EUROMOT

Small Handheld Nonroad SI Engines

- future small SI engines -

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TYPICAL INSTALLATIONS OF HANDHELD SI ENGINES



WORLDWIDE EMISSION LEGISLATION OF SMALL SI ENGINES



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LIMIT VALUES ARE WORLDWIDE HARMONIZED





IMPLEMENTATION TIMES



DUE TO MISSING ABT, THE NRMM DIRECTIVE INCLUDES EXEMPTIONS AND DEROGATIONS TO ALLOW TECHNOLOGY ROLL OUT

		20	04	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
chainsaw > 45 cm³ EN ISO 11681-1	45 - 50 cm³							01.02	2.2011				
	≥ 50 cm³								01.02.2012				
augers / drills EN ISO 11681-2	< 50 cm ³							01.02	2.2011				
	$\geq 50 \text{ cm}^3$								01.02	.2012			
brushcutter, trimmer > 40 cm³	40 - 50 cm³							01.02	2.2011				
	$\geq 50 \text{ cm}^3$								01.02.2012				
hedge trimmer tree service chain saws	≥ 20 cm³										01.02	.2014	
Cut off machines > 50 cm ³ EN 1454									01.02	.2012			
small volume families < 5000/a max. 25.000/a per manufacturer													
	Stufe I								Stufe II				

EMISSION LIMITS AND ACHIEVED REDUCTIONS (SH:2 20-50 CM³)





TECHNOLOGIES TO MEET STAGE 2 LIMITS





WHY ARE SO MANY DIFFERENT TECHNOLOGIES USED FOR SMALL HANDHELD SI ENGINES ?

- Highly diverse market with several hundred different applications (olive tree shaker, cork harvester, rail cutter, ice auger, bed redefiner, etc.) resulting in different requirements for vibration stability, noise, low temperature operation or operation environment such as abrasives or flammable saw dust.
- Many products such as chain saws are not assisted by a harness, so the user carries the full product weight with his hands.
- Many products are multi-position tools, such as hedge trimmer, chain saws, cut off machines operated in various positions, so sophisticated lubrication is essential to allow lubrication of the engine.

REQUIREMENTS OF APPLICATION VS ENGINE TECHNOLOGY





2 STROKE TECHNOLOGIES



CONCLUSION 1

- There is not a single technology meeting all requirements
- Portable products are very compactly built and thus sensitive to aftertreatment heat
- Close to body operations such as hedge trimmer and top handle chainsaws are even more sensitive to engine or aftertreatment heat
- Multiposition products have to use sophisticated lubrication
- Handheld products need minimum weight



REAL LIFE EMISSION REDUCTIONS

- Due to the lack of proper market surveillance many non compliant products are sold on the EU market (often there is no emission certification at all)
- Products purchased in DIY market in 2011/2012 and measured
- Non compliant
 engines frequently emit
 5-6 times above the legal
 limit



chain saws bought in DIY markets



REAL WORLD EMISSIONS BASELINE SCENRIO



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REAL WORLD EMISSIONS ARE DOMINATED / DOUBLED BY NON COMPLIANT ENGINES



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CONCLUSION 2

- Enforcement of the NRMM is needed to eliminate non compliant high emitters
- Enforcement is needed to stop unfair competition and create a level playing field where every participant on the market has to invest into emission control technology



PM EMISSIONS

• Depend on oil / fuel ratio (1:25 to 1:50) used in the engine

 Scavenging losses of the engine are the dominant source for PM emissions for 2-Stroke and Stratified charged engines (TGA indicates 2-3% solid fraction)









PM EMISSIONS FROM SMALL SI ENGINES

- Has been investigated by the California ARB
- Results:
 - For engines running with mixed lubrication, there is a close correlation between HC emissions and PM emissions
 - Within the certification process the oil /petrol ratio of the HC emissions are calculated to be the PM emissions
 - The PM analyzed are predominantly liquid and therefore a reproducible measurement procedure is not given, due to the different properties of engine oils used





TEST RESULTS ON PM EMISSIONS



test data from a Euromot member company

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CONCLUSION 3

- PM emissions derive from scavenging losses of 2 Stroke engines; 97% unburned engine oil
- CARB concluded not to require measurement of PM from small SI engines due to the chemical nature and difficulties to quantify emissions
- The CARB limit corresponds to an approximate oil/fuel ratio of 1:50
- Mandate oil/fuel ratio of 1:50 to eliminate the use of frequently required 1:25 mixing ratio and reduce PM emissions



WHAT ABOUT CATALYSTS?

 Catalysts are used today in multi million numbers on non heat sensitive applications by many small SI engine manufacturers



- Additional weight and costs are caused mainly because of heat shielding and additional cooling air, not because of the price of the catalyst itself.
 (An 2 kW engine emits 2 kW of heating power)
- Several technical barriers/limitations need to be solved



CATALYST POISONING BY LUBE OIL ADDITIVES





CATALYST DEACTIVATION CAUSED BY LUBE OIL





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EVERYTHING WORKS IN A FRESH STAGE, HOW TO PREVENT LUBE OILS TO POISON THE CATALYST?

- In analogy to diesel engines and low sulfur fuels, catalyst poisoning needs to be limited by standards for lube oils
- No current oil standards mandate limit values for:



HEAT DEVELOPMENT IN CLOSE TO BODY OPERATIONS



Catalysts increase exhaust gas temperatures. There are specific requirements from tree service specialists using top handle chain saws, to limit surface temperatures on housings (skin burn hazard) or exhaust gases to prevent melting of ropes or safety gear.



CONCLUSION 4

- Ca and S from lube oils deactivate catalysts
- Lube oil standards are needed to prevent catalyst poisoning on the market
- Technical barriers from the additional catalyst heat in close to body applications, limit the use of catalyst due to safety hazards.
- EPA GHG reporting rule requires to report of N₂O for engines equipped with a catalyst

FINAL CONCLUSION

- The highly diverse product portfolio of handheld tools require several engine technologies
- PM emissions derive from scavenging losses not from the combustion process (oil droplets), reduction of lube oil from 1:25 to 1:50 will reduce these emissions
- Technical barriers include additional heat (close to body operations) and catalyst poisoning from lube oils. In analogy to low sulfur fuel, a low Ca and S standard is needed to prevent catalyst deactivation.
- Non compliant engines are the biggest threat for the environment today (potential is 50% emission reduction)



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