



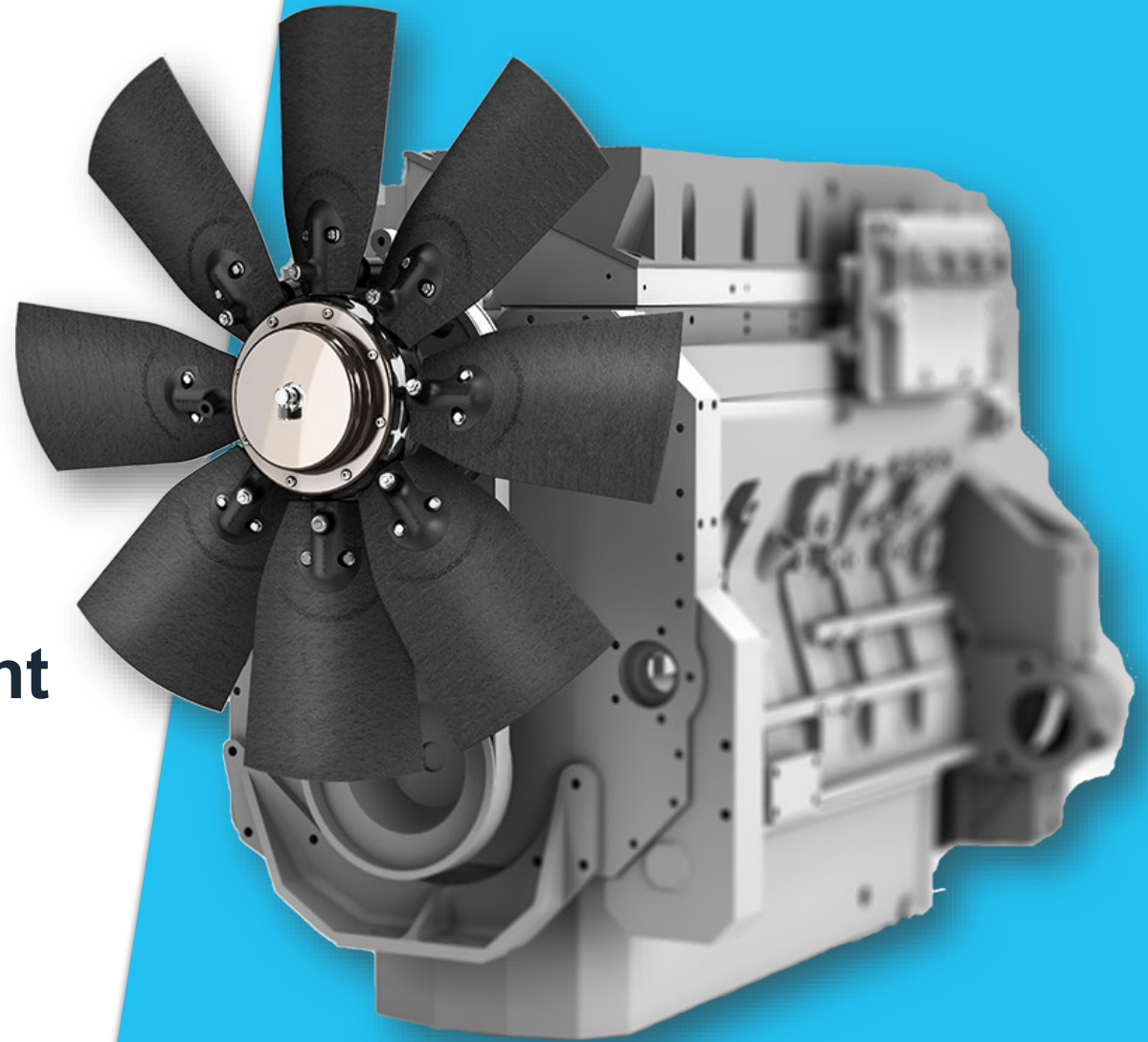
FLEXXAIRE

The reversible fan for diesel engines.

Variable Air Flow Fans for efficient high performance applications

Robert Speck – Flexxaire

Michael Stürmer – Magna

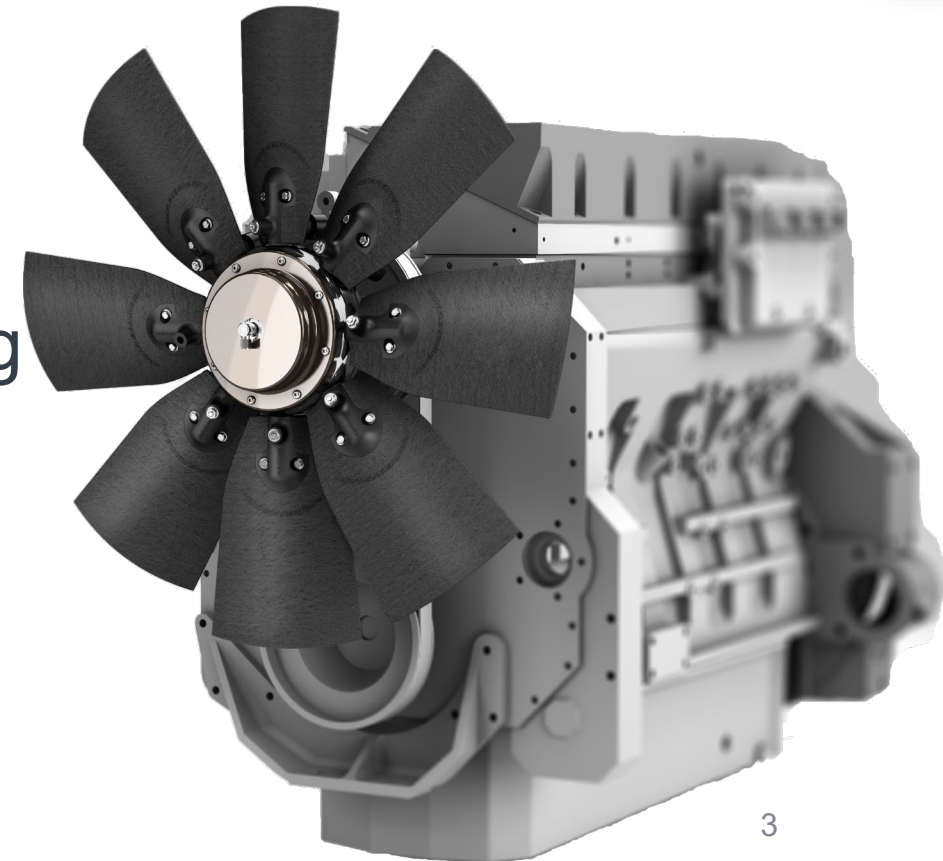


CONTENT

1. Introduction
2. Functionality of the fan and control
3. Test setup / initial situation
4. Execution of the test
5. Results
6. Modeling in KULI

1. INTRODUCTION

- Providing optimized airflow solutions since 1989
- Product engineering, design, and manufacturing in **Edmonton, Canada**
- Core competencies
 - Variable pitch fan systems engineering and manufacturing
 - Professional airflow engineering and optimization services

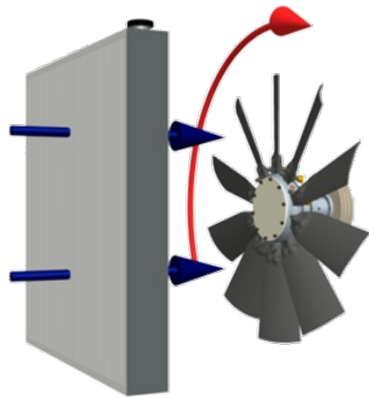


1. INTRODUCTION

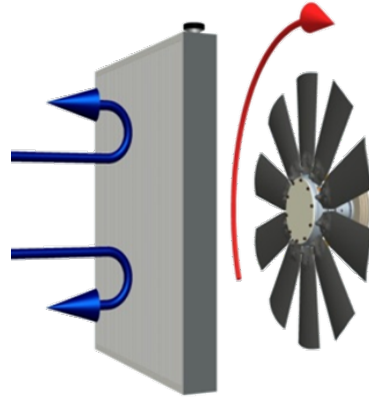
- Robert Speck
- Mechanical Engineer
- 25 years experience in the field of heat exchangers
- with Flexxaire since 2 years
- located in Germany
- responsible for D/A/CH markets



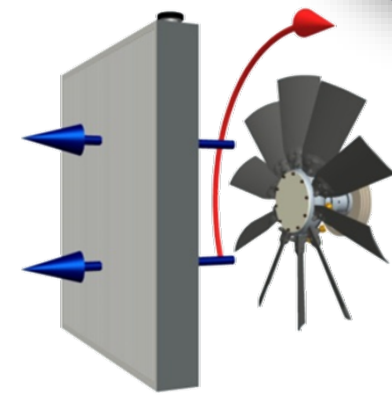
2. FUNCTIONALITY OF THE FAN AND CONTROL



DEFAULT



NEUTRAL



REVERSE

All Flexxaire fans adjust blade pitch at full speed through **Default**, **Neutral** and **Reverse** pitch positions

Benefits



Radiator
Cleaning



Increase
Productivity



Reduce
Downtime



Fuel
Savings



Reduce
Emissions



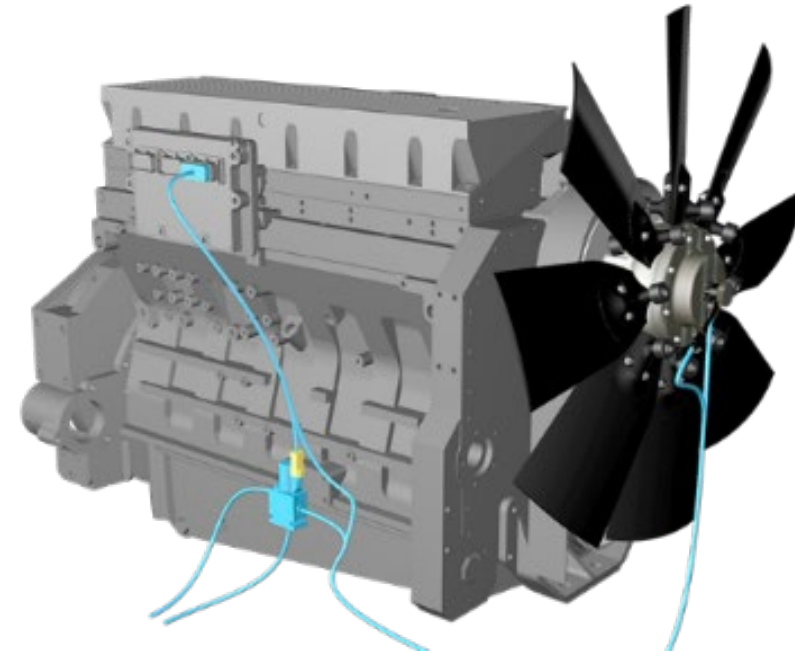
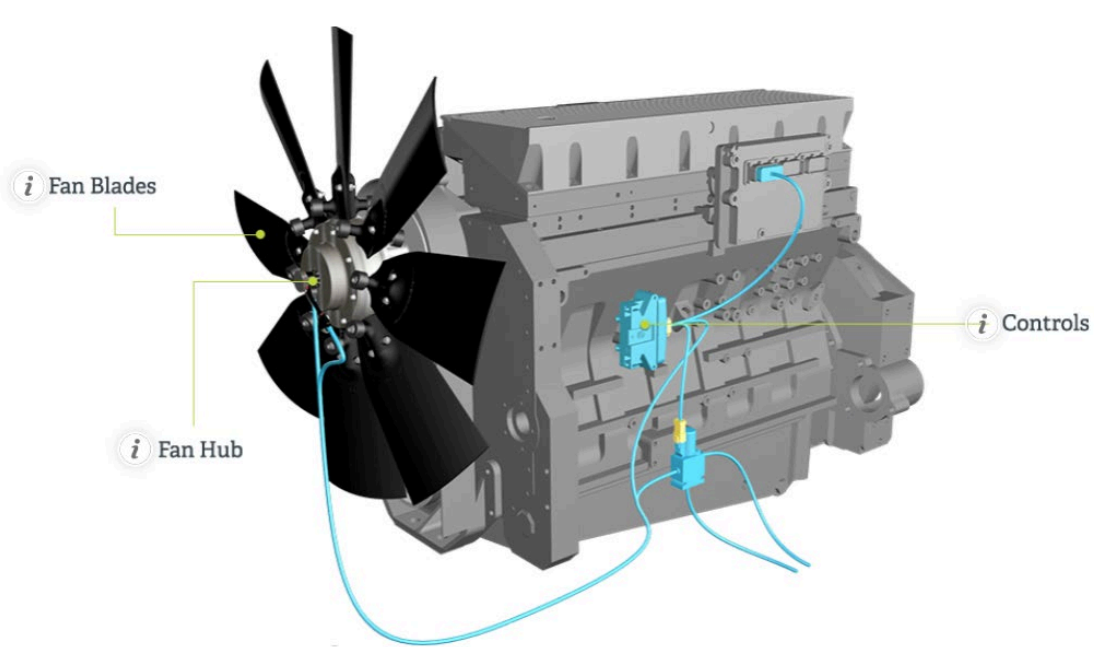
Avoid
Overcooling



Noise
Reduction

2. FUNCTIONALITY OF THE FAN AND CONTROL

IVP (Infinite Variable Pitch) can be used with Flexxcontrol or integrated into engine electronics



3. TEST SETUP / INITIAL SITUATION

PURPOSE of the test

determine the fan power and fuel savings delivered by a variable pitch fan compared to the standard OEM fixed pitch fan

A stand-alone datalogger was installed on a Claas Jaguar 930 forage harvester for 19 days while the farmer harvested the first cut of haylage

3. TEST SETUP / INITIAL SITUATION

CLAAS Jaguar Forage Harvester

Mercedes-Benz OM 460LA 4i
359 kW @ 1800 1/min

Sucker fan D=1168 mm
gearbox mounted / pulley driven

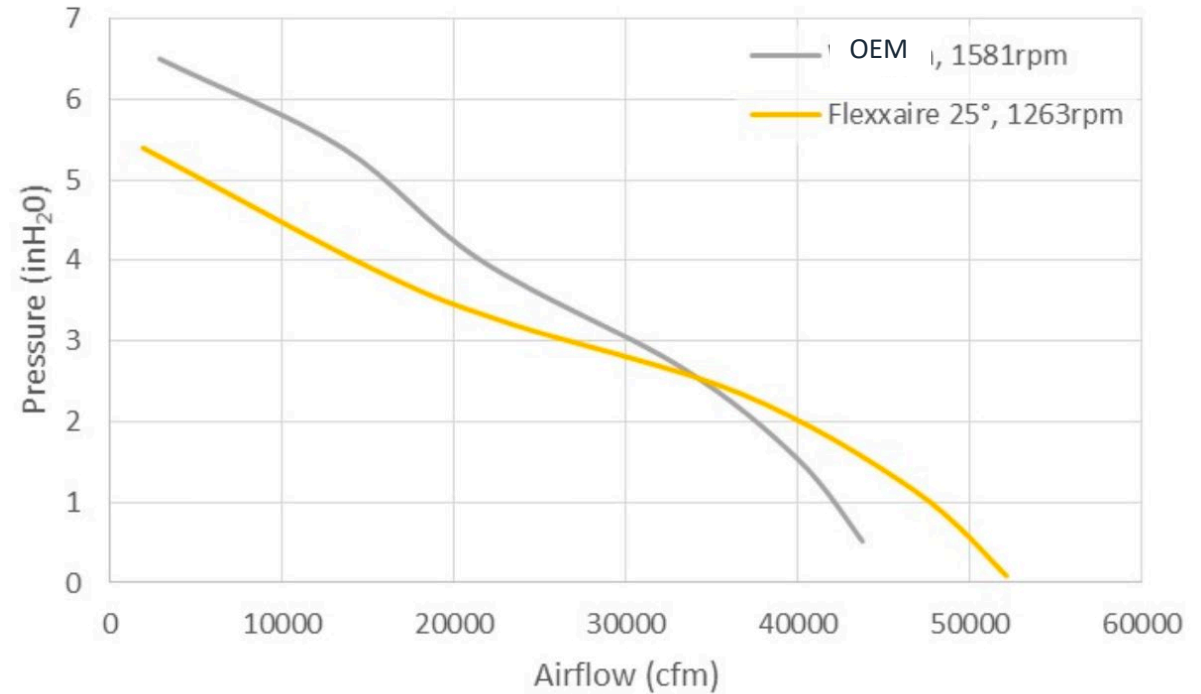
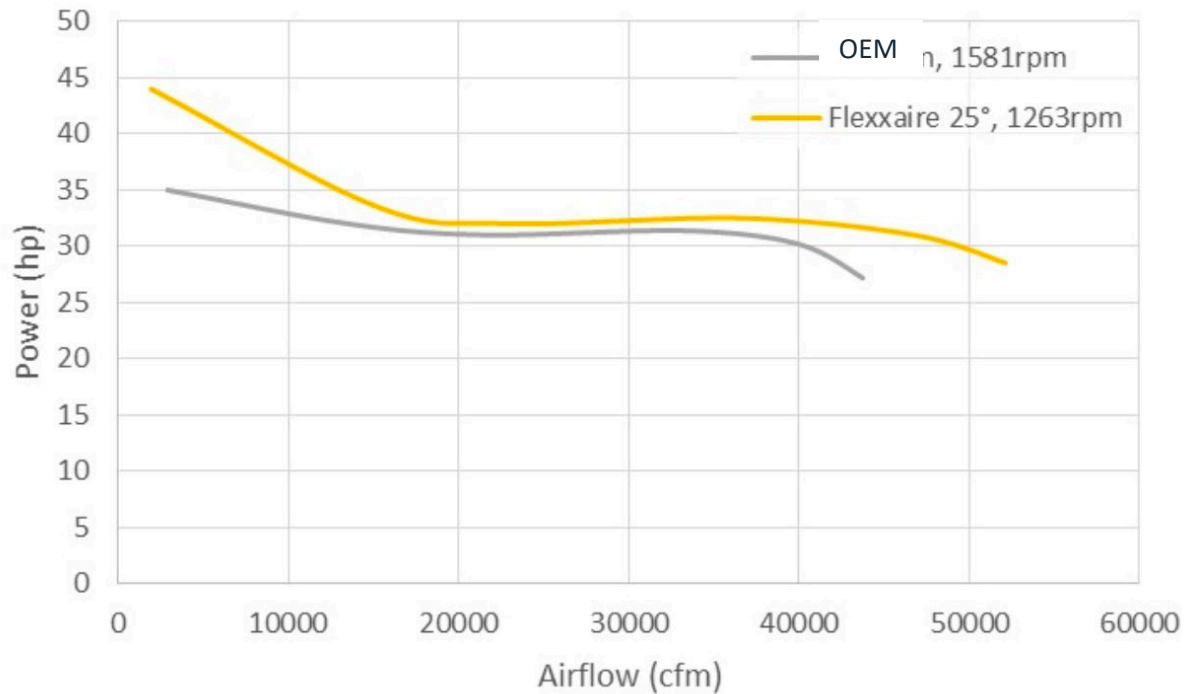
Ratio 1:1,27 (reduced fan speed)



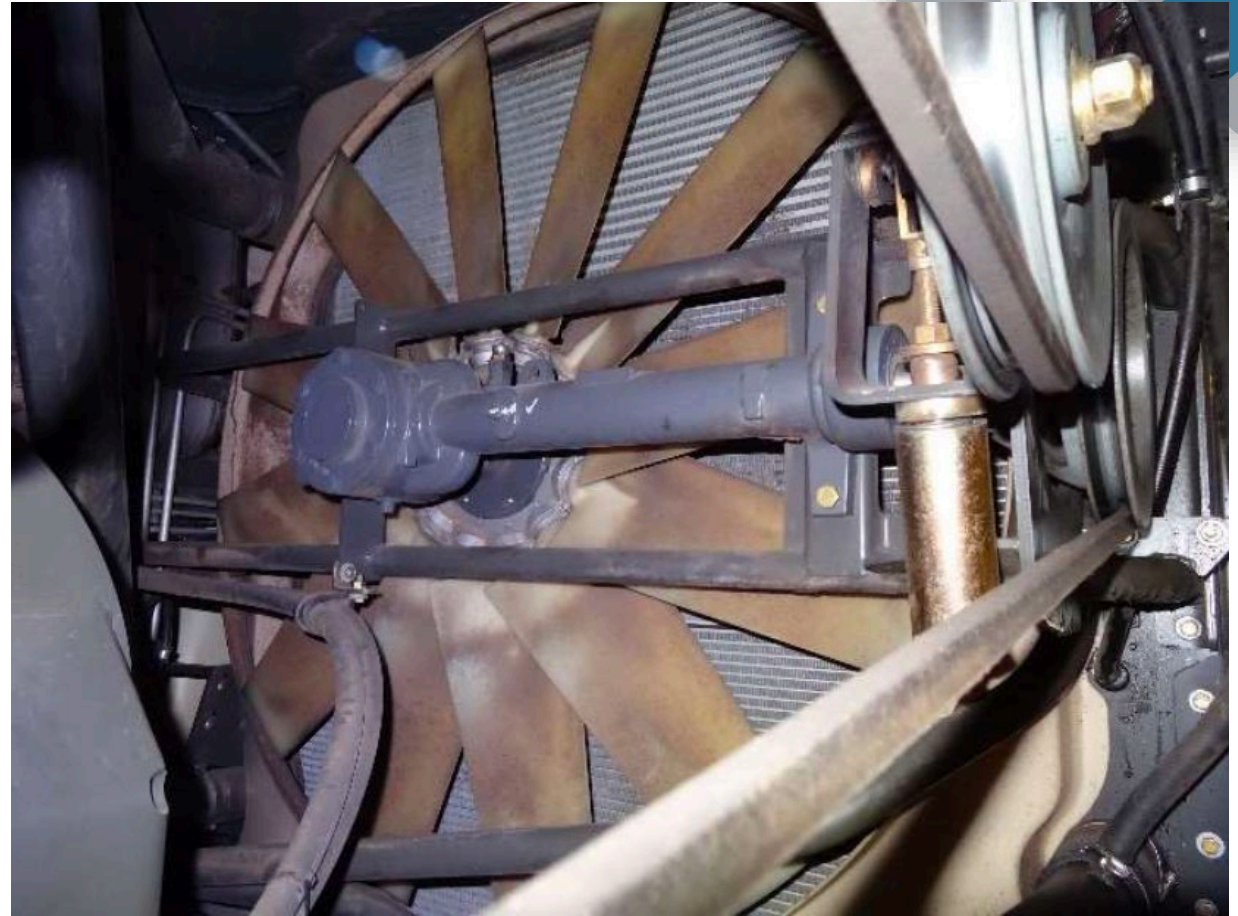
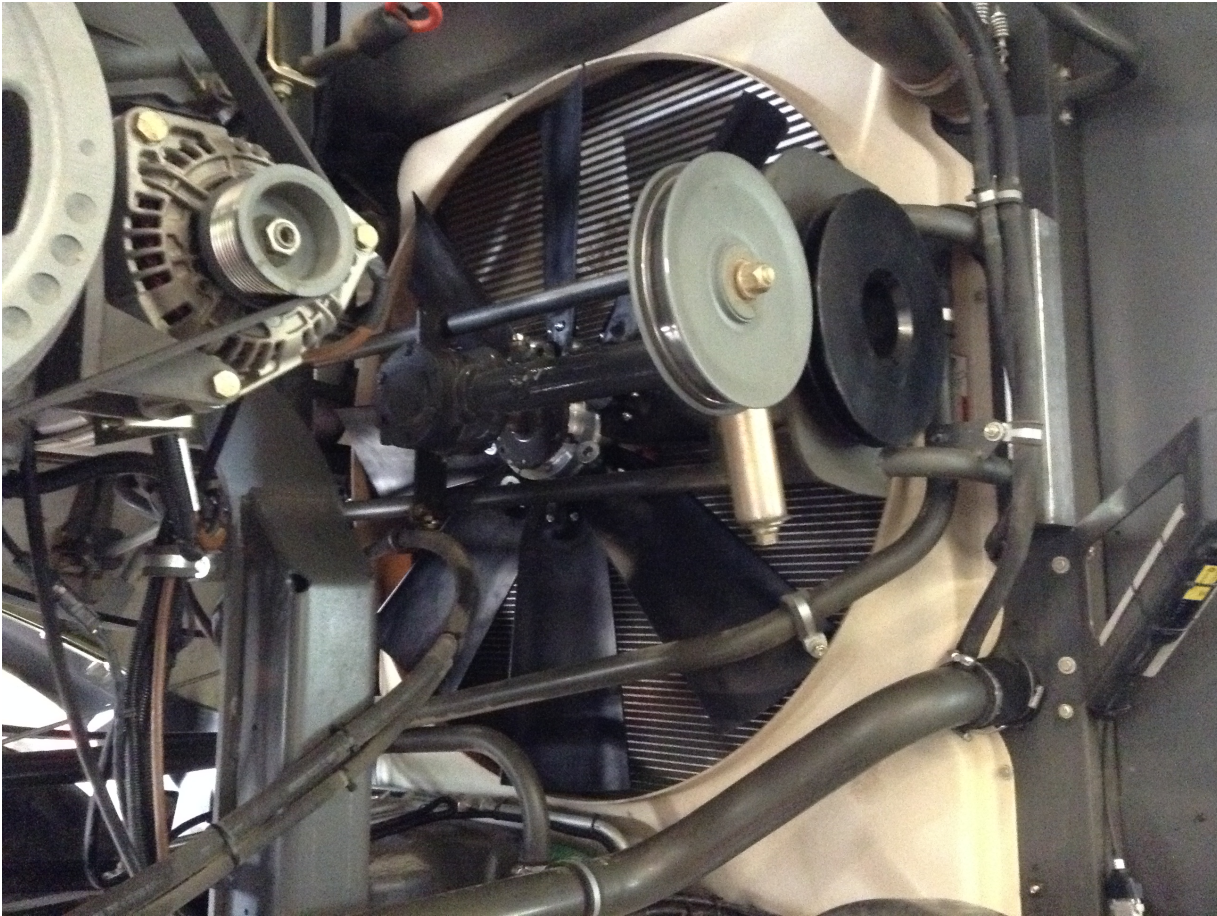
Figure 1, Claas Jaguar 930 Forage Harvester

3. TEST SETUP / INITIAL SITUATION

Choose the right fan by calibration in the wind tunnel



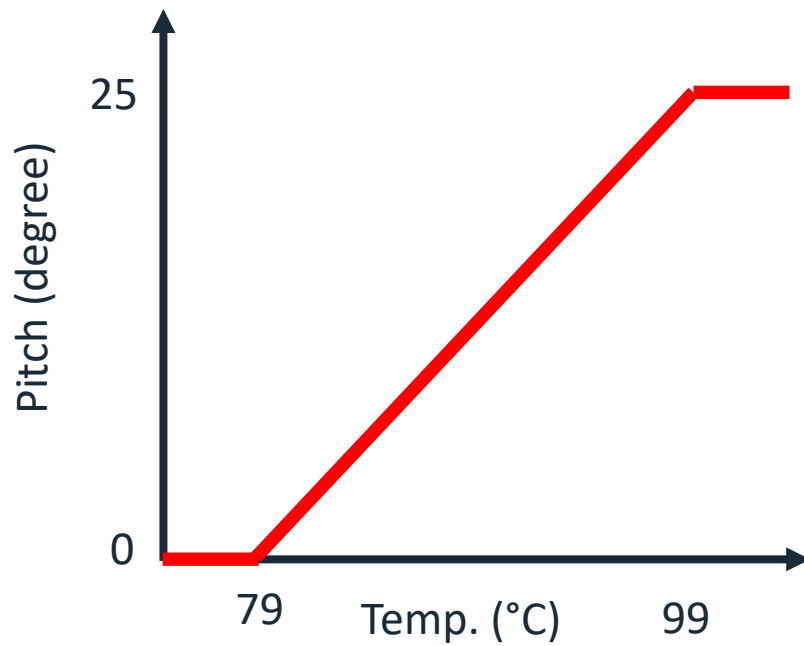
3. TEST SETUP / INITIAL SITUATION



4. EXECUTION OF THE TEST

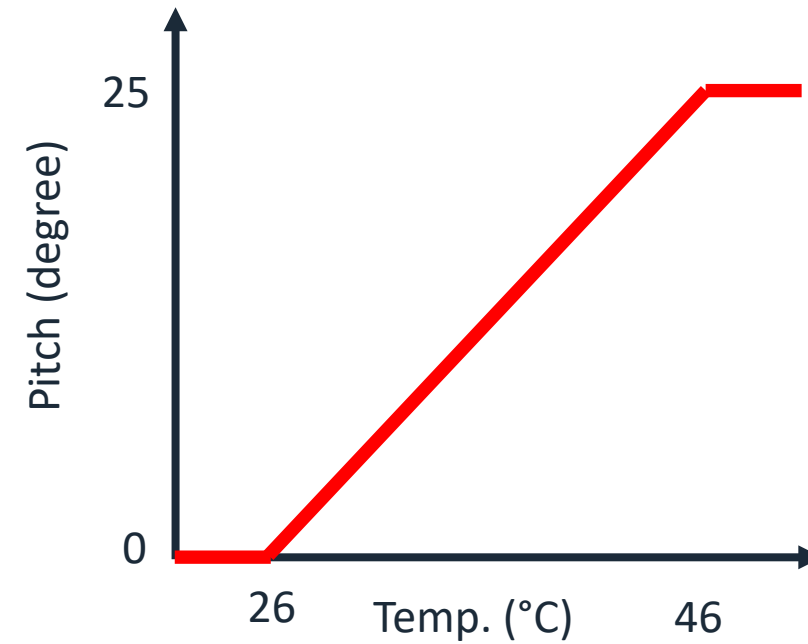
Control Settings of the IVP System

Coolant



OR

Intake Manifold



4. EXECUTION OF THE TEST

Summary of results / Fan power comparison

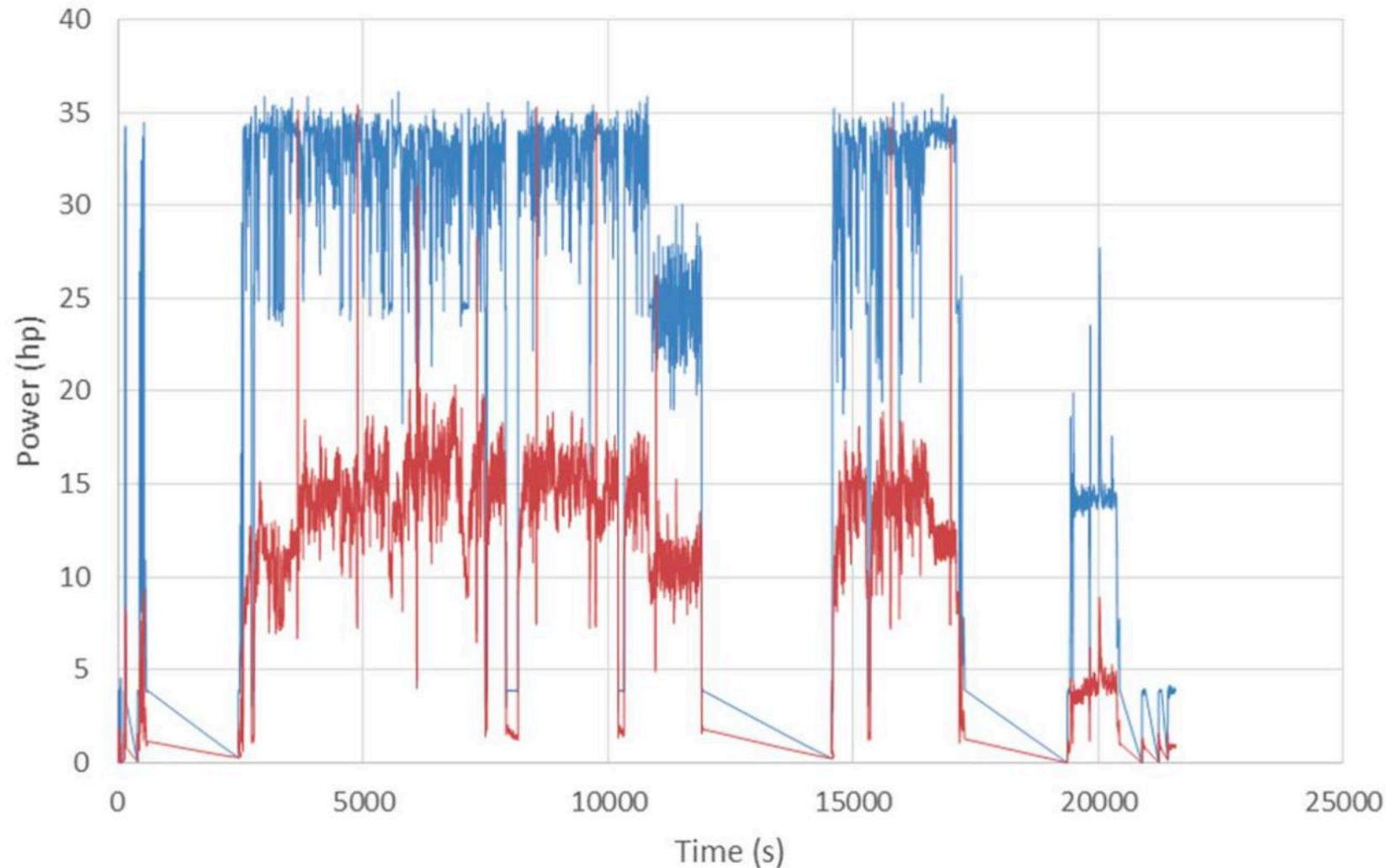
Filename	Date	Avg Power OEM (hp)	Avg Power (Flexxaire, hp)	# of Data Points	Avg x Num OEM	Avg x Num (Flexxaire)
Claas_930_Filter_set_1_(002-015).xlsm	26/06/2014	10.8	4.3	8065	87102	34679.5
Claas_930_Filter_set_1_(016-020).xlsm	28/06/2014	19.2	7.9	16708	320793.6	131993.2
Claas_930_Filter_set_1_(021-030).xlsm	29/06/2014	27.4	12.2	13926	381572.4	169897.2
Claas_930_Filter_set_1_(031-034).xlsm	30/06/2014	3.6	1.3	336	1209.6	436.8
Claas_930_Filter_set_1_(035).xlsm	02/07/2014	10.3	3.4	70	721	238
Claas_930_Filter_set_1_(036-047).xlsm	03/07/2014	11.9	4.7	12269	146001.1	57664.3
Claas_930_Filter_set_1_(048).xlsm	06/07/2014	18.7	8.1	17260	322762	139806
Claas_930_Filter_set_1_(049-053).xlsm	10/07/2014	20.4	8.1	44875	915450	363487.5
Claas_930_Filter_set_1_(054-057).xlsm	11/07/2014	21.1	8.7	38366	809522.6	333784.2
Claas_930_Filter_set_1_(058-059).xlsm	12/07/2014	17.8	7	10210	181738	71470
Claas_930_Filter_set_1_(060-064).xlsm	14/07/2014	18.4	7.3	16636	306102.4	121442.8
Claas_930_Filter_set_1_(065-074).xlsm	15/07/2014	19.3	8	33666	649753.8	269328
Claas_930_Filter_set_1_(075-090).xlsm	16/07/2014	18.8	7.9	37495	704906	296210.5
Claas_930_Filter_set_1_(091-098).xlsm	17/07/2014	18.4	7.7	34139	628157.6	262870.3
Claas_930_Filter_set_1_(099-100).xlsm	18/07/2014	3.1	1.1	95	294.5	104.5
Claas_930_Filter_set_1_(101-106).xlsm	21/07/2014	2.8	1	161	450.8	161
Claas_930_Filter_set_1_(107-110).xlsm	25/07/2014	2.1	0.7	511	1073.1	357.7
Claas_930_Filter_set_1_(113-115).xlsm	01/08/2014	3.5	1.3	207	724.5	269.1
Claas_930_Filter_set_1_(116).xlsm	02/08/2014	3.7	1.3	93	344.1	120.9
Sum				285088	5458679.1	2254321.5
Power, Weighted Avg. [$\Sigma(\text{avg x Num}) / \Sigma(\text{\# of Data Points})$], hp					19.1	7.9

Average saving:

11,2 HP = 8,4 kW

4. EXECUTION OF THE TEST

Summary of results / Fan power comparison

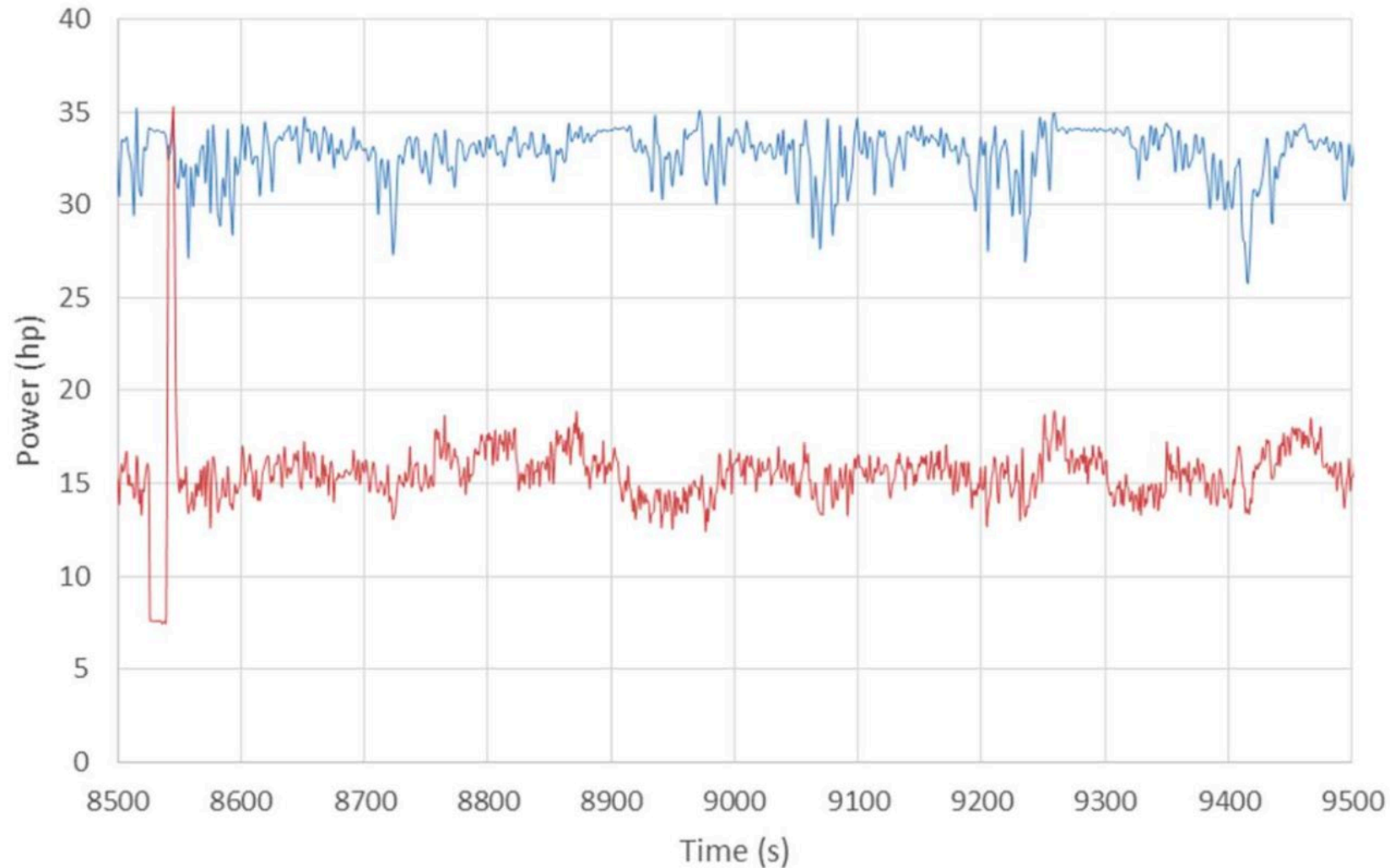


Average saving:

11,2 HP = 8,4 kW

4. EXECUTION OF THE TEST

Summary of results / Fan power comparison



Average saving:

11,2 HP = 8,4 kW

5. SUMMARY

79 hours of harvesting operation in total

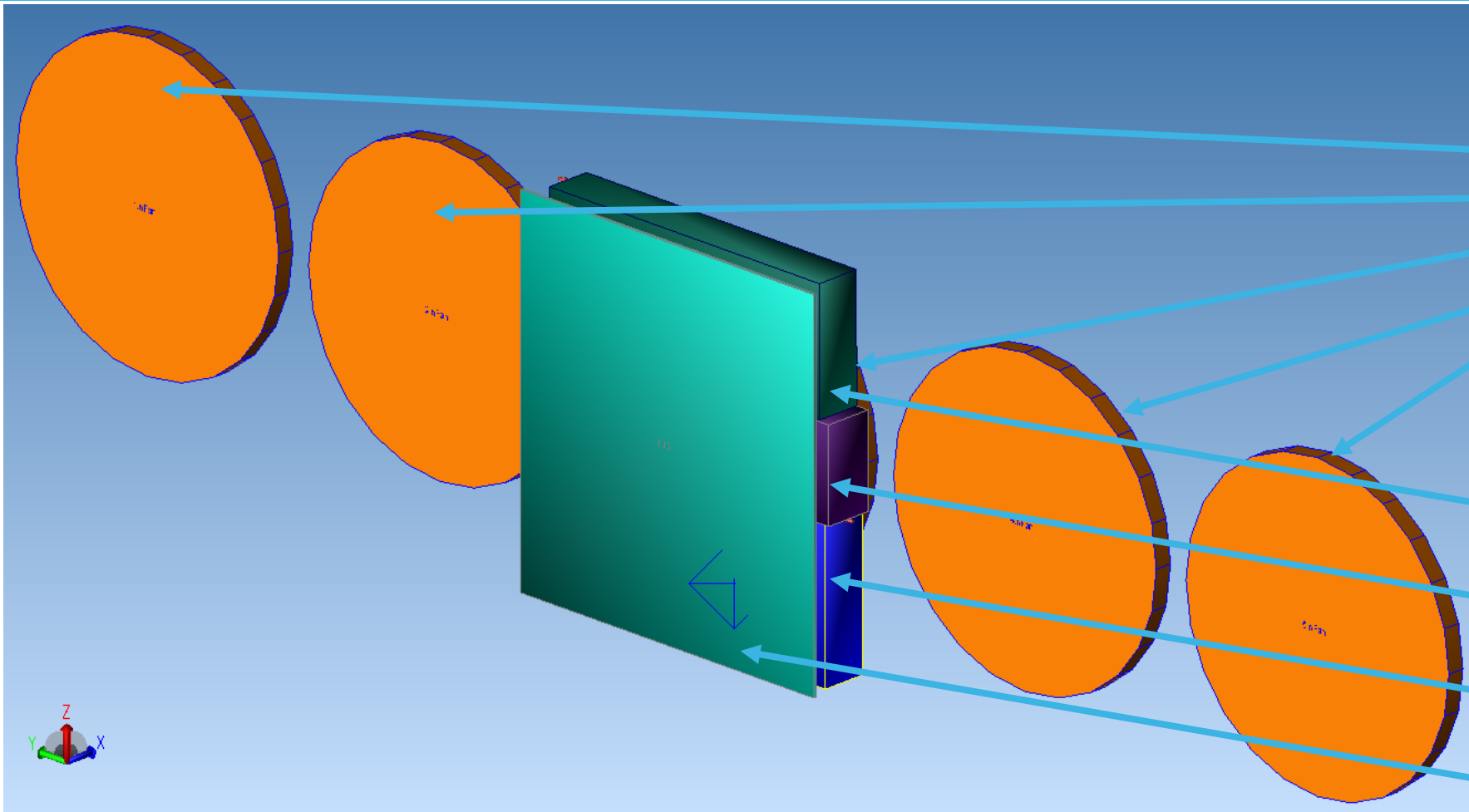
Average saving of 8,4 kW

Calculated fuel saving of 1,8 l / hour

600 hours of annual use of the harvester means a fuel saving of 1080 l per year

6. MODELING IN KULI

Air path



modeling of variable blade
geometry via 5 speed-
controlled fans in parallel
→ pitch angles from 0° to 25°

charge air cooler

oil cooler

radiator

inlet grid

6. MODELING IN KULI

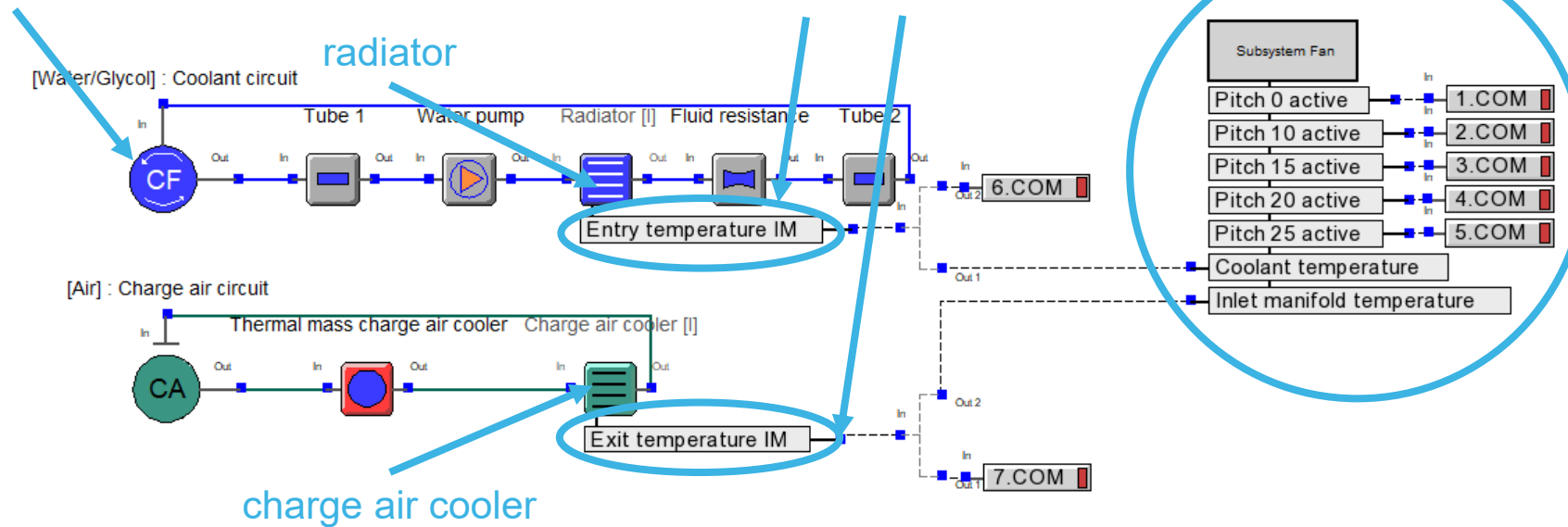
Signal path – cooling system

dynamic solver in the coolant circuit to:

- consider the coolant's inertia effects
- avoid oscillation in the fan control

subsystem inputs:

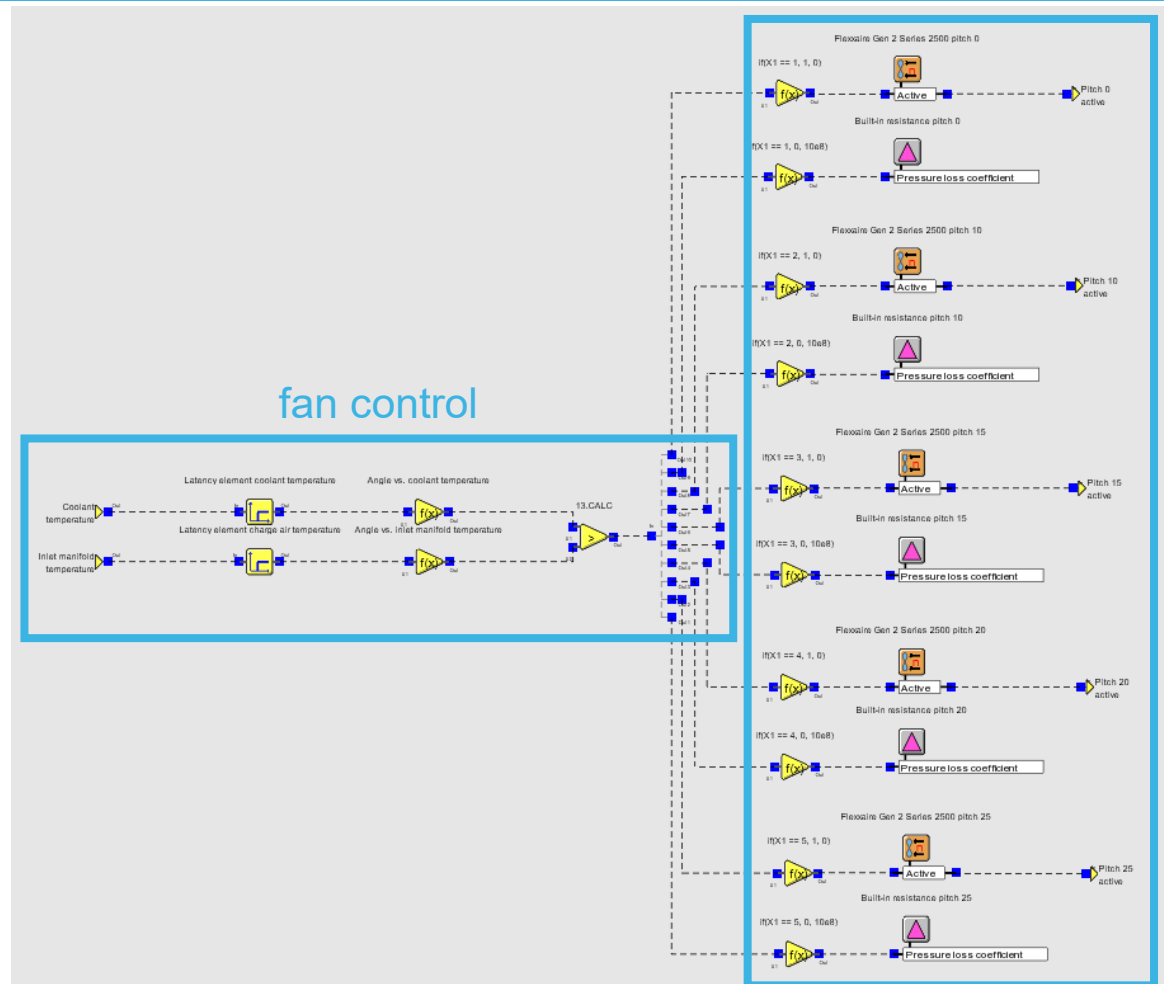
- coolant temperature (upstream)
- charge air temperature (downstream)



fan's subsystem

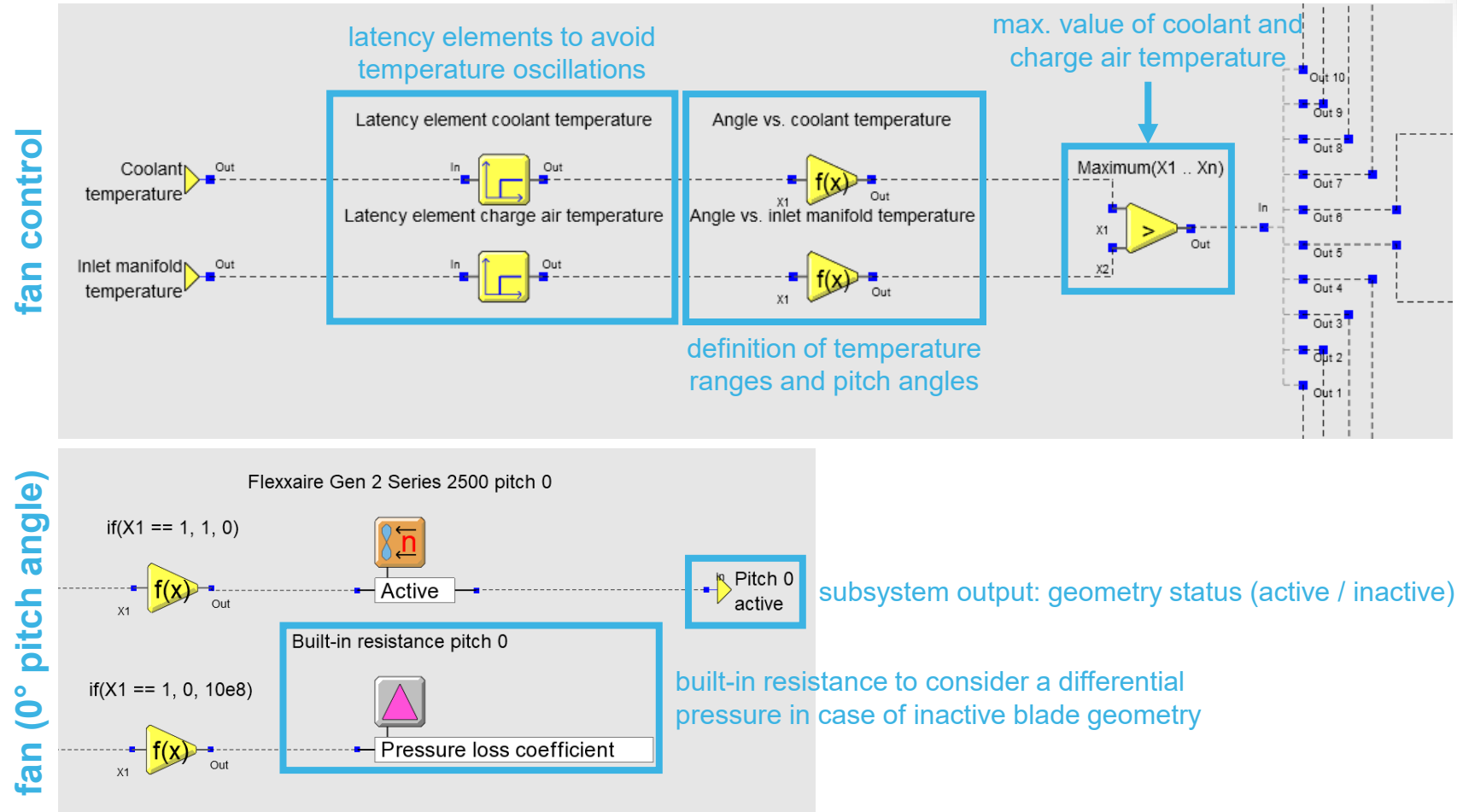
6. MODELING IN KULI

Signal path – fan’s subsystem (overview)



6. MODELING IN KULI

Signal path – fan's subsystem (detail)



6. MODELING IN KULI

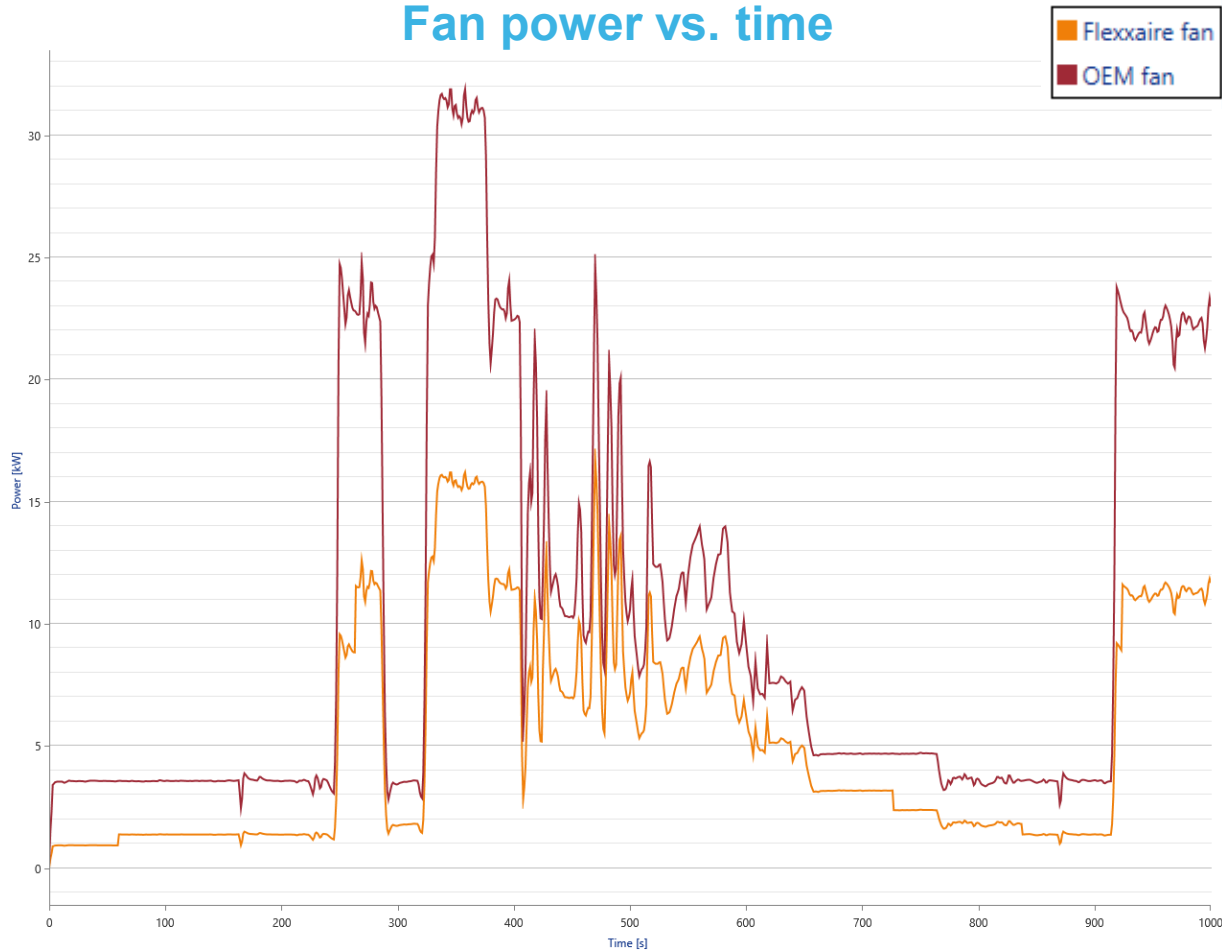
Fan control



6. MODELING IN KULI

Results

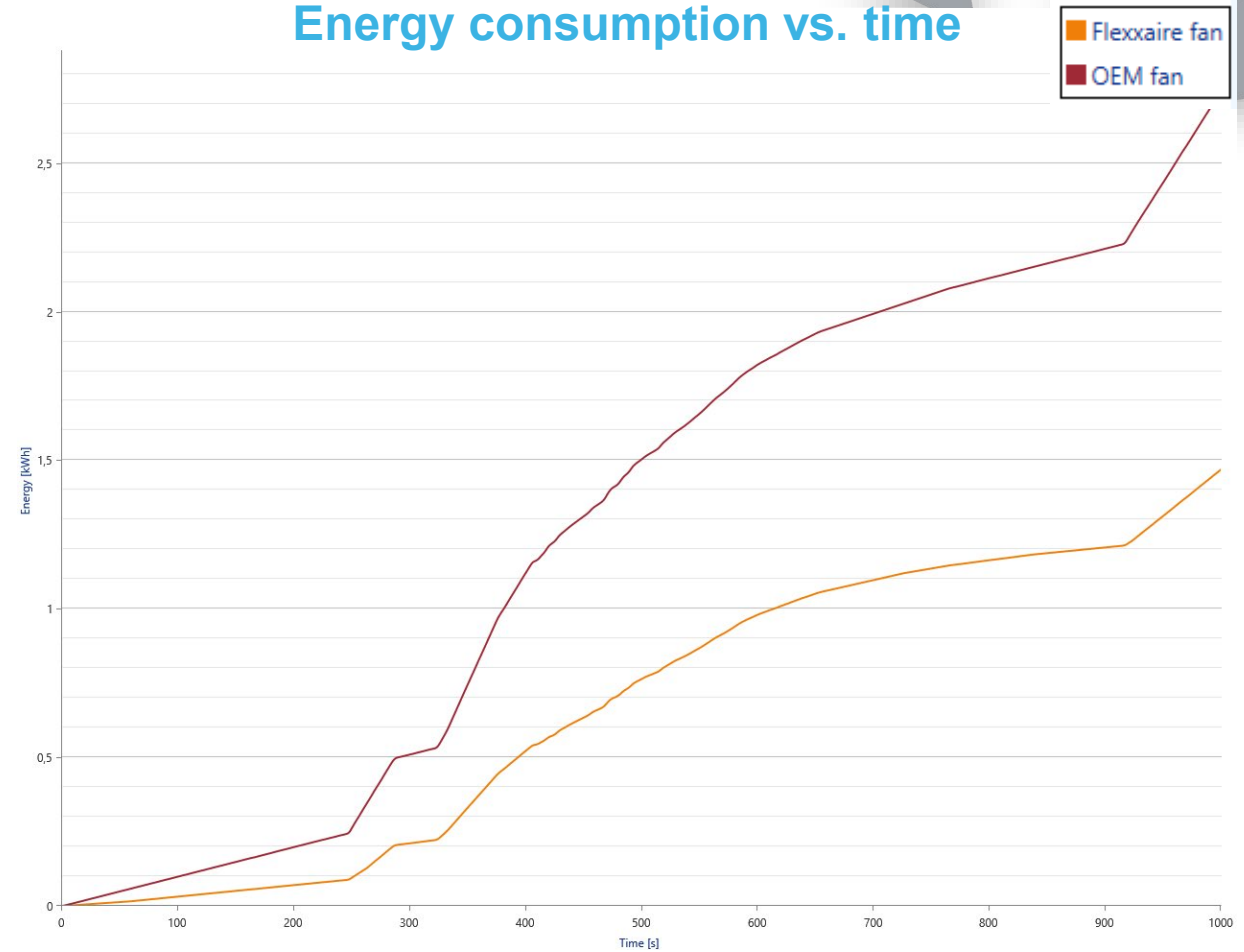
Fan power vs. time



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Energy consumption vs. time



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QUESTIONS?

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