EuroPHit

D5.1.18_Guidelines_Regenerative_MVHR_alternating_type

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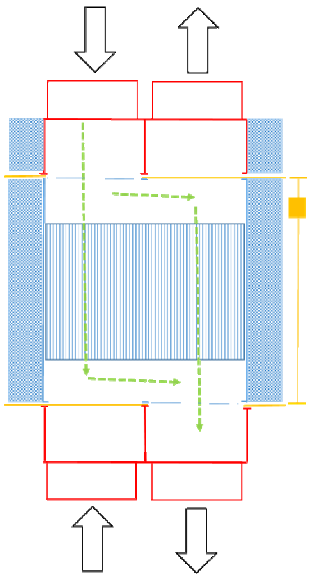

INTELLIGENT ENERGY – EUROPE II

Energy efficiency and renewable energy in buildings

IEE/12/070

EuroPHit

[Improving the energy performance of step-by-step refurbishment and integration of renewable energies]

Contract N°: SI2.645928

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Technical References

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Table of Contents

0 Abstract

This document deals with the possibilities a domestic MVHR of the alternating regenerative type might present. In this arrangement unlike the thermal-wheel type two fixed blocks of regenerator matrix are provided along with devices to switch the airstreams between them periodically. This layout is used in a few large scale air handling units. To the knowledge of the author it is, however, not currently used in any domestic scale MVHR unit with 100-150 m³/h capacity as it is typically required in EnerPHit and Passive House projects.

Regenerative systems offer a number of advantages over recuperative systems, some of which are especially welcome in retrofit settings: In central European climates freezing is of no concern and in turn a preheater is unnecessary; no condensate drain is required and the heat recovery rate can be adjusted without any need for a bypass flap by simply altering the cycle length. Some humidity is recovered, especially at low outdoor air temperatures when it is most urgently needed.

Regenerative units of the thermal wheel type with suitable capacity for domestic use are available and on the market, but suffer a few downsides. Sealing the wheel along its circumference as well as across its diameter is challenging and the additional power need for constantly driving the wheel against the friction of the seals makes itself felt in the overall power demand of the unit. A purging chamber only works when the pressure conditions allow and might be sensitive if not set up properly. These challenges also tend to drive cost.

Such troubles are avoided when stationary regenerators are used - at the expense of introducing new moving parts for switching the air streams. When implemented as *rotary slide valves* the author is confident that they are simple and cheap to manufacture, reasonably tight and not of excessive friction. Driving power is further limited as it is only required periodically.

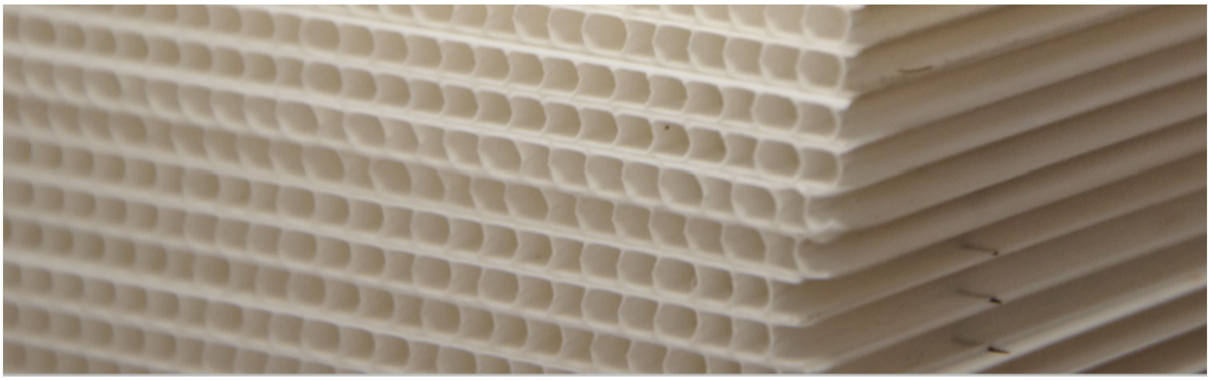

Figure 1: Polypropylene (PP) twin wall panels

A suitable and inexpensive material for the regenerators would be polypropylene (PP) twin wall panels. These are widely used for displays and packaging, the material is non-toxic, easy to cut and the price is less than 2 € per m² including VAT. Stacking rectangular cuts of 2,5 mm thick panels results in a regenerator block with very high surface and low pressure drop. In principle this type of material would also be suitable for the structural casing parts, if air tight ways of joining can be devised. Additional thermal insulation would, however, be required.

This could result in a very lightweight unit, easy to fit and fix.

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1 Alternating regenerative MVHR for domestic use

1.1 Requirements and testing

Requirements and testing procedures follow the certification criteria for ventilation units suitable for Passive Houses, available for download at www.passiv.de. Thus an effective heat recovery rate of > 75% in combination with power consumption including any controls and auxiliary drives must be < 0,45 W/(m³h). Further demands relate to air tightness and the carry-over of extract air into the supply air.

Any newly developed unit must strive for higher performance, heat recovery rates > 80% and electrical efficiencies < 0,35 W/(m³h) are now common.

Furthermore features like auto-balancing outdoor air and exhaust air flows and easy commissioning are key for uncomplicated use and practicality.

Another important demand is the price. To make MVHR systems a mass-phenomenon the price of current units (2000 + €) must drop by a factor of 2 to 3 very soon. Simple and fast assembly from inexpensive parts, manufactured on standard machinery is therefore important.

2 Design principles

To illustrate the concept for a regenerative MVHR unit of the alternating type the key parts will be explained in more depth below.

2.1 Regenerator

A suitable and inexpensive material for regenerators would be polypropylene (PP) twin wall panels. These are widely used for displays and packaging, the material is non-toxic, easy to cut and the price is less than 2 € per m² including VAT. The density of polypropylene is around 0,9 g/cm³, the thermal capacity 1700 J/(kgK).

For this concept a capacity of the MVHR unit of 120 m²/h (± 30) was assumed and calculations were performed to estimate a suitable size for the regenerators.

Stacking rectangular cuts of 2,5 mm thick panels results in a regenerator block with very high surface and low pressure drop.

It was found that a block 300 mm wide and 150 mm deep with a length (flow path) of 250 mm would be a good orientation. According to first numerical estimates a pressure drop in the range of 28 Pa @ 120 m³/h can be expected (Δp [Pa] ≈ 0,234 * V [m³/h]), with heat recovery efficiency above 80 %. It must be noted that this is the HR efficiency of the regenerator alone and does not take into account fan power, any heat flows across the casing or by air leakages. It therefore cannot be considered a prediction of the MVHR unit performance. However, if the casing offers a good level of air tightness and insulation a well-performing unit appears feasible.

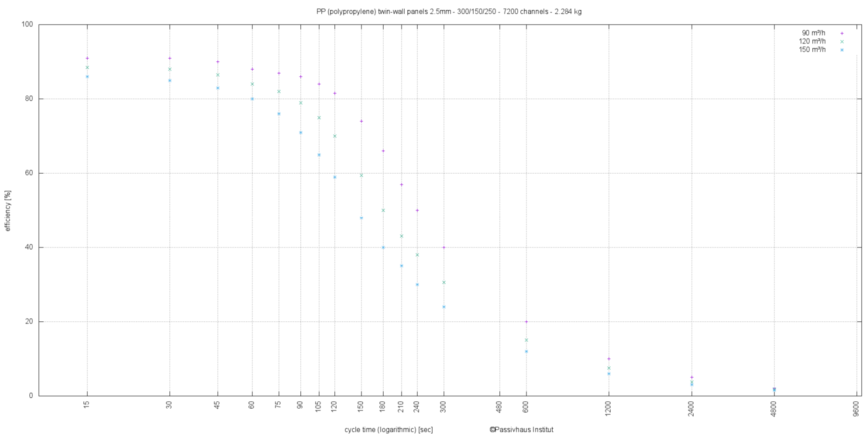

Figure 2: heat recovery efficiency for the suggested regenerator. Simulation results, apply to regenerator only. (No prediction of unit performance.)

The suggested regenerator block could be stacked of 60 layers of 2,5 mm twin wall panels (total less than 5 m² or 10 €) and yields a mass of around 2,2 kg and almost 16 m² of surface exposed to the air stream (~ 1400 m²/m³ specific surface).

Air velocity in the individual channels is around 1 m/s (laminar flow), the time constant is estimated to ~90 sec.

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As all surfaces of the regenerator an take part in the heat exchange internal air tightness of the regenerator block is not required. A simple stack inserted into a matching space in the casing will suffice.

From the perspective of the heat exchanger this approach is hard to beat in terms of price, ease of manufacture and assembly as well as uncomplicated nature e.g. as regards air tightness.

2.2 Rotary slide valves and drive

Large scale MVHR systems of the alternating type normally use two arrays of four multi-leaf dampers each, with electric drives. Simply scaling down this arrangement would be prohibitively expensive and probably also too likely to fail early.

A simple estimation may illustrate this:

With a switching period of 60 sec and 5000 h of operation already 300.000 cycles must be performed annually. Over a 20-year lifecycle this adds up to 6 million cycles. The implementation must therefore be very simple and robust.

One possible way of achieving this is to use a rotary slide valve. In its simplest form this has the form of a flat disc, but it could also be made conical, yielding somewhat larger clear openings. Only the flat disc variety will be further elaborated here, keeping in mind that the conical approach might be an interesting optimisation for the future. Figure 3 gives a schematic of the approach.

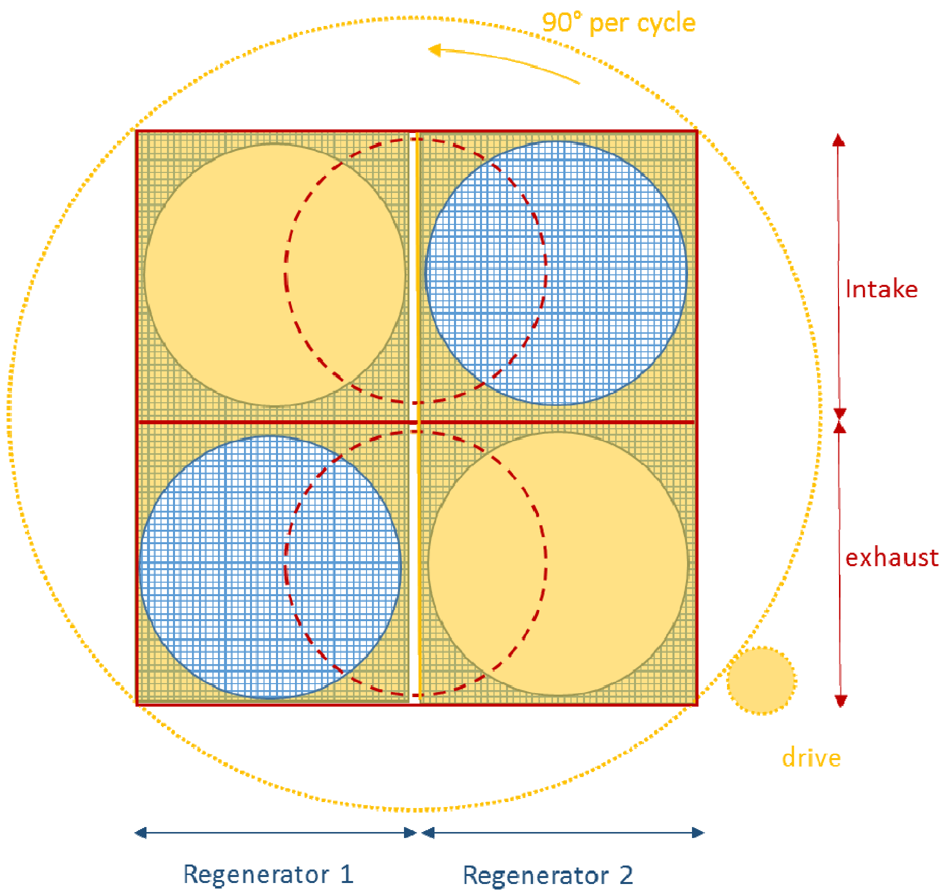

Figure 3: rotary slide valve. Each 90° turn of the yellow disc switches intake and exhaust between regenerator 1 and regenerator 2

The same device is mirrored at the other end of the regenerators, but driven in the same sense (the same motor via a common shaft). The holes in the slide are, however, shifted by 90°. This will ensure equal flow path lengths from valve to valve across the whole regenerator block.

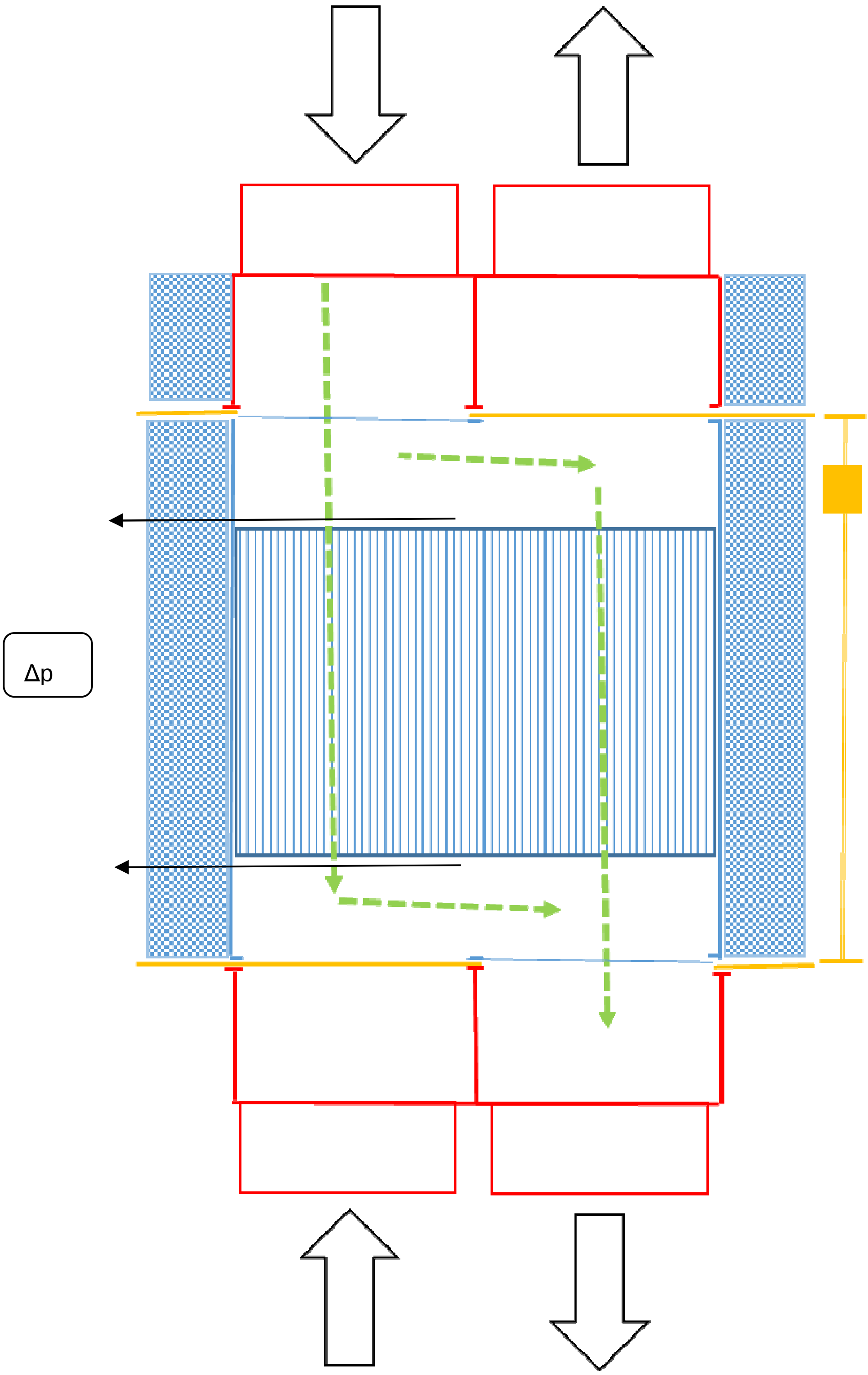

Figure 4: schematic section of regenerator and rotary slide valve. (Fans not shown)

One simple option to drive the valves could be using a common shaft on a single stepper motor that engages with a toothed rim on the valve disc itself.

The valve could comprise a base of sheet steel, with four holes for air and one central pin, on which a PTFE (-coated) slide disc with two opposing holes for air rotates. A third layer is a magnetic foil to ensure even pressure on the valve disc for tightness (principle of fridge door seal), again with four holes for air.

2.3 Air flow measurement and balancing

The straight channels of the regenerators with their length to diameter ratio > 100 represent a good approximation of a Laminar Flow Element (LFE) as it is used in highly accurate flow measurement. The air flow is undisturbed for relatively long times during each cycle. Measuring the actual pressure difference across the regenerator via a ring line either end is therefore promising to yield a useful measure of the actual flow. The unit can thus be controlled to deliver a specified absolute flow rate (simplifies commissioning!), but also balancing the air streams can be accomplished at all times (adjustment for changes in duct system, e.g. filter wear; practicality!). Reasonably accurate pressure sensors have become available relatively cheaply (25 €) and can easily be integrated in the control logic via I^2C.

As both air streams pass through the same regenerator and the measuring principle is independent from flow direction one differential pressure sensor is sufficient. Any systematic error in the measurement will thus also apply to intake and exhaust air such that added accuracy in balancing the air streams is possible and balancing is robust even when the sensor suffers some drift.

2.4 Cost and weight

To gain a better understanding of the proposed unit's economic feasibility a rough estimate of cost and weight of the required parts was made.

The result suggests that it should be possible to market such a device for a substantially lower price than current products, with comparable performance. Learning- and scale effects are expected to further decrease the manufacturing costs, such that a sales price of under 1000€ would not be unrealistic.

Not factored in is further engineering work and, especially, cost for official testing and approvals. The time consuming and extensive procedures in this field are a major cause for slow progress on the market and also drive cost of the products in many Member States of the European Union. Moreover they favour large companies and discourage SME's to enter the market with Innovations.

A comprehensive approach with simple compliance to European Norms ensuring access to the whole Common Market would greatly assist a more dynamic development.

prototype level cost and weight

HX		20.00 €	2.2	
fans		100.00 €	0.3	
valves			1	
	PTFE disc	20.00 €		
	steel	5.00 €		
	magnetic	5.00 €		
stepper motor		20.00 €	0.1	
toothed wheels		2.00 €	0.05	
casing		10.00 €	1	
insulation	EPDM	20.00 €	2	
nozzles	DN 150, 4x	20.00 €		
filters			0.5	
	ODA F7	20.00 €		
	ETA G4	5.00 €		
control unit			0.2	
	Arduino MEGA	50.00 €		
	RTC	5.00 €		
	Display	20.00 €		
	ODA SHT75	20.00 €		
	SUP STS21	5.00 €		
	Pressure +/- 50 Pa	25.00 €		
	Stepper motor driver	10.00 €		
		382.00 €	**7.35**	**kg**
Assembly	5*40€	200.00 €		
Test run		50.00 €		
		632.00 €		

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