A novel, simple, easy to implement nozzle innovation for significant reduction in driftable fines during aerial applications.

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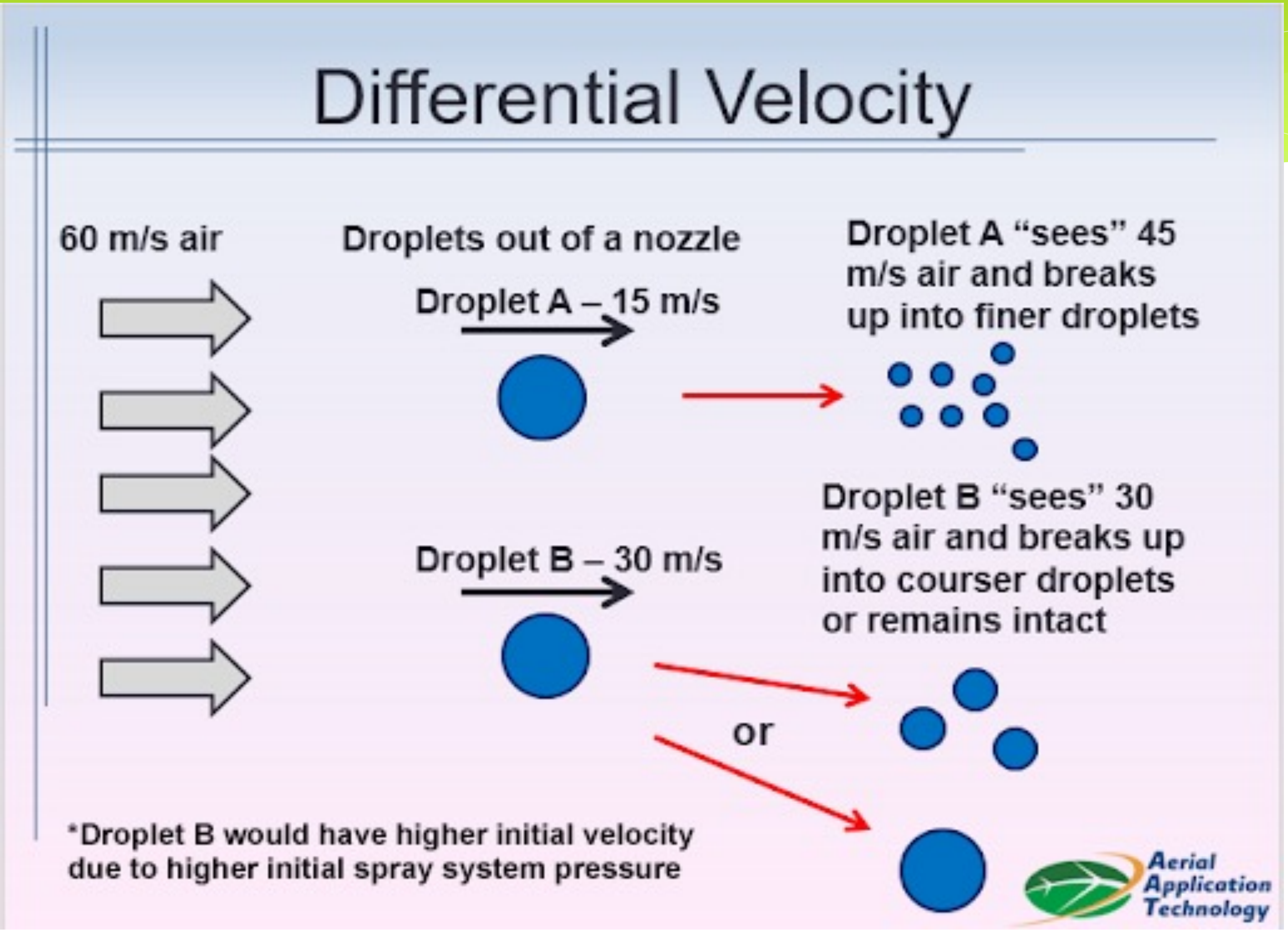
Public Service Announcement: don't do this!

Why do we care?

* Straight stream nozzles do a very good job, but there are still limits.
* High Delta (difference in the liquid jet and air speed) limits airspeed due to excessive fines formation
* Fines increase in-swath Coefficient of Variation and Drift
* Ability to spray at higher speeds and maintain label required droplet size and percent fines **could equal more acres per hour**
* Reduced driftability at current speeds could give wider range of **conditions that could be sprayed in (also more acres)**

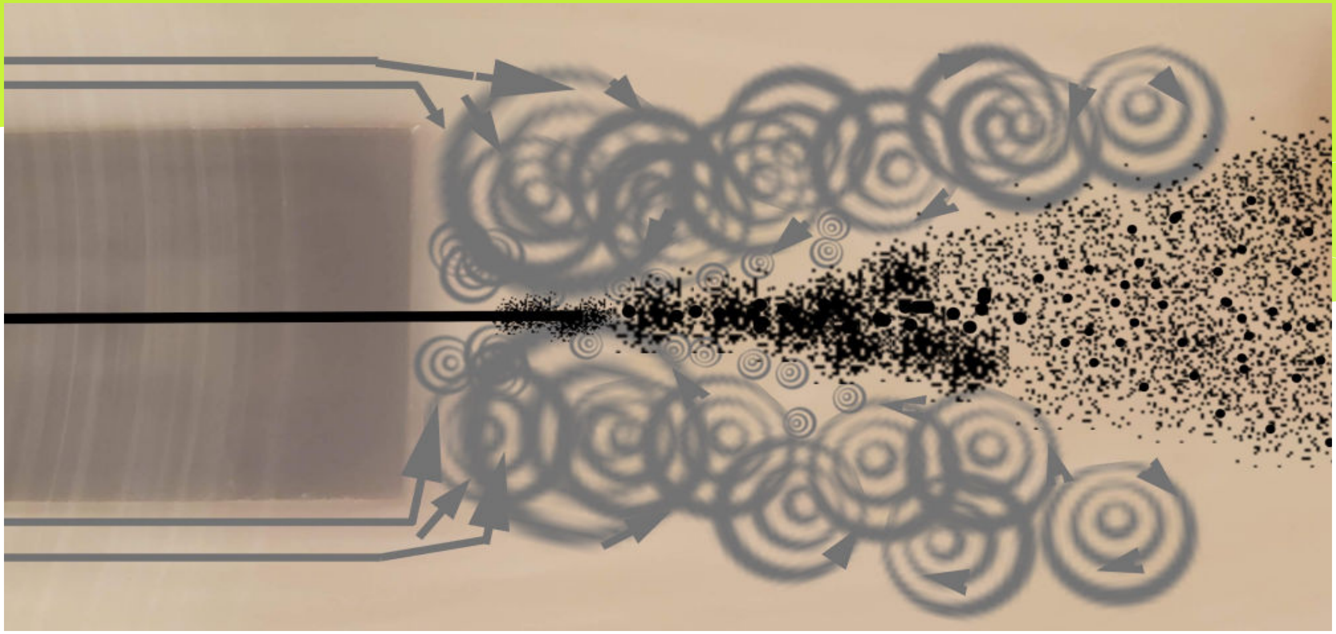
Differential Velocity is the enemy



Original thesis:

1. Reduce the magnitude of turbulence at the nozzle face.

2. reduced delta will result in reduced fines formation



Microturbulence is a big deal

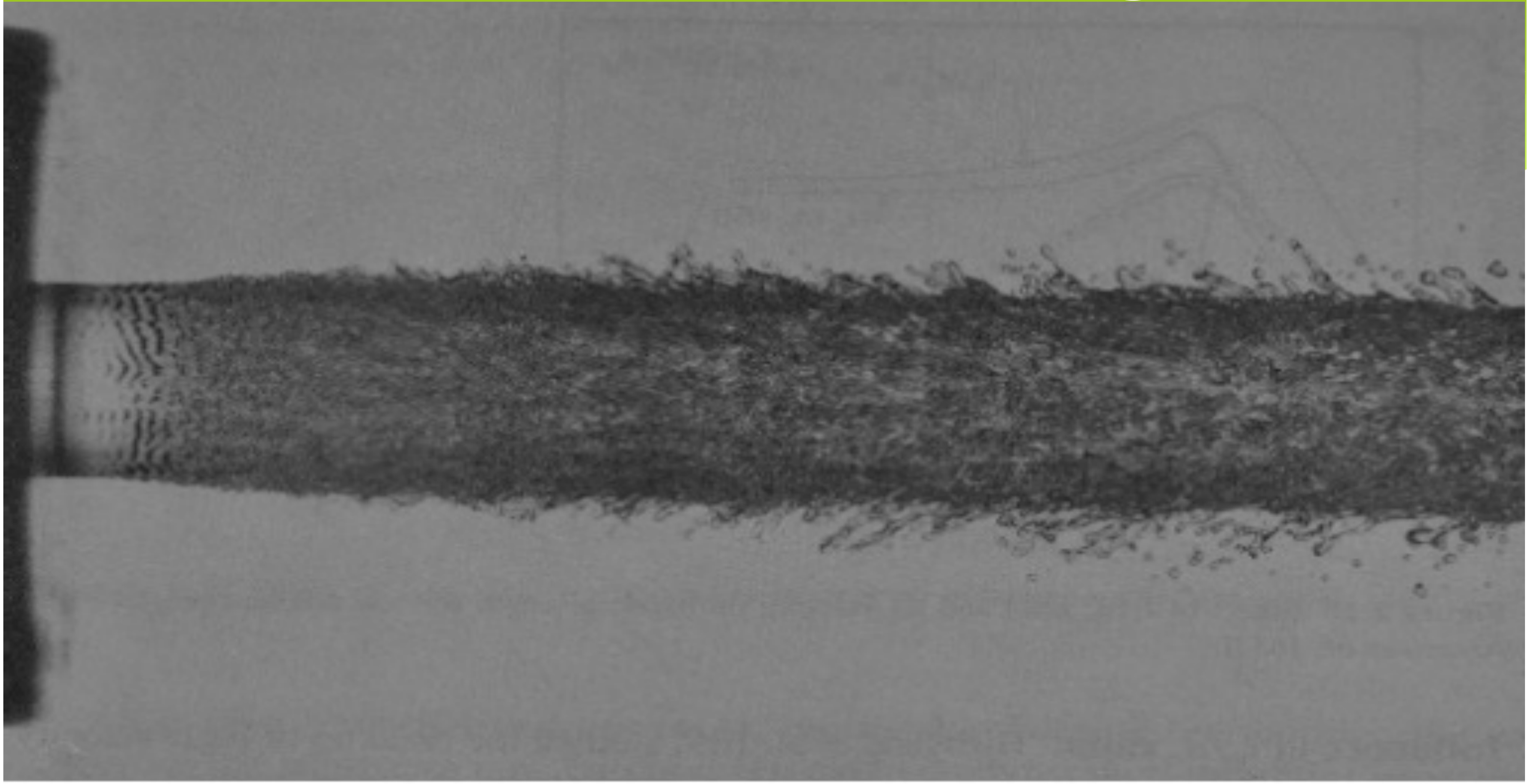
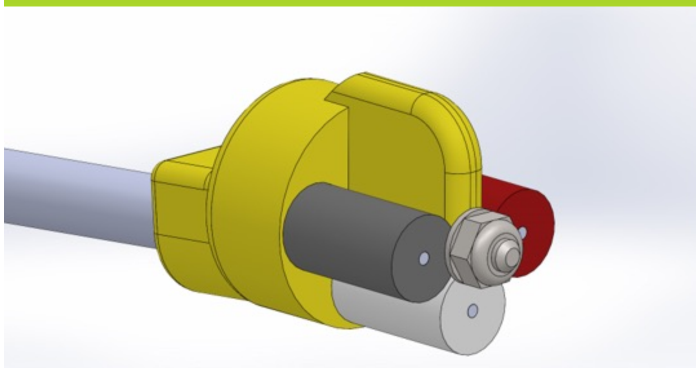
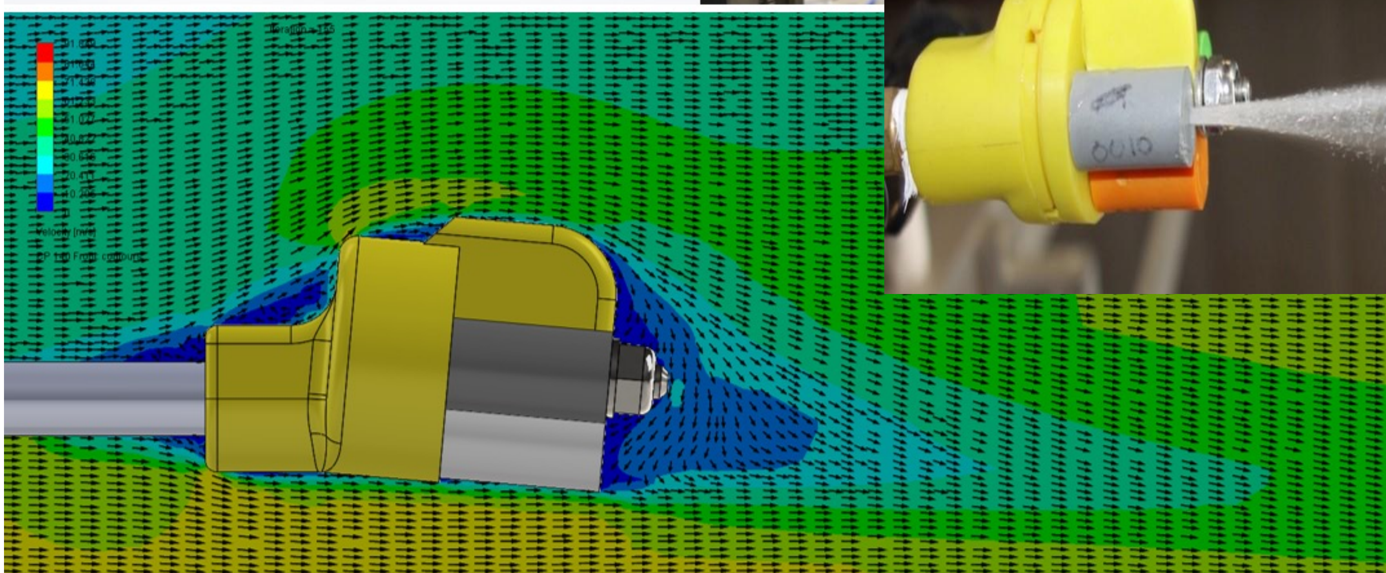


Figure 4. Cylindrical water jet in high speed coaxial air showing oscillation and fibrous spray detachment. Note wide flat nozzle face. From Atomization and Sprays, 2nd Edition, page 34; Original Source Taylor, J.J. and Hoyt, J.W., Exp. Fluids, 1,113-120, 1983

Flat faces, shear, fines and Low D_V 50’s

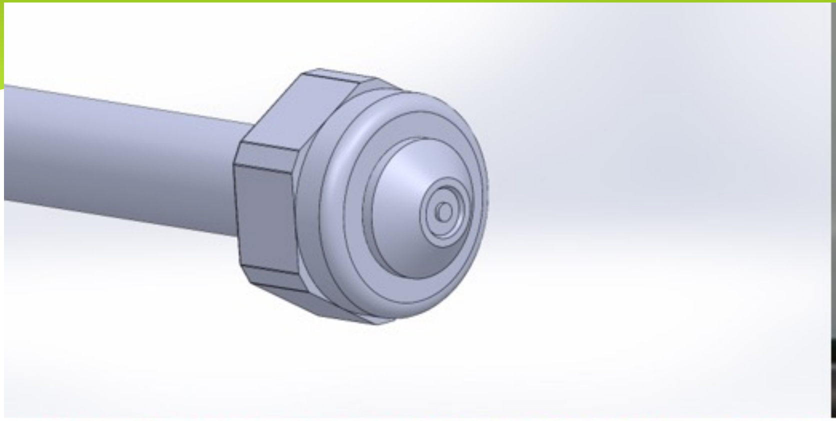


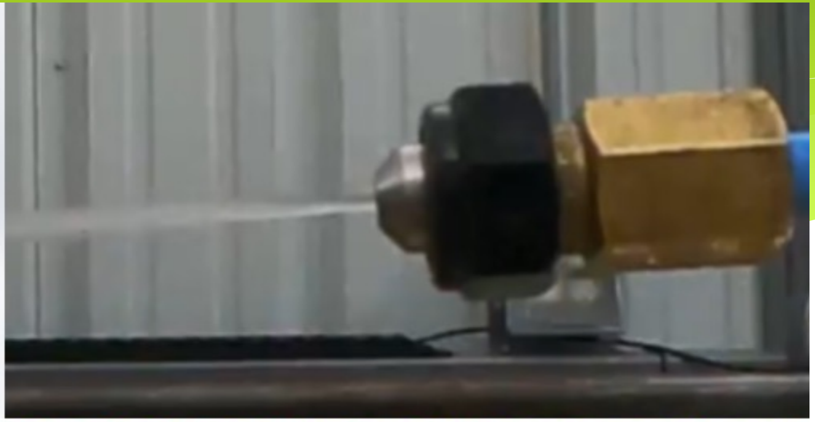


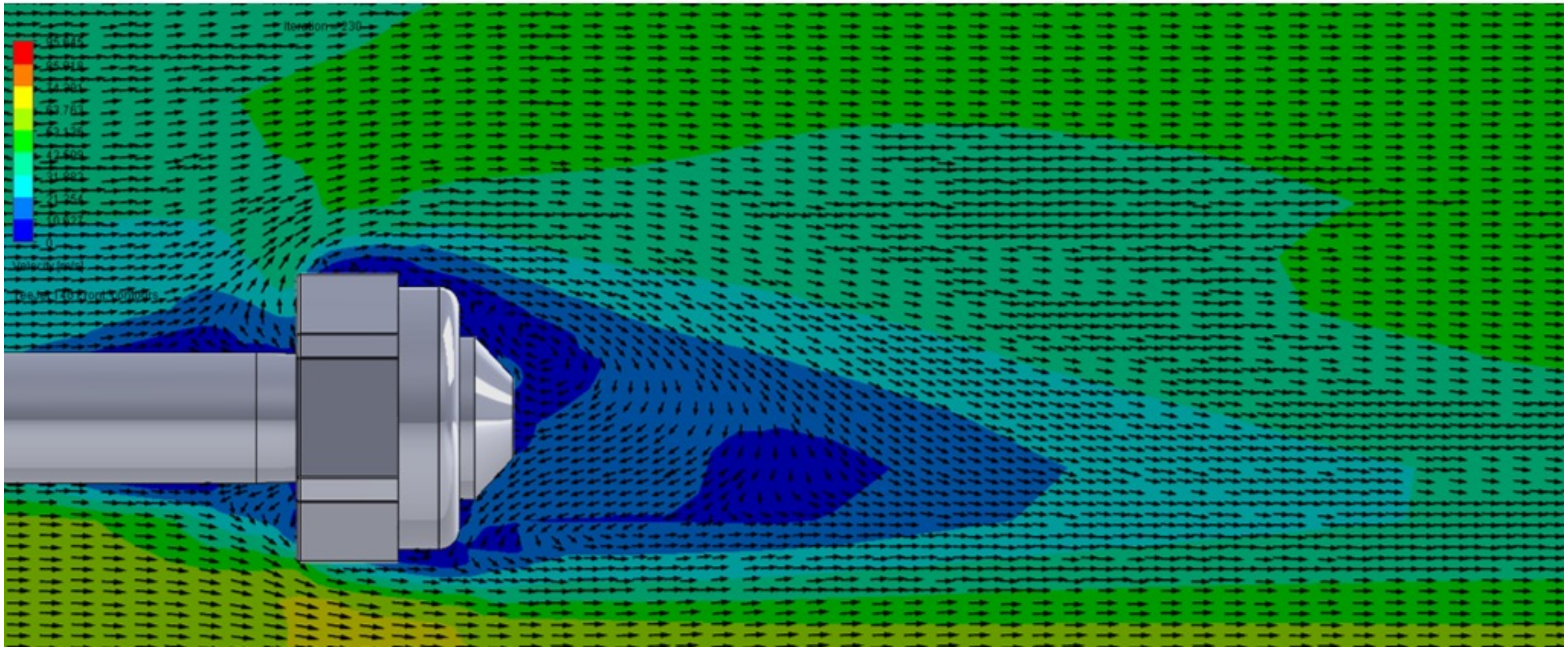
Our measurements for CP11

Nozzle	Pressure (psi)	Airspeed (mph)	DV10 (µm)	DV50 (µm)	DV90 (µm)	Span	CV<100µm (%)	CV<200µm (%)
CP 11TT-6	40	140	160.8	383.7	695.1	1.393	3.77	15.35
CP 11TT-6	60	140	178.1	421.4	718.8	1.280	3.03	12.67
CP 11TT-6	40	160	115.9	277.1	504.6	1.403	7.49	28.27
CP 11TT-6	60	160	131.6	311.3	587.3	1.460	5.75	22.64
CP 11TT-10	40	140	163.1	383.5	692.2	1.380	3.57	15.03
CP 11TT-10	60	140	195.8	454.6	822.5	1.380	2.31	10.46
CP 11TT-10	40	160	126.8	308.3	580.8	1.473	6.30	23.71
CP 11TT-10	60	160	144.7	347.2	643.5	1.433	4.72	18.85
CP 11TT-12	40	140	164.7	392.7	714.5	1.400	3.49	14.72
CP 11TT-12	60	140	191.3	455.9	849.8	1.443	2.47	10.95
CP 11TT-12	40	160	128.6	316.1	598.7	1.487	6.08	23.07
CP 11TT-12	60	160	149.1	365.0	697.0	1.500	4.42	17.75

Teejet straight streams



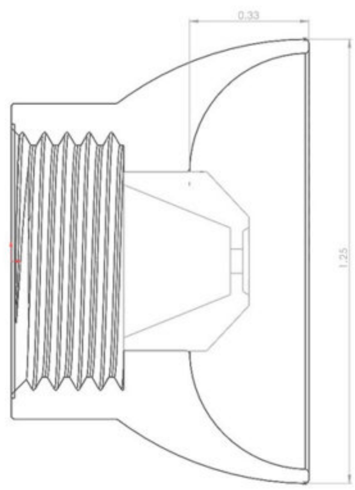


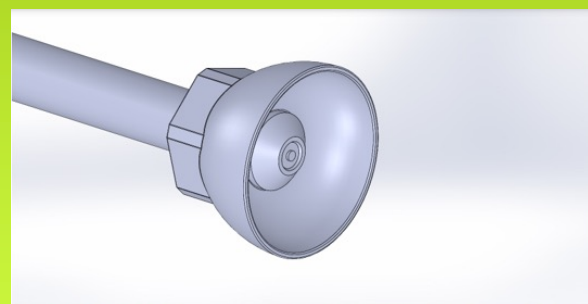


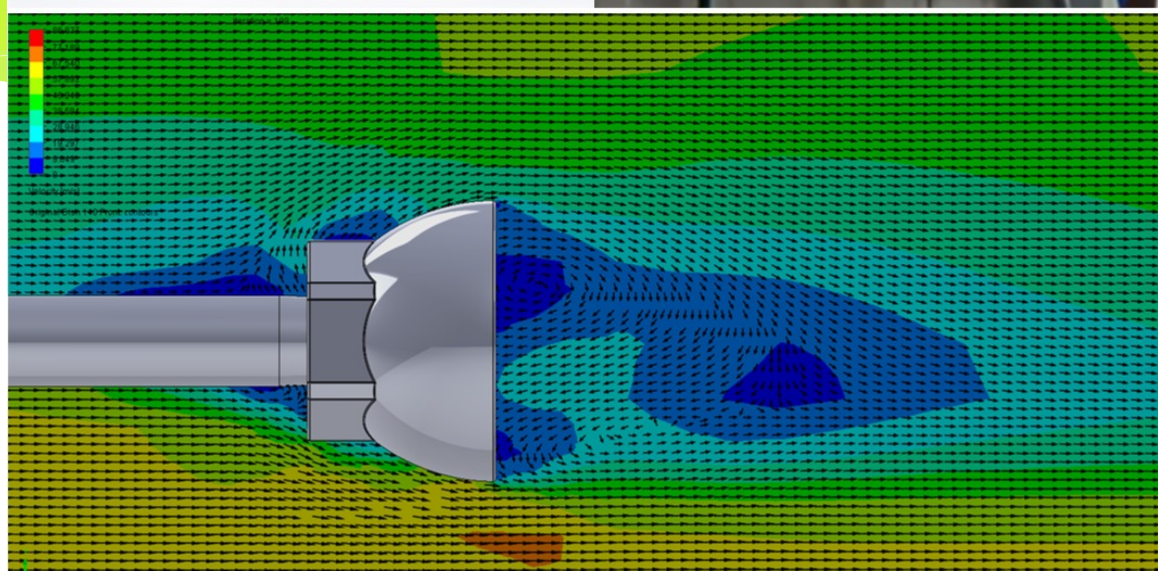
Straight Stream Nozzle Data

Spray Tip	P (psi)	Airspeed (mph)	DV10 (µm)	DV50 (µm)	DV90 (µm)	Span	CV<100 µm (%)	CV<200 µm (%)
TP0003-SS	40	140	168.9	379.7	641.3	1.243	3.46	13.97
TP0003-SS	60	140	200.7	450.6	759.5	1.237	2.34	9.92
TP0003-SS	40	160	132.7	306.6	532.7	1.303	5.75	22.10
TP0003-SS	60	160	151.4	348.3	600.7	1.293	4.40	17.31
TP0006-SS	40	140	169.7	389.1	678.4	1.307	3.34	13.90
TP0006-SS	60	140	202.8	468.4	822.9	1.323	2.22	9.74
TP0006-SS	40	160	129.6	304.5	537.9	1.340	6.04	23.14
TP0006-SS	60	160	147.9	347.5	617.7	1.350	4.56	18.09
TP0009-SS	40	140	171.4	398.7	710.4	1.350	3.20	13.65
TP0009-SS	60	140	208.2	490.4	966.4	1.547	2.07	9.25
TP0009-SS	40	160	136.2	324.9	594.4	1.410	5.38	21.04
TP0009-SS	60	160	157.9	378.0	715.3	1.473	3.89	15.94
TP0011-SS	40	140	170.4	402.1	738.7	1.413	3.22	13.79
TP0011-SS	60	140	209.0	498.8	980.6	1.547	2.03	9.18
TP0011-SS	40	160	136.3	327.5	612.8	1.453	5.34	21.00
TP0011-SS	60	160	153.8	370.9	702.3	1.477	4.11	16.78

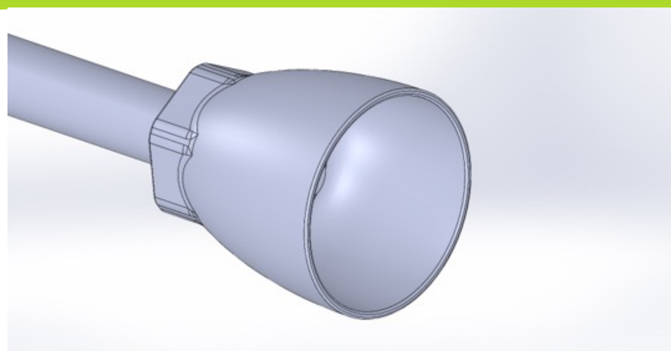
What worked: reduce the turbulence and differential speed between air and liquid by ***blocking the wind.***

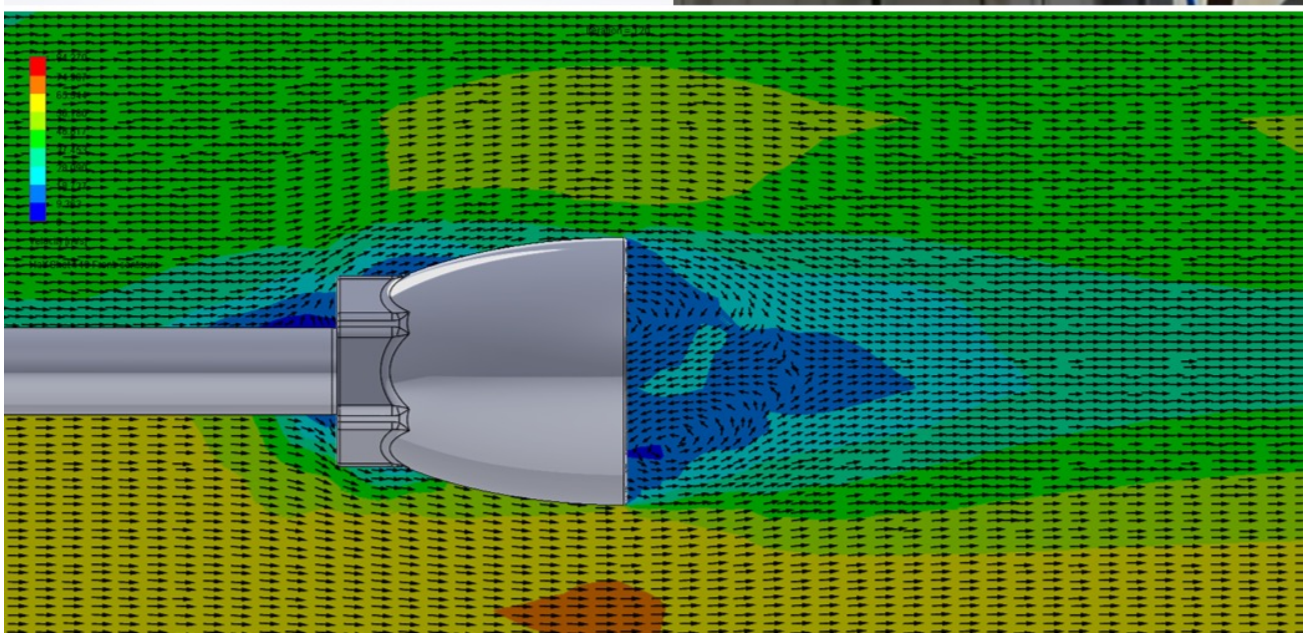






What worked better: “half-shot”



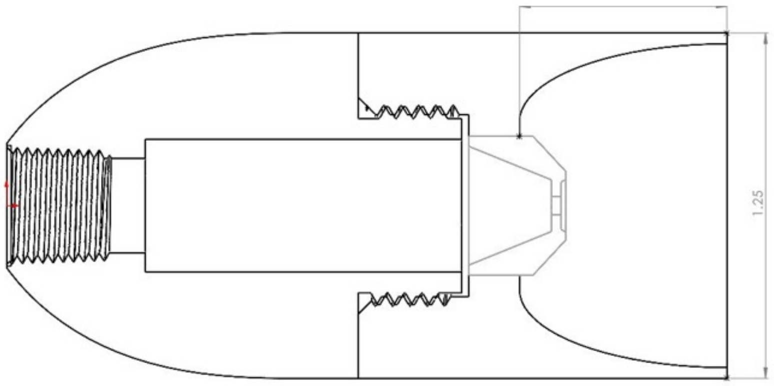


Half Shot Stats, percent reduction (black) or increase(negative/red) in fines vs. CP and SS straight stream nozzles

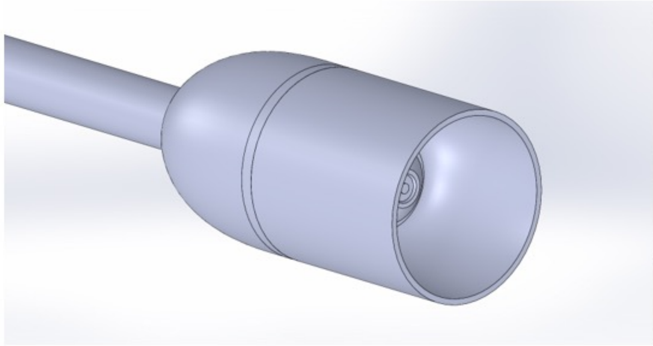
Half Shot + Spray Tip	Pressure (psi)	Airspeed (mph)	CV<100 µm (%)	reduction vs. measured CP11TT	reduction vs. measured Teejet SS	CV<200 µm (%)	reduction vs. measured CP11TT	reduction vs. measured Teejet SS
0003	40	140	2.44		29.5%	10.38		25.7%
0003	60	140	1.64		29.8%	7.56		23.8%
0003	40	160	4.61		19.7%	18.61		15.8%
0003	60	160	3.53		19.8%	14.72		14.9%
0006	40	140	2.40	36.3%	28.0%	10.75	22.6%	22.6%
0006	60	140	1.40	53.6%	36.7%	6.78	30.4%	30.4%
0006	40	160	4.81	35.8%	20.3%	19.70	14.9%	14.9%
0006	60	160	3.53	38.7%	22.7%	14.97	17.3%	17.3%
0009	40	140	2.29	35.7%	28.3%	10.54	22.8%	22.8%
0009	60	140	1.32	43.1%	36.4%	6.47	30.0%	30.0%
0009	40	160	4.95	21.4%	8.0%	20.09	4.5%	4.5%
0009	60	160	3.33	29.4%	14.4%	14.21	10.8%	10.8%
0011	40	140	2.35	32.7%	27.1%	10.77	21.9%	21.9%
0011	60	140	1.45	41.1%	28.6%	7.02	23.5%	23.5%
0011	40	160	5.27	13.3%	1.2%	21.07	-0.3%	-0.3%
0011	60	160	3.82	13.7%	7.2%	15.94	5.0%	5.0%

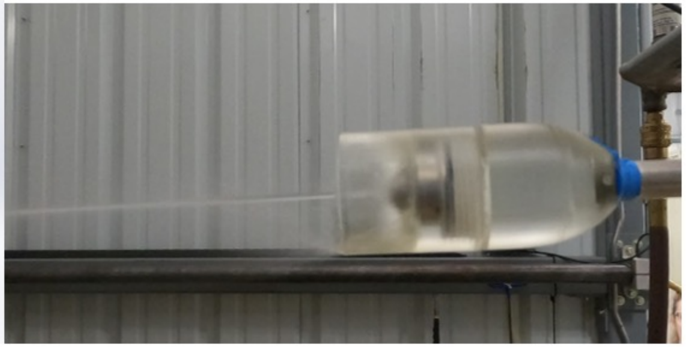
Even better: "the Bullet"

Bullet (best treatment overall)



In addition to the 1.25" Half Shot design, the air approach was optimized to smooth the airflow and minimize the creation of turbulence on the approach. This was successful at reducing fines and managing Dv50 and Dv90 in all use cases.



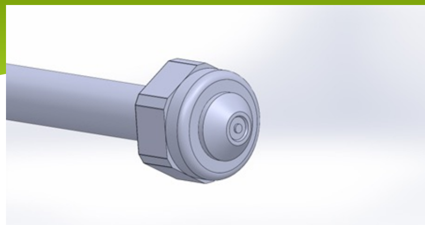


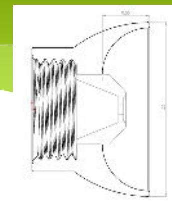
Bullet compared to straight stream and CP11

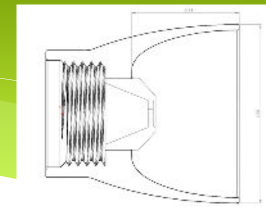
Bullet + Spray Tip	Pressure (psi)	Airspeed (mph)	CV<100 µm (%)	reduction vs. measured CP11TT	reduction vs. measured Teejet SS	CV<200 µm (%)	reduction vs. measured CP11TT	reduction vs. measured Teejet SS
0003	40	160	5.28		8.1%	20.69		6.4%
0003	60	160	3.61		17.9%	14.86		14.1%
0003	40	140	2.68		22.6%	11.31		19.1%
0003	60	140	1.96		16.5%	8.33		16.1%
0006	40	160	5.05	32.5%	16.3%	20.43	11.7%	11.7%
0006	60	160	3.39	41.0%	25.6%	14.60	19.3%	19.3%
0006	40	140	2.78	26.4%	16.7%	11.95	14.0%	14.0%
0006	60	140	1.90	37.1%	14.0%	8.68	10.9%	10.9%
0009	40	160	4.94	21.5%	8.2%	20.22	3.9%	3.9%
0009	60	160	3.70	21.5%	4.9%	15.59	2.2%	2.2%
0009	40	140	2.55	28.5%	20.3%	11.54	15.4%	15.4%
0009	60	140	1.64	29.0%	20.7%	7.84	15.2%	15.2%
0011	40	160	5.22	14.2%	2.2%	21.02	-0.1%	-0.1%
0011	60	160	3.58	19.0%	12.9%	15.43	8.0%	8.0%
0011	40	140	2.55	26.8%	20.8%	11.58	16.0%	16.0%
0011	60	140	1.72	30.4%	15.6%	8.17	11.0%	11.0%

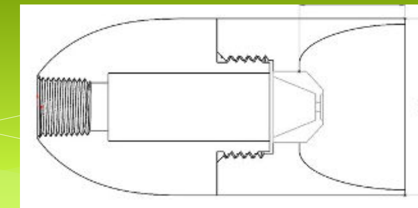
How do they compare?

- **Key:**
- **CV100 < than corresponding CV for 00SS nozzle = Green.**
- **CV >value for 00SS = Red**
- **CV200 > 15% = Red. Excessive driftable fraction.**
- **Dv50 >/= 475µm or < 280 = Red**
  (This range is approx. Coarse/Extra Coarse ASABE S572)
- **Dv90>/= 900 = Red. Excessively large.**









Spray Tip/ pressure/ airspeed	00SS				Original Dish				Half Shot Second best modification overall				Bullet Best modification overall			
	CV<100	CV<200	DV50	DV90	CV<100	CV<200	Dv50	Dv90	CV<100	CV<200	Dv50	Dv90	CV<100	CV<200	DV50	DV90
3/40/140	3.46	13.97	379.7	641.3	3.40	13.57	390.9	665.8	2.44	10.38	437.5	728.4	2.68	11.31	412.9	696.0
3/60/140	2.34	9.92	450.6	759.5	2.14	9.25	459.7	792.4	1.64	7.56	494.6	828.4	1.96	8.33	492.4	837.4
3/40/160	5.75	22.10	306.6	532.7	5.48	21.54	304.6	512.1	4.61	18.61	328.3	572.7	5.28	20.69	314.3	533.8
3/60/160	4.40	17.31	348.3	600.7	4.03	16.05	355.2	604.9	3.53	14.72	371.1	653.3	3.61	14.86	367.8	630.2
6/40/140	3.34	13.90	389.1	678.4	3.02	12.80	396.4	680.9	2.40	10.75	428.3	730.6	2.78	11.95	414.6	715.2
6/60/140	2.22	9.74	468.4	822.9	1.92	8.60	477.4	839.1	1.40	6.78	525.9	996.4	1.90	8.68	481.2	840.7
6/40/160	6.04	23.14	304.5	537.9	5.11	20.33	320.2	560.7	4.81	19.70	324.8	572.8	5.05	20.43	320.6	563.7
6/60/160	4.56	18.09	347.5	617.7	3.30	13.78	388.6	697.7	3.53	14.97	372.7	663.1	3.39	14.60	376.3	677.6
9/40/140	3.20	13.65	398.7	710.4	3.08	13.25	398.1	702.4	2.29	10.54	439.9	783.7	2.55	11.54	422.1	757.2
9/60/140	2.07	9.25	490.4	966.4	1.97	8.99	481.8	935.9	1.32	6.47	552.9	1064.3	1.64	7.84	508.1	962.5
9/40/160	5.38	21.04	324.9	594.4	5.85	22.64	308.2	558.8	4.95	20.09	331.4	602.0	4.94	20.22	327.7	593.0
9/60/160	3.89	15.94	378.0	715.3	4.11	16.60	362.6	673.9	3.33	14.21	399.7	737.6	3.70	15.59	379.0	705.8
11/40/140	3.22	13.79	402.1	738.7	2.75	12.23	414.0	752.9	2.35	10.77	441.8	805.4	2.55	11.58	428.2	767.3
11/60/140	2.03	9.18	498.8	980.6	1.76	8.20	510.8	997.9	1.45	7.02	549.2	1084.0	1.72	8.17	507.5	952.3
11/40/160	5.34	21.00	327.5	612.8	5.14	20.56	326.8	608.1	5.27	21.07	326.3	609.9	5.22	21.02	325.9	604.0
11/60/160	4.11	16.78	370.9	702.3	3.75	15.63	376.5	705.2	3.82	15.94	379.5	723.1	3.58	15.43	382.3	717.8
# instances	N/A	8	2	2	2	7	3	2	0	5	4	3	0	6	4	2
Averages	3.83	15.55	386.6	700.8	3.55	14.63	392.0	705.5	3.07	13.10	419.0	759.7	3.29	13.89	403.8	722.1

Next Steps:

- Patent has been filed
- This could go to field testing now
- Optimize design for different use cases
- Looking for a path to Commercialization

- What do you think?

Thank you!

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