Power required to rotate a cylinder in a moving air

Notations : for more uniformed formulations and ease further comparison,
U is the upstream flow (= the apparent wind when a sailing ship is considered)
v is the tangential speed of rotation at the surface of the rotor (>> speed ratio = v/U)
D and H are the diameter and the height of the rotor.
Sw the "wetted" surface of the rotor is then : π D H
>>> Norwood uses rotor radius a , rotor height 1,5 a and the rotational speed w, so the correspondance are :
D = 2 a , H = 1,5 a and v = a*w
ρ is the air mass volumic of air (kg/m3)
Cf is the friction coefficient, computed using Re = U*D/v and Cf = 0,075 / (log10(Re) - 2)^2
v = air cinematic viscosity (m2:s)

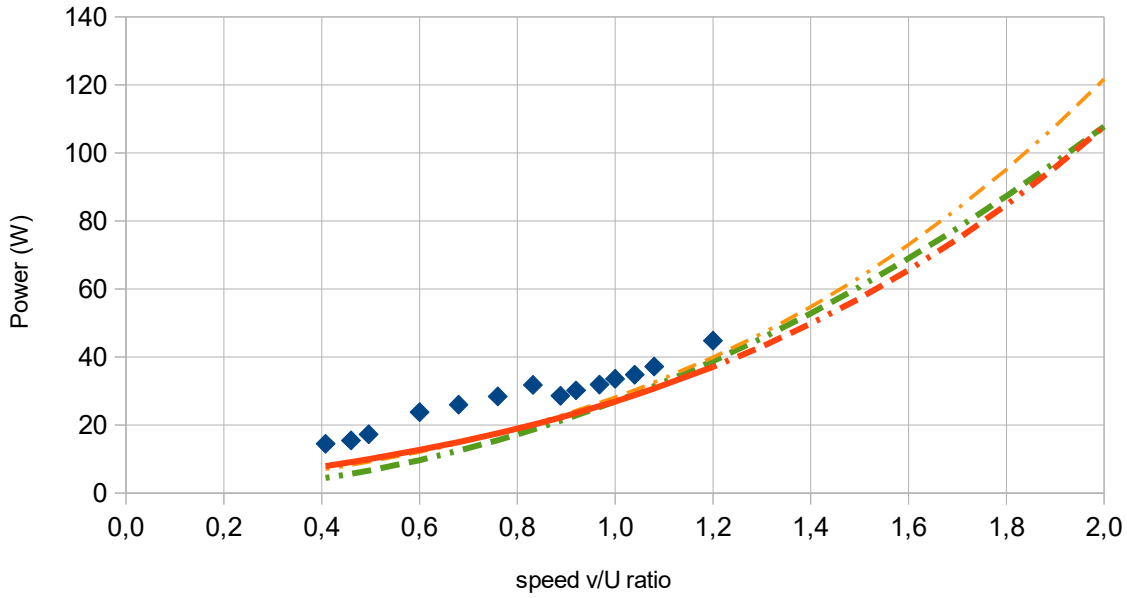
Formulations :
« Norwood » formulation (rewritten with the above notations) :
Pm = Cf * (1/2 * ρ * Sw) * (2 * U^2 + v^2) * v
« **Norwood bis »** (when considering v for the integration in the 4th quadrant) :
Pm = Cf * (1/2 * ρ * Sw) * (3/2 * U^2 + 2/π * U * v + v^2) * v
« Thom » formulation , derived from its torque formulation :
Pm = Cf * (1/2 * ρ * Sw) * (k * U * v) * v , with k ~ 3 (?)

>>> that presentation of the formulations highlights on the origin of the power computation (a friction force x a tangential speed of rotation) and especially on the quadratic function of (U,v) dimensioned as a squared speed and resulting from the integration on the cylinder perimeter.

Comparison with Reid Naca 1924 measurements :
Data of the experiments :
D = 0,1143 m ; H = 1,5232 m
v = 1,429 E-5 m2/s (estimated)
ρ = 1,23 kg/m3 (estimated)
Cf computed with Re = U D / v and Cf = 0,075 / (log10(Re) - 2)^2 >> Cf = 0,0079
Measurements done with U = 15 m/s and for 14 values of v/U from 0,4 to 1,2

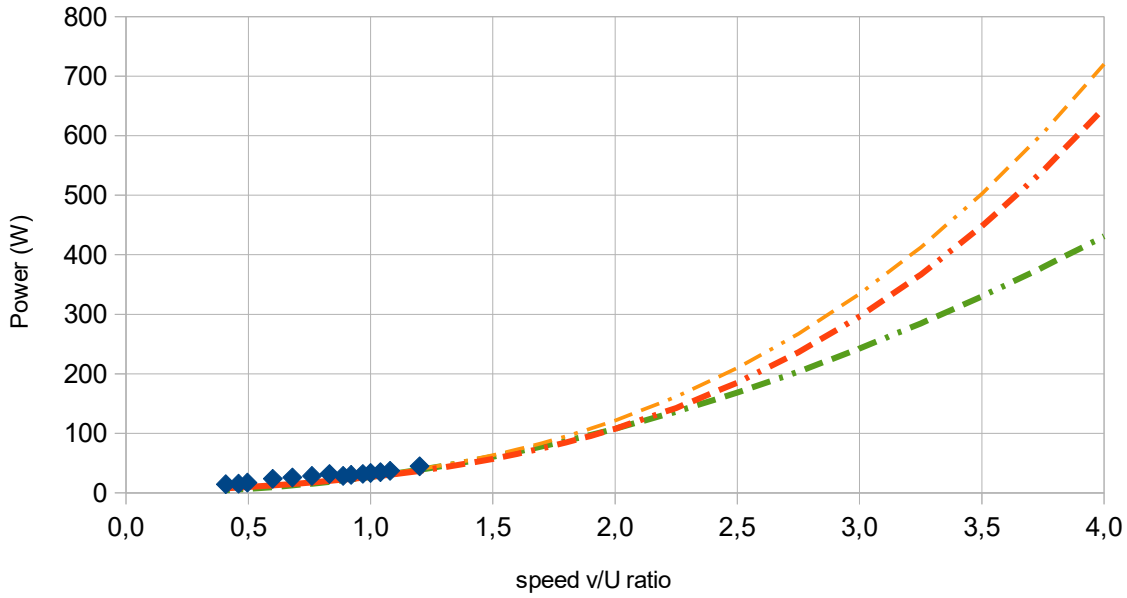
Pm "Norwood" and "Thom" versus Pm "Reid/Naca" measurements

Blue measurements
Red "Norwood" ; Orange "Norwood bis" ; Green "Thom k=3"



Pm "Norwood" and "Thom" , extension to v/U = 4

Blue measurements
Red "Norwood" ; Orange "Norwood bis" ; Green "Thom k=3"



Pm formulations / Naca Reid measurements

D (m)	H (m)	nu (m2/s)	Rho (kg/m3)	U (m/s)	>>> Re	Cf	½*Rho*Sw
0,1143	1,5232	1,43E-005	1,23	15	1,20E+005	0,00791	0,33638

Pm Reid (Watts)	N (rpm)	v/U	v (m/s)	Pm Norwood 2*U^2 + v^2	P (Watts)	Pm Norwood bis Quadratic	P (Watts)	PmThom k=3 P (Watts)
14,5	1000	0,408	6,12	487,45	7,94	433,40	7,06	4,48
15,5	1115	0,460	6,90	497,61	9,14	451,00	8,28	5,70
17,3	1240	0,496	7,44	505,35	10,00	463,90	9,18	6,63
23,8	1500	0,600	9,00	531,00	12,72	504,44	12,08	9,70
26,0	1700	0,680	10,20	554,04	15,04	538,94	14,63	12,46
28,4	1900	0,760	11,40	579,96	17,59	576,32	17,48	15,56
31,8	2080	0,832	12,48	605,75	20,12	612,43	20,34	18,65
28,6	2220	0,888	13,32	627,42	22,24	642,12	22,76	21,25
30,2	2300	0,920	13,80	640,44	23,52	659,72	24,23	22,80
31,9	2420	0,968	14,52	660,83	25,53	686,99	26,54	25,25
33,6	2500	1,000	15,00	675,00	26,94	705,74	28,17	26,94
34,8	2600	1,040	15,60	693,36	28,78	729,83	30,30	29,14
37,2	2700	1,080	16,20	712,44	30,71	754,64	32,53	31,43
44,8	3000	1,200	18,00	774,00	37,07	833,39	39,92	38,80
		1,3	19,50	830,25	43,08	903,96	46,91	45,53
		1,4	21,00	891,00	49,79	979,04	54,71	52,81
		1,5	22,50	956,25	57,25	1058,61	63,38	60,62
		1,6	24,00	1026,00	65,52	1142,68	72,98	68,97
		1,7	25,50	1100,25	74,66	1231,26	83,55	77,86
		1,8	27,00	1179,00	84,71	1324,33	95,15	87,29
		1,9	28,50	1262,25	95,73	1421,90	107,83	97,26
		2	30,00	1350,00	107,77	1523,98	121,66	107,77
		2,25	33,75	1589,06	142,71	1798,85	161,55	136,40
		2,5	37,50	1856,25	185,23	2101,85	209,74	168,39
		2,75	41,25	2151,56	236,17	2432,97	267,06	203,75
		3	45,00	2475,00	296,37	2792,22	334,35	242,48
		3,25	48,75	2826,56	366,67	3179,59	412,46	284,58
		3,5	52,50	3206,25	447,92	3595,09	502,24	330,04
		3,75	56,25	3614,06	540,95	4038,71	604,51	378,88
		4	60,00	4050,00	646,62	4510,46	720,13	431,08