SURVEY OF THE CLIMATIC BEHAVIOR OF MOTOR HOMES AN ASSESSMENT OF THE HYGROTHERMAL PERFORMANCE OF RECREATIONAL VEHICLES

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MOTOR HOMES

"Motor homes are automobiles with facilities for living. The living area with its equipment must be able to accommodate one or more persons ..." [Road Traffic Licensing Regulations – Germany (StVZO) §19; 20; 21]. Basically, motor homes can be divided into two categories:

- Vans and platform cars

Platform-cars have a living unit fixed to the chassis. They may be divided into three categories:

- alcove vehicles, partly integrated driver's cabin and fully integrated driver's cabin

Figure 1: Campervan

Figure 2: Alcove-vehicle

Figure 3: partly integrated driver's cabin

Figure 4: fully integrated driver's cabin

MOTOR HOMES IN DIFFERENT CLIMATES

Motor homes are used in varying parts of the world and can thus be exposed to extreme climatic changes, possibly at short intervals. A long holiday in the snowy areas of the Swiss Alps can be followed by a short trip to the warm regions of the Mediterranean Sea or even North Africa.

To date, no studies have been done of the factors involved in optimizing energy behavior and increasing the comfort of motor homes.

INVESTIGATIONS INTO THE THERMAL-ENERGETIC BEHAVIOR OF MOTOR HOMES AND THE THERMAL-HYGRIC BEHAVIOR OF THE EXTERIOR SHELL

Calculations

One important additional task of the investigation was to test and evaluate the suitability of building physics software for realistic estimations of the thermal-hygric and the thermal-energetic behavior of a motor home and its components taking user and construction specific data into account.

The classification of the numerical methods conforms with applications in recreational vehicle construction:

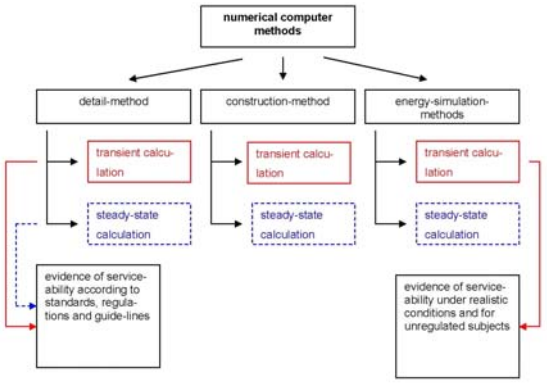

Figure 5: Classification of numerical methods for research on climate in motor homes

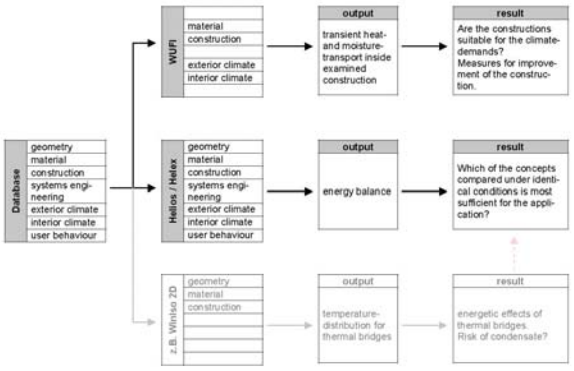

Figure 6: Structure of the software

Investigations into the thermal behavior of the motor home with the software system Helios-Helex 2.1 / TRNSYS*

Major tasks of the investigation of motor homes with Helios and Helex 2.1 / TRNSYS* (econzept Energieplanung GmbH–Schweiz / Energy Laboratory of the University of Wisconsin-Madison) were:

- Computation of the air temperatures inside a motor home during a specified simulation period.
- Calculation of the heat transmission losses.
- Determination of the losses due to air exchange.
- Study of the heat storage behavior of the interior construction elements.
- Determination of heat gains due to radiation through transparent elements.
- Determination of performance specifications for heating and cooling systems.
- Comparison and evaluation of various element and vehicle variations under identical conditions.

DESCRIPTION OF USER BEHAVIOR AND AMBIENT CLIMATE IN COMPUTER PROGRAMS

The mobility of motor homes and their use for recreation involves changes in outdoor climate and user behavior. Paying regard to these special features we generated specific input data sets for the calculations.

INVESTIGATION INTO THE THERMAL BEHAVIOR OF MOTOR HOMES

The investigations using the software Helios/Trnsys are basically divided into two parts:

- Calculation of heating and cooling energy demand with respect to user behavior and different outdoor climates, including optimization of components, to reduce energy consumption and the associated high costs for heating and/or cooling in Europe.
- Calculation of indoor temperatures in winter and summer with respect to different outdoor climates, including optimization of components, to increase user comfort in motor homes.

Figure 7: Investigated (insulated) indoor area of the motor home

Temperatures inside a motor home in summer

For comparison and evaluation purposes, we calculated temperature development inside the motor home in summer without taking air conditioning into account, in order to show the climatic influence of the variables. A calculation with air-conditioning would fail to demonstrate dependencies. The data sets for motor home climate and user behavior served as a basis for our calculations.

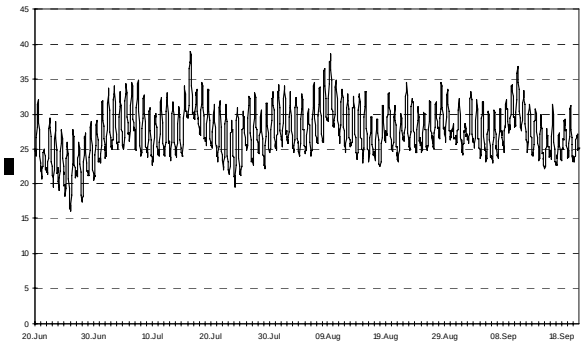

Figure 8: Outdoor temperature during calculation-period in winter – Almeria, Spain

Climate during summer-period – Almeria, Spain

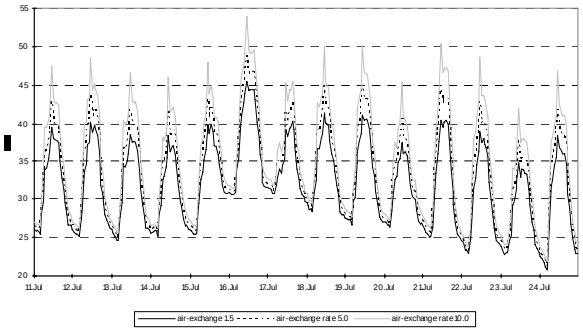

Figure 9: indoor temperatures against air-exchange-ratio(AER); AER = 1,5 – blue; AER = 5,0 – gray; AER = 10,0 – red; outdoor temperature – black

The calculations for the temperature behavior under summer conditions show the following results for Almeria, Spain:

- Increase of insulation thickness has almost no influence on indoor temperatures in motor homes. Caravan users often remark that a thicker insulation layer worsens the summer indoor climate ("barrack-climate"). This could not be confirmed.
- Indoor temperatures can be decreased by means of controlled shading of the large transparent building elements.
- Decrease of indoor temperatures can be achieved by a high air-exchange-ratio.
- In all cases studied, the indoor temperatures develop in line with the outdoor temperature. Due to the low heat storage capacity, it is not possible to smooth the temperature peaks.
- With current technology, on hot summer days, indoor temperatures can not be brought under outdoor temperature without use of air-conditioning.
- Pursuing further the investigations described here can help to establish characteristic diagrams for the control of ventilation and shading, among other things.
- Furthermore, to save energy in midsummer, before using air conditioning, the interior should be ventilated to lower indoor temperatures.

Temperatures inside a motor home in winter

To evaluate the influences of the outdoor climate more precisely, the calculations were carried out without taking any heating system into account, in order to show the climatic influence of the variables. A calculation with heating would fail to demonstrate dependencies. The data-sets for motor home climate and user behavior served as a basis for our calculations.

To obtain a clear overview of the calculated variables, a period with low and relatively constant temperatures between January 26th and February 8th was chosen.

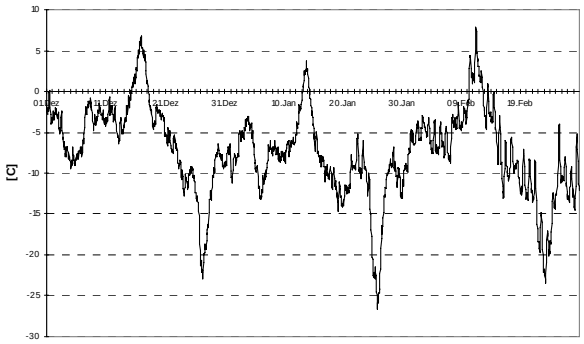

Figure 10: Outdoor-temperature during winter – Moscow, Russia

Climate during winter-period Moscow/Russia

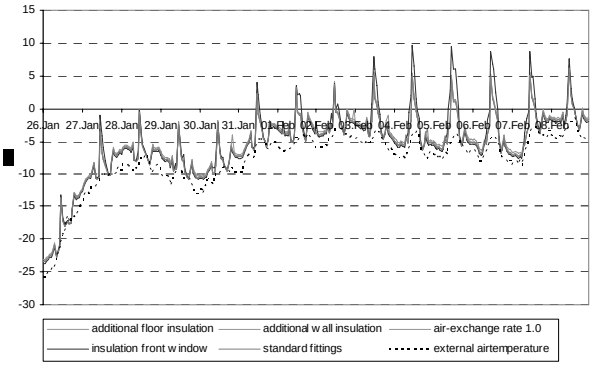

Figure 11: indoor-temperatures against thermal resistance of exterior shell elements

The calculations for the temperature behavior under summer conditions show the following results for Moscow, Russia:

- Additional thermal insulation is most effective on elements with broad surfaces and those with poor thermal properties.
- Improving the thermal insulation of the body is of little use unless the poor insulation of the windscreen is addressed.
- Thermal upgrade of the transparent elements is necessary, but their energy transmission should not be reduced.

A controlled glare shield with good thermal insulation represents the optimal solution. On the one hand, heat loss via transparent elements can be minimized by closing the glare shield at night, while an open glare screen on sunny winter days brings solar radiation to the interior of the motor home.