2017
Great Lakes Hop & Barley Conference

Hop Drying & Conditioning

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Hop Quality Group


HOP QUALITY
GROUP
OILS OVER ALPHA EST. 2010

Hop Quality Group

Bell's Brewing
Founder's Brewing
New Glarus Brewing
Boulevard Brewing
Summit Brewing
Urban Chestnut Brewing
Boston Beer
Brooklyn Brewing
St. Louis Brewing
New Belgium Brewing
Dogfish Head Brewing
Crux Fermentation Project
Karl Strauss Brewing

Odell Brewing
Stone Brewing
Firestone Walker Brewing
Russian River Brewing
Deschutes Brewing
Full Sail Brewing
Ninkasi Brewing
3 Floyd's Brewing
Sierra Nevada Brewing
Oscar Blues Brewing
Brew Hub
Allagash Brewing
Real Ale brewing

Hop Drying & Conditioning

- Objectives:

- Reduce hop moisture from 80% to 10%.
- Uniformity of moisture within the bed of hops.
- Uniformity of moisture within the cone.
- Minimize cone breakage during handling & baling.

Problems with improperly dried hops

- Too much or too little moisture makes hops subject to spontaneous combustion.
- Over-dried hops lack aroma, break up when baled and age more quickly. Most frequent reason for hop rejection.
- Hops when insufficiently dried will take on a musty off-aroma.
- Un-dried hops still respirate and if deprived of oxygen will develop a musty aroma and discolor.

Spontaneous Combustion

Improperly dried & cooled bales pose a fire risk.

A number of warehouses lost in last two decades.

Hop Drying

Cleaned hops dried with air (120 – 150˚F)

Moisture drops from 80% to 10%

Cooled & baled


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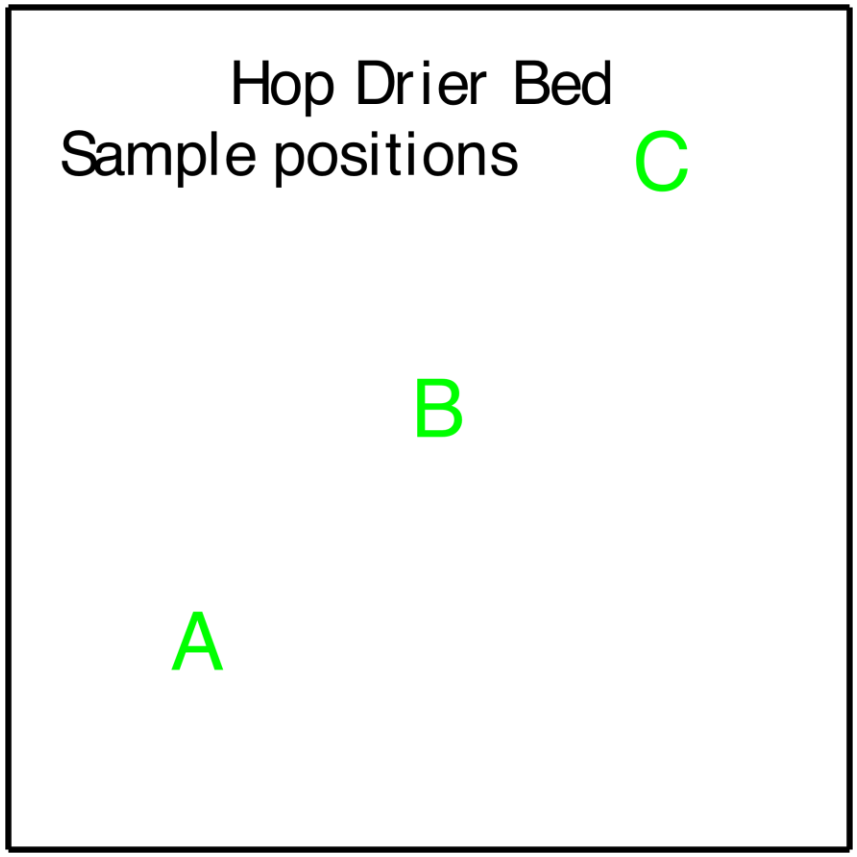
2012 Drying Study in Yakima

9 samples from each drier load. Samples from top, middle and bottom 3 inches of the bed at positions A, B & C.

3 drier loads @ 130° F & 3 loads @ 150° F in each test.

Cascade in one test, Citra in the other.

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2012 Cascade – Loftus Ranches

Bed depth 27” – 30 “ – deeper at back of kiln

130° F Moisture Data

	Bottom Avg	Middle Avg.	Top Avg.
Kiln #1	6.04%	14.22%	20.51%
Kiln #3	7.83%	12.05%	15.95%
Kiln #5	6.70%	9.33%	13.44%
Avg	6.86%	11.87%	16.63%

150° F Moisture Data

	Bottom Avg	Middle Avg	Top Avg
Kiln #2	3.75%	8.45%	15.97%
Kiln #4	4.58%	9.61%	17.98%
Kiln #6	4.24%	11.59%	16.48%
Avg	4.19%	9.88%	16.81%

Cascade Data

Drying Times

Kiln # 130° F	Hrs	Kiln # 150° F	Hrs
1	8:14	2	5:48
3	7:24	4	4:52
5	7:06	6	4:32
7	7:03	8	5:56
9	8:05	10	4:55
11	7:07	12	4:17
Avg	7:29		5:03

130° & 150° kiln loads baled separately

	130° F	150° F
Lot bale H_2O	9.7%	9.2%
Alpha	8.2%	8.8%
Beta	7.1%	7.5%
H.S.I.	0.215	0.230
Batch oil	2.0%	2.0%

Cascade Observations

- Piled, cooled hops: Aroma much stronger in the mixed 130° F hops than the mixed 150° F.

- Cascade samples from the bottom of the kiln at both temperatures had a garlic/onion aroma. Maybe stronger in the 150° F samples.
- Samples from the middle & top at both temperatures had little of this off-aroma.

2012 Citra® - Haas Golding Farm

Bed Depth 26 inches

130° F Moisture Data

	Bottom Avg.	Middle Avg.	Top Avg.
Kiln #7	7.80%	13.66%	21.70%
Kiln #9	5.99%	10.39%	18.09%
Kiln #11	4.76%	8.66%	20.10%
Avg	6.18%	10.90%	19.96%

150° F Moisture Data

	Bottom Avg.	Middle Avg.	Top Avg
Kiln #8	7.47%	11.83%	24.13%
Kiln #10	3.51%	3.20%	12.39%
Kiln #12	2.96%	6.39%	19.36%
Avg	4.65%	7.14%	18.63%

Citra® Dried with Diesel Fuel

130° F

Kiln #	Drying Minutes	Fuel Used Gallons	Bale H_2O
7	770	203	9.6%
9	800	221	9.6%
11	855	226	9.3%
Avg	808	217	9.5%

150° F

Kiln #	Drying Minutes	Fuel Used Gallons	Bale H_2O
8	560	205	9.5%
10	745	217	9.5%
12	660	196	9.5%
Avg	655	206	9.5%

Citra® Baled Lots data

	Alpha	Beta	H.S.I.
130° F	14.6%	3.6%	0.270
150° F	14.7%	3.4%	0.280

- Lots baled separately

Citra® Observations

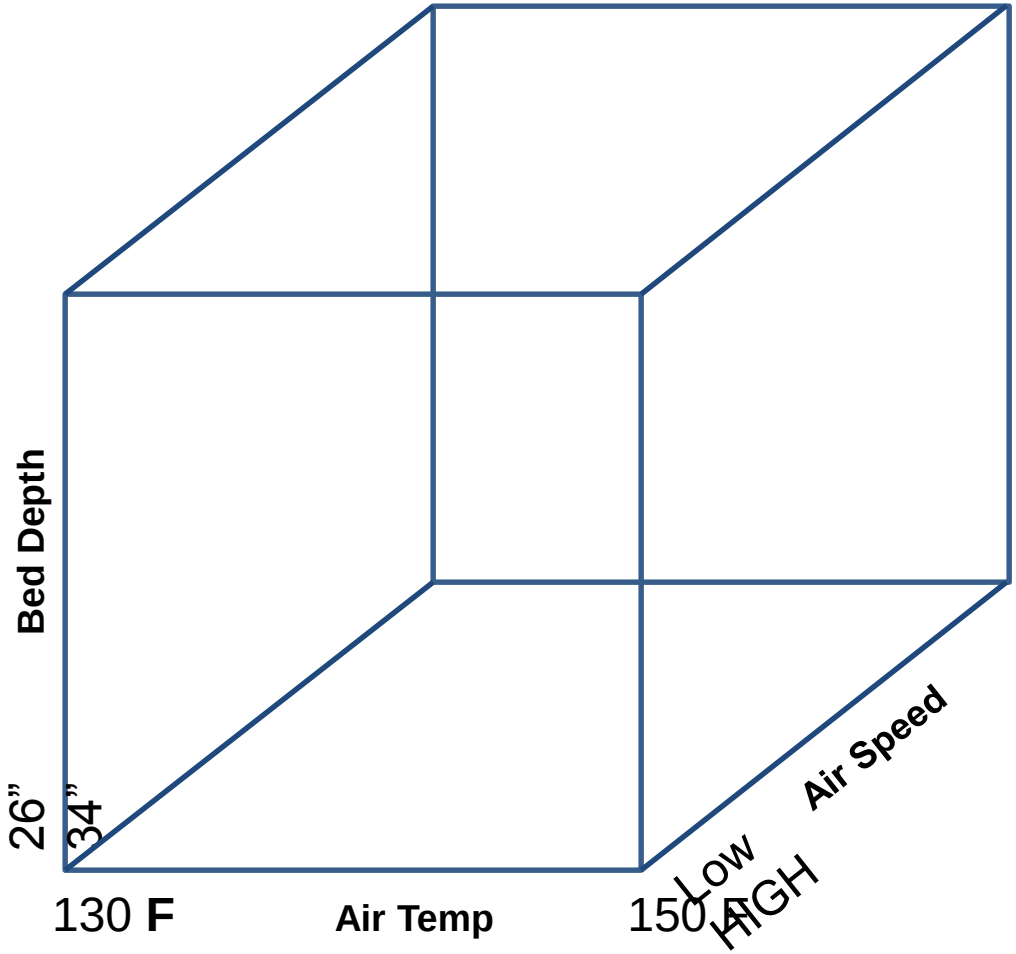
- Hops from the bottom have onion/garlic aroma similar to the Cascade samples.
- Samples from bottom @ 150˚ F reported to have stronger onion/garlic aroma than bottom of 130˚ F. Middle samples @ 150˚ F also have some of this, but not middle at 130˚ F

2013 Drying Tests

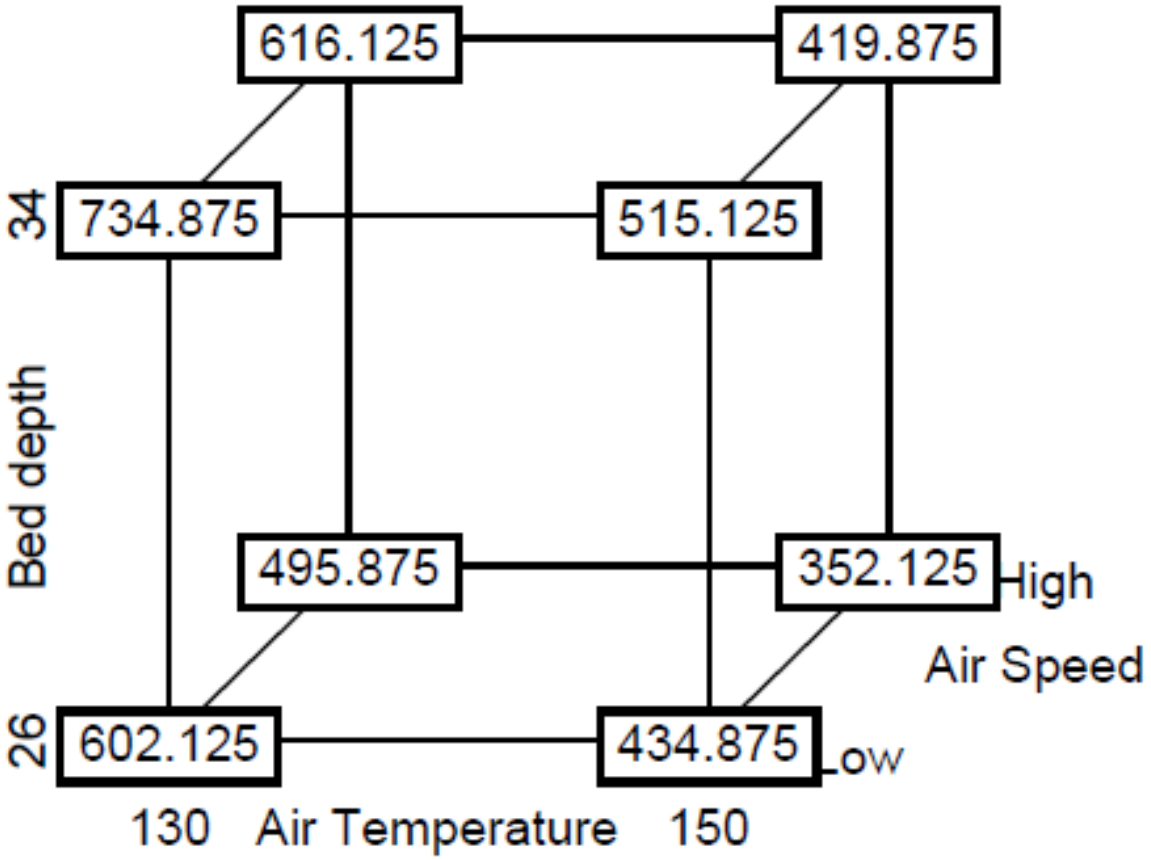
- Simcoe

- Studying temperature, air flow and bed depth

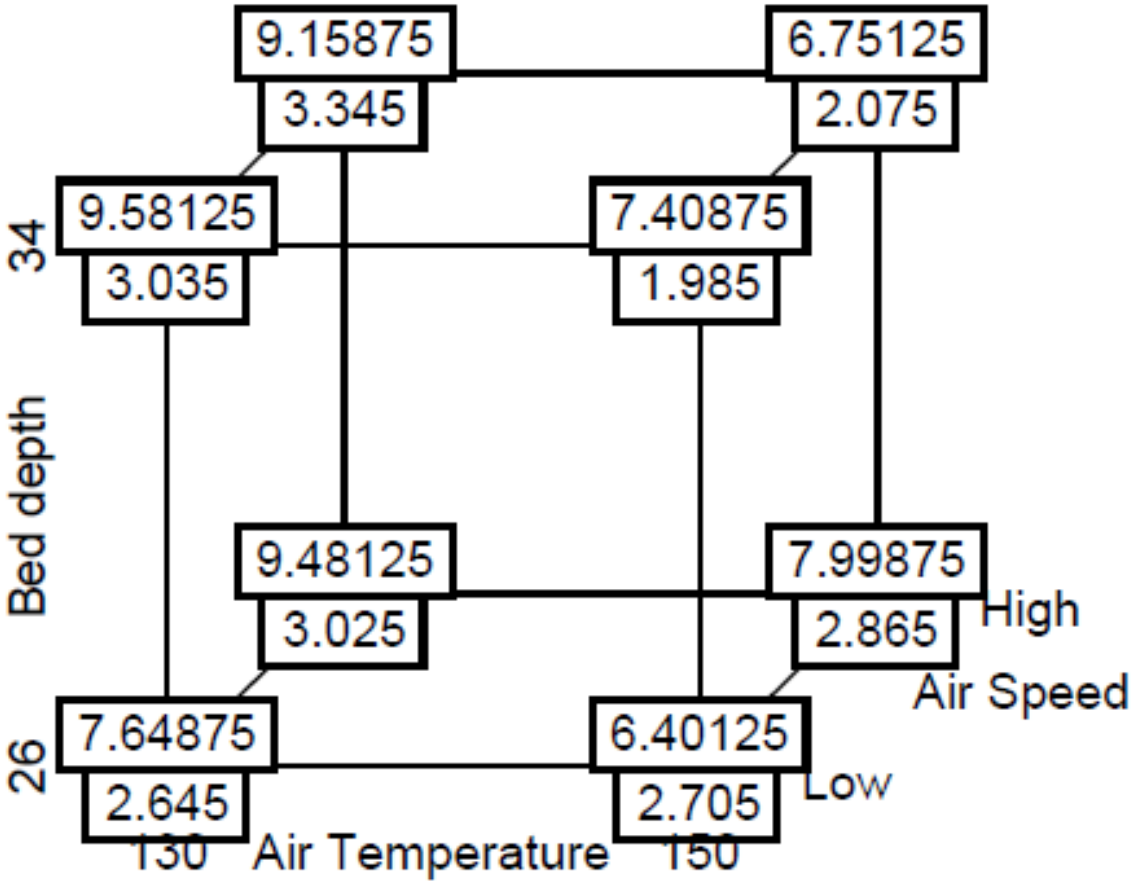
Geometric View – 2^3 Factorial



Drying Time (minutes)



Composite M.C. / Composite % Oil



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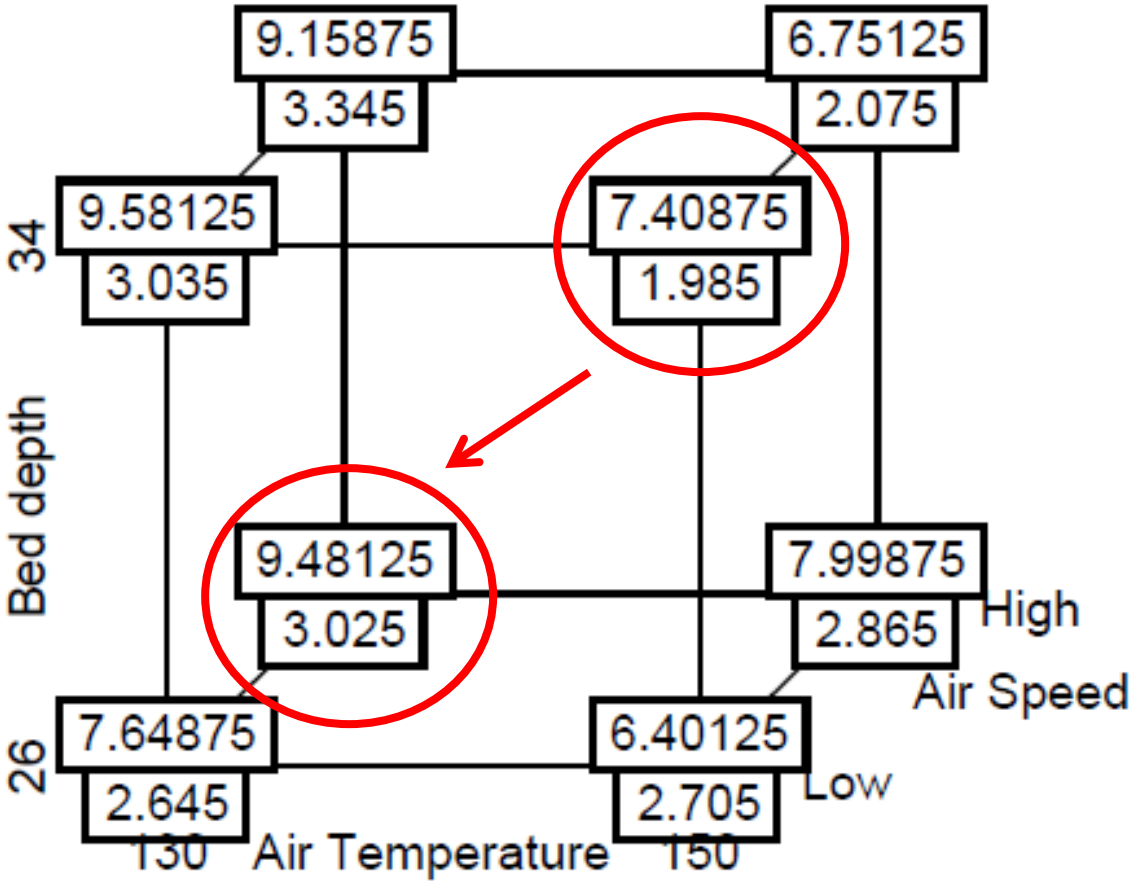


Conclusions & Future Work

- At high flow, low bed depth, low temp. it is very difficult to over dry your hops.
  - Decreased throughput, countered by higher quality
- Raising Air Temp form 130 F to 150 F starts oxidation of sesquiterpenes.
- Loss of oil observed at 150 F drying at 34” bed height.
- MORE AIR!

Problems with American Hop Drier

- Very poor moisture uniformity

- Hard to control final moisture

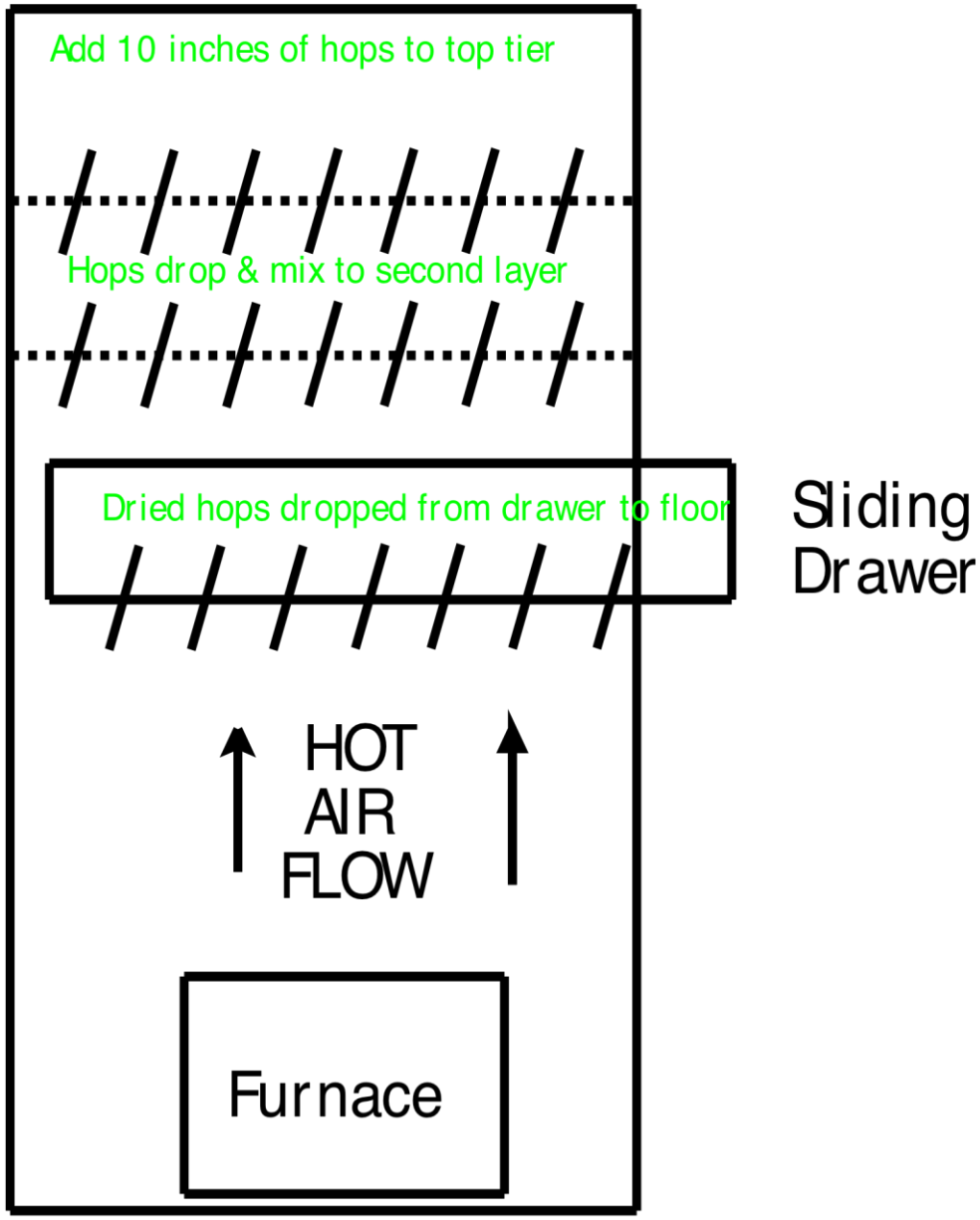
  Low Temperature, shallow bed depth & fast airflow results in lower bed moisture gradient. Low temperature greatly expands the proper time window for stopping the drying.

German Wolf Drier

3-tier system

Mixes hops when louvers opened and hops drop to next level

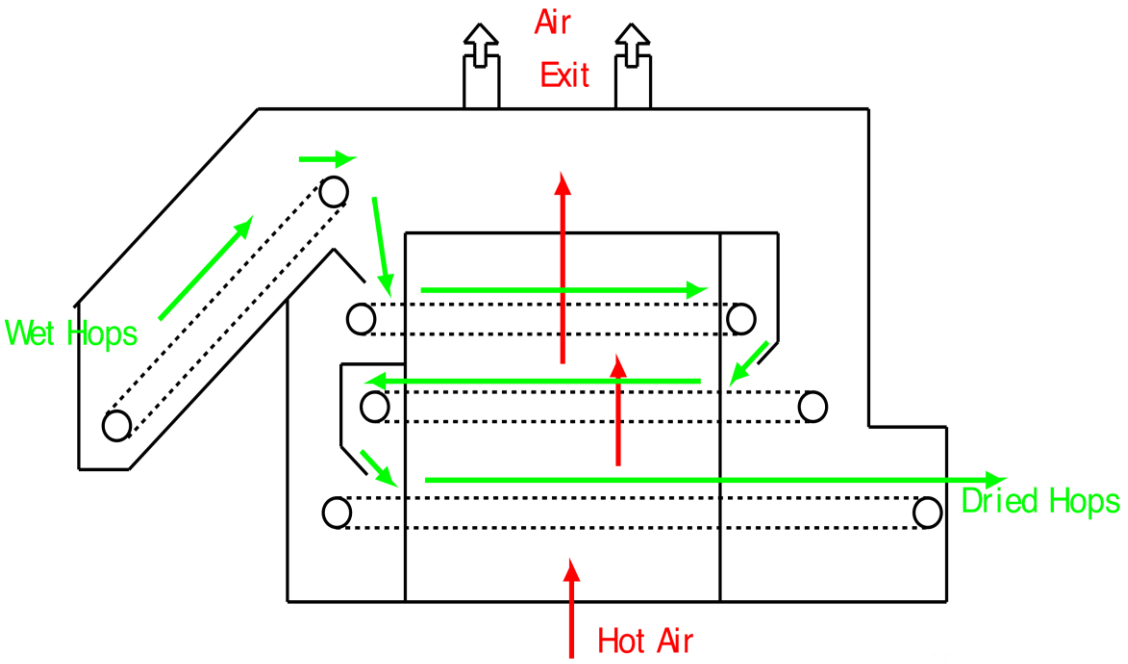
Much better moisture uniformity



Czech continuous drier

Very hard to control final moisture because weather and state of incoming hops always changes.

Hops are over-dried and sent to a humidifying chamber to bring up moisture. Results in oxidized hops and loss of aroma.



Hop Cooling/Conditioning

- When drying complete, moisture is not uniform from cone to cone and within the cone. Americans typically blow unheated air thru bed for an hour to “cool”.
- Some aerosol water (5-10 gallons in ten minutes) into the bottom of the drier to quickly cool building surfaces & reduce air temp and add a little water to the over-dry bottom of the hop bed – Continues to dry the top & middle!

More conditioning

- Then hops are dropped on the floor and allowed to “cool” for 12-24 hr. Some growers pile the hops on a vent system that blows ambient air thru the pile of hops to reduce temperature and move moisture from wetter to drier cones.
- Capillary action within the cones move moisture from the wet strig to the dry/brittle bracts and bracteoles.

German Conditioning Chamber

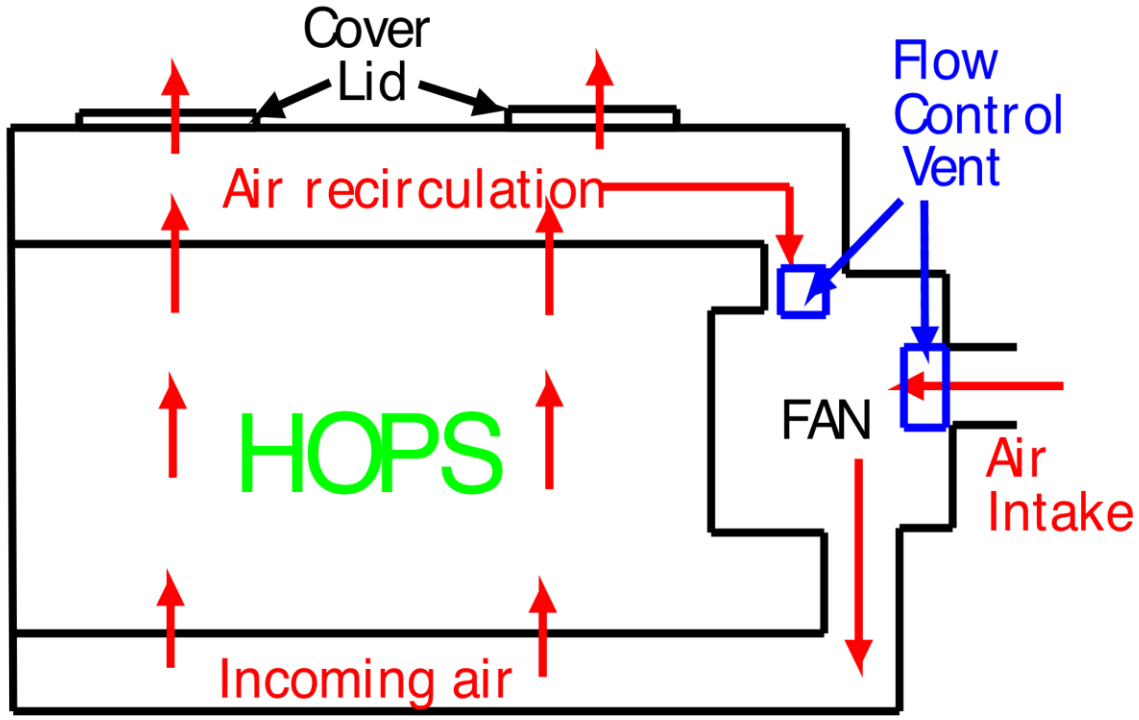
- The German stacked driers do not allow growers to blow unheated air thru hops.
- Traditionally, German growers would just drop the hops on the floor to “cool” for a day or two before baling.
- Many now load the dried hops into a conditioning chamber for 6-24 hr.

German Hop Conditioning Chamber

Air recirculated through bed of hops to transfer moisture from wetter to drier cones.

Ambient air can be added (with additional moisture) by flow controllers. Want 60-65% RH & 18-24° C.

Also helps move moisture from wet strig to the dry/brittle bracts and bracteoles



Summary

- Uniform drying to 9.5-10.0% moisture.
- Lower Temperature gives better control, but requires longer drying time. Shallower bed depth & greater airflow result in better uniformity and shorter drying time.
- Hops must be “conditioned” after drying to allow moisture redistribution within the cone.