Fan Speed for Solar Kilns

Editor's Rating ★★☆☆☆

Advice on maintaining appropriate air flow over the stack in a solar drying kiln.
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Question
I am planning to build a solar kiln based on the VT design. I've read that most of the builders use attic fans. I live in France where such fans are not commonly used. So I contacted a company I know that sells industrial fans and they asked me what kind of static pressure the fans will be operating at.

I calculated the CFM needed to obtain a 150 ft/min speed through the stack, but they told me that with the static pressure the efficiency of the fans goes down quite quickly, and that if I take the fans that move 1500 CFM at zero pressure I might in reality move only 750 CFM.

I've also read other speeds on this website like 250 ft/min for oak which I will mainly be drying. Also, when the kiln will be half loaded, the air speed will become higher. How do I estimate static pressure on the fans? Is it needed? How precise is this air speed issue?

Forum Responses
(Sawing and Drying Forum)
From contributor U:
While I do not consider myself an expert, I am currently designing a dehumidifier kiln, and have spent a lot of time researching this very question. (Note: The below may not apply to solar kiln designs.)

Here are some key issues I found: Fan CFM will decrease as the static pressure increases from zero to 0.1 to 0.2 inches of water column (WC.) At this pressure most small axial fans will lose approximately 50% of the rated CFM at zero back pressure. Or, a 500 CFM max fan will flow approx. 250-300 CFM at 0.1 – 0.2 inch WC pressure. This can vary considerably with the particular fan design. So it is best to ask for a performance curve for the fans you are considering and confirm a reasonable max back pressure to achieve at least 50% - 60% max flow.

Regarding air flow rate, this is difficult to determine because the air must flow through a very difficult path through the stack. I found the math over my head trying to calculate the rate, and that calculation would only apply to one stack arrangement. So I have estimated the required flow rate as follows: First, calculate the total volume (cubic feet) of the largest possible stack, including the wood and space between each layer. Consider a total fan flow rate sufficient to change this volume ten times every minute. In actual practice, this will result in a

higher air velocity because the flow is going only through the spaces between wood layers. Be careful when drying less than the maximum load of wood, as this will result in higher back pressure due to less open spacing in the stack. For this situation you might consider larger stickers to produce more open space.

Assuming about 50% of max fan CFM, calculate total fan CFM = Number of Fans X 50% rated CFM. Divide Total Fan CFM by Total Stack Volume (CF) to find Number of Air Changes per minute. (I estimate 8 – 12 should be workable.) If it is less than 8, either add fans or make the stack smaller.

In order to hopefully make the air flow even across the full stack length, I plan to control the flow with a thin perforated hardboard just in front of the stack (between the fans and the stack.) To begin, the total area of the holes is approximately three times the total area of fans. Air velocity can be estimated by dividing total area of holes (Feet) by Total Fan CFM to find Feet per Minute.

I will measure the back pressure with an angle manometer (clear tube of colored water tipped at an angle) with the high pressure side (bottom) connected downstream of the fan and the low pressure side up stream of the fan. If the back pressure is too high, I will increase the size of the openings in the hardboard.

Regarding the type of fans available, for physical size reasons I am using four 500 CFM electronic cabinet cooling fans from a surplus electronics supplier. My dryer is designed to handle 700 board feet max (11' x 4' x 3') or 132 cubic feet volume. The fan curve indicates a flow of 300 CFM at 0.15 in WC. This low back pressure may be difficult to achieve, but I am optimistic. I hope some of this will prove useful.

From the original questioner:
I haven't seen your way of calculating yet. The more common way seems to be to calculate the necessary air movement to achieve a given air velocity through the stack with each species having its optimum air velocity. On this website you'll easily find this information. I'll calculate your way to see what kind of result I find. Your idea to use larger stickers when the kiln is half loaded can result in too fast drying and might cause drying defects. There will be more air moving over the wood surface which means more humidity evaporating. It might be a better idea to lower the fan speed, or not to not use all of your fans at a time.

Your idea to use a plywood sheet with holes to obtain an even airflow made me think of a screen with holes you could open or close (a plenum). In this way you could modify air flow as you want when needed.

Anyway, all I found on static pressure is that in general kilns work under 0.15 to 0.5 wc of static pressure. 0.15 to 0.5 wc makes quite some difference for the small fans we would use in a VT style solar kiln. So does anybody have some information about this?

From contributor U:
I must apologize. I did not consider your question accurately. In my situation the lumber has been air dried to 15% to 20% MC. At this condition, I was not concerned about the air velocity. With fresh cut lumber, the air velocity should be near the recommendations you mention, depending on the wood type being dried. Several books and articles I have read recommend 150 FPM as a good objective. However, I think this velocity will be difficult to achieve in practice.

To check my design process against this 150 FPS: My stack has a volume of 110 Cubic Feet, times ten air changes per minute = 1100 CFM total fan volume. The maximum open area in my stack is 19 one inch high spaces each 10 feet long = 15.8 square feet. So the estimated velocity is: 1100 CFM divided by 15.8 Ft2 = 69.6 feet / min. Therefore, I should add more fans, or use larger fans.

Based on the recommended 150 Ft/min velocity, my estimating procedure should use 20 to 25 air changes per min.

From Gene Wengert, forum technical advisor:
We seldom worry about static pressure. The calculation of fan CFM is (sticker height in inches divided by 12 to get it into feet)] times (the length of the lumber in feet) times (number of sticker openings) times (desired air velocity in fpm) equals CFM.

Now add about 50% for leaks, inefficiency and so on. Example: Sticker thickness is 0.75", lumber length is 12 feet there are 24 layers, so there are 25 openings, and the desired air flow is 150 fpm. The calculated cfm is about 2800 cfm and then add 50% to get 4200 cfm. As mentioned, for air dried stock, air velocity is not very critical as we are waiting for the moisture to move to the surface and not for the air to scrub the moisture off the surface.

From the original questioner:
I was not sure the +50% added to the necessary CFM, included fan inefficiency due to static pressure. So this question is solved. Also, air velocity is important to about 40 % MC. From here and lower, the time waiting for the moisture to reach the surface is so long that evaporating rate becomes less important
.
(The following article also treads this subject: "The Importance of Air Velocity in Drying") by Dr. Fred M. Lamb. I still have two questions: I've read different recommendations on air velocity for green oak, like in the article by Dr. Fred M. Lamb, he writes : "It is best to keep the air velocity on green oak to a maximum of about 300 to 350 feet per minute (and maybe even less for lowland or thicker stock)." 300 to 350 ft/min is twice as much as 150 ft/min.

Or Dr. Wengert: 250 ft/min. for oak. While in articles on solar drying I mostly see 150 ft/min as reference. Are those values different because of the different types of kilns? Does the solar kiln use lower air velocities? I really want to dry oak freshly sawn because the air drying conditions here are very unpredictable. Second: I also wish to dry softwoods like European larch and Oregon pine. Will I need to install more fan capacity for this (solar kiln)?

From Gene Wengert, forum technical advisor:
A large size kiln with accurate control systems will run at 87% RH. Lumber at that RH can tolerate 250-300 fpm safely. A solar kiln has more variable conditions, so we need a slower fan. Plus, electrical use and cost increases dramatically as the fan speed goes up. Softwoods and other non-checking-risk hardwoods can tolerate higher air and often this higher air is essential to maintaining good color (whiteness).

From the original questioner:
Thanks for this clear response. The problem of whiteness might go for me as those woods are used often for construction, not high-end furniture. If I select fan power to obtain approximately 150 FT/min will I not risk fungi stains on softwood or beech?

- KnowledgeBase: Primary Processing
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