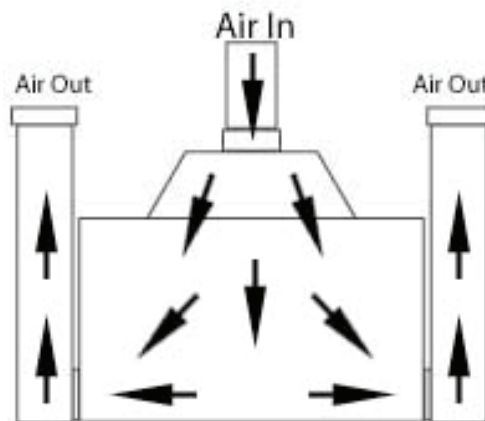


Fig. 2. Side draft paint booth model [4]

Downdraft spray booths bring air in through the ceiling and down through the floor into an exhaust chamber which is exhausted at the rear of the paint booth (see Fig. 3). Downdraft spray booths will provide the cleanest possible finish. It is what is used in high-end auto body facilities due to the clean finish provided. The downside to downdraft booths is that they typically require a raised floor or concrete pit which can be an additional expense. This also requires a building with higher ceiling. Downdraft paint booths provide the best finish when it comes

to painting several items at once, as the air is filtered from the top down, and pulled away from whatever is being painted. They are typically a bit more expensive to install, as there will be concrete work required to accommodate the venting system in the floor, but the price can be well worth it for achieving high-quality finishes. Downdraft paint booths also tend to not work as efficiently with very large vehicles, as it's difficult to orient a project to the air flow, since it runs in accordance to the width and height of the building [3].

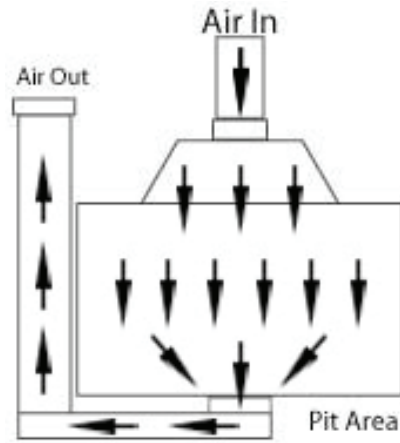


Fig. 3. Downdraft spray booth model [4]

There is alternative air circulation for painting booths as well, such as open face and reverse flow.

Open face spray booths include a ceiling, two sidewalls, and a rear exhaust plenum (see Fig. 4). Air flows through the open front and out through the rear exhaust system where air cleaning filters are placed.

Open type booths are popular choices for woodwork and finishing furniture. These booths are also found in auto facilities, from manufacturing to repair centres. It is relatively cheap to install and maintain but provides lower finish quality [2].

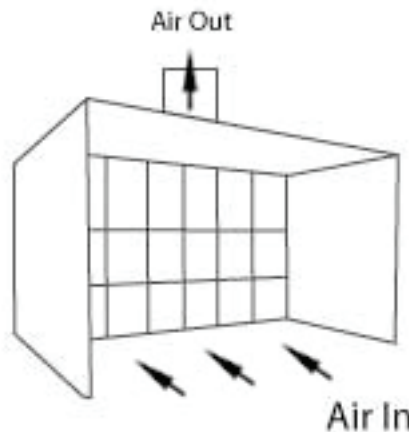


Fig. 4. Open face spray booth model [4]

In reverse flow painting booth, the exhaust is located at the front near the drive-in doors and the fresh air enters through the rear wall (see Fig. 5). This allows any debris near the drive-in door to be pulled

directly into the exhaust. This paint booth provides great air filtration at the entrance of the booth, limiting shop dust from entering the booth.

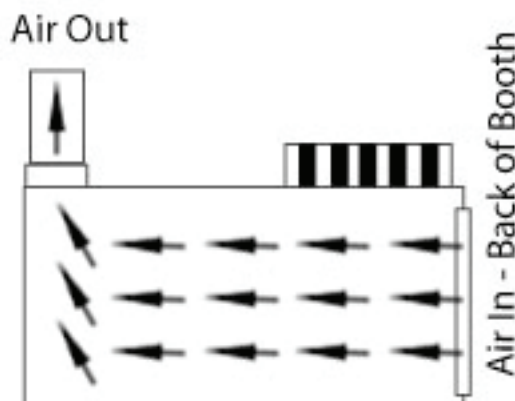


Fig. 5. Open face spray booth model [4]

Analysis of options

In order to quantify each option and compare it with each other, it is necessary to determine common evaluation criteria. Taking into account the requirements and the nature of the work, the following are being used:

1. Painting booth price (X_1) – total cost of booth itself and building it;
2. Simplicity of the construction (X_2) – the simpler the construction the better;
3. Paint finish quality (X_3) – what level of finishing is possible to achieve;
4. General spray booth size (X_4) – the size required for the whole system;

5. Energy consumption (X_5) – the amount of energy consumed by air flowing system.

Table 1 shows the evaluation of each variant examined. The higher the score the more the option is relevant to the criteria. The maximum possible rating is one point. If all the criteria considered are of equal importance, the best option is the one with the highest score or product. However, the importance of the criteria varies, thus we cannot choose the best option. Therefore, weighting coefficient a_{xi} will be used for evaluation of the criteria. The values of these coefficients are given in Table 2.

Table 1. *Variation evaluation by criteria*

Style \ Mark	X_1	X_2	X_3	X_4	X_5
Cross draft	1	0.8	0.4	1	0.6
Side draft	0.8	0.6	0.6	0.8	0.8
Downdraft	0.8	0.6	1	0.6	1
Alternative	1	1	0.4	1	0.6

Table 2. *Values of coefficients*

Coefficient	Value
X_1	1
X_2	0.4
X_3	1
X_4	0.8
X_5	1

Table 3. *Generalised decision criteria values*

Style	Generalised decision criteria value
Cross draft	3.12
Side draft	3.08
Downdraft	3.52
Alternative	3.2

Generalised decision criteria W is being calculated

$$W = \sum_{i=1}^n a_{xi} \cdot X_i;$$

- W – generalised decision criteria;
- a_{xi} – importance value of coefficients;
- X_i – criteria;
- n – count of styles.

In table 3 the generalised decision criteria value calculations are being shown.

Obviously this type of decision making is based on personal opinion, intelligence, and competence. However, it provides greater neutrality compared to any heuristic method.

Conclusions

1. The most optimal spray booth in regard to price, simplicity of construction, paint finish quality, general spray booth size and energy consumption is downdraft.
2. The least suitable spray booth type according to all of the criteria is side draft.

References

1. Guerrero C.A., Wang J., Li J., Arinez J., Biller S., Huang N., Xiao G., 2011 February 10, Production system design to achieve energy savings in an automotive paint shop, International Journal of Production Research, [interactive], [retrieved 2018 November 22]. Access through internet: <https://www.tandfonline.com/doi/full/10.1080/00207543.2010.535042>.
2. Taylor J. R., O'Shaughnessy P. T., Reynolds S. J., 2010 August 17, Estimating Personal Exposures Based on Mass Balance Material Usage Rates: Validation of a Ventilation Model in a Spray Paint Booth, Journal of Occupational and Environmental Hygiene, [interactive], [retrieved 2018 November 23]. Access through internet: <https://www.tandfonline.com/doi/abs/10.1080/15428119591017097>.
3. Goyer N., 2010 June 04, Performance of Painting Booths Equipped with Down-Draft Ventilation, American Industrial Hygiene Association Journal, [interactive], [retrieved 2018 November 23]. Access through internet: <https://www.tandfonline.com/doi/abs/10.1080/15428119591017097>.
4. Spray booth manufacturing, [interactive], [retrieved 2018 November 23]. Access through internet: <https://sprayboothsolutionsinc.com/spray-booth-manufacturing/>.

Summary

REVIEW AND EVALUATION OF DIFFERENT PAINT BOOTHS DEPENDING ON THEIR AIR FLOW

Paulius Skėrys

All companies aim to produce the best quality product and receive the highest profit. Also ensuring a healthy environment for employees is of high importance. Choosing the right type of spray booth will assure the latter in any company that is involved in painting. The article reviews and evaluates different airflow type spray booths. Using analysis of options the optimal decision is determined taking into account the price, simplicity of construction, paint finish quality, general spray booth size and energy consumption.

Keywords: *paint booth, side draft, cross draft, downdraft, air flow.*

Santrauka

DAŽYMO KAMERŲ ORO SRAUTO TIPŲ APŽVALGA IR ĮVERTINIMAS

Paulius Skėrys

Kompanijoms, siekiančioms pagaminti geriausios kokybės produktą ir gauti didžiausią pelną, labai svarbu sukurti saugią ir nekenksmingą sveikatai darbo aplinką. Įmonėse, užsiimančiose dažymo darbais, šie tikslai pasiekiami išsirinkus tinkamiausią dažymo kamerą. Šiame straipsnyje apžvelgiami ir įvertinami skirtingi oro srautų tipai dažymo kamerosse. Variantų analizės metodu parenkamas optimalus sprendimas įvertinant bendrą įrenginio kainą, konstrukcijos paprastumą, nudažyto paviršiaus kokybę, įrenginio dydį ir energijos suvartojimą.

Prasminiai žodžiai: *dažymo kamera, šoninis traukimas, kryžminis traukimas, apatinis traukimas, oro srautas.*

Įteikta 2018-10-18

Priimta 2018-11-20