

KLIMEN® - A COMPUTER PROGRAM FOR VENTILATION AND AIR CONDITIONING SYSTEMS

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ABSTRACT

Fast development of computer technology and the greater use of it in all spheres of activity have caused the development of software support in the field of HVAC systems. Considering the fact that today time is of great value and that contemporary technical systems demand economy and rationalisation of operating costs and energy, the qualitative and user-friendly computer-aided engineering is of maximum importance.

The software package KLIMEN is one of the few, if not even the first program dealing with designing of ventilation and air-conditioning units, including air-conditioning in general as well as air - conditioning and dehumidifying of indoor swimming pools.

By using the Windows environment this software program enables a project engineer to make a total calculation of ventilation and air-conditioning, to select air-handling units according to the user's wish and to make a schedule with complete technical data of the chosen air-handling unit. The results may be printed or saved in the text-file for the later use in word processors.

The advantage of the software package KLIMEN is the possibility of changing and correcting the data and getting the new results simultaneously.

It enables the users to make extensive projects in the shortest time possible. With the possibility of changing the data and air-handling principles, both optimisation and rationalisation of energy use can be achieved at the same time.

1 AN INTRODUCTION OF THE SOFTWARE PACKAGE KLIMEN®

The software package KLIMEN has been produced to help engineers dealing with ventilation and air -conditioning systems. Klimen is designed for Windows environment. It is simple and user-friendly computer program that allows interactive work and creative participation of engineers.

The software package Klimen offers a possibility to do calculations of ventilation and air-conditioning process with heat or cooling recovery from exhaust air in the following ways :

- steady regeneration
- double recuperation
- single recuperation
- indirect adiabatic evaporative cooling

Owing to specific demands, air-conditioning is divided into two fields, namely :

- ventilation and air -conditioning in general
- air-conditioning of indoor swimming-pools

The results obtained are thermodynamic calculations, a selection of the appropriate handling units and schedules.

2 THEORY

The basis for thermodynamic transformations of air humidity condition is the diagram or Mollier's diagram. Each and every process in the air-handling unit can be demonstrated by this diagram. Thanks to the h-x diagram, project engineers do not have to waste their time by calculating points of air humidity condition in ventilation and conditioning processes. Nevertheless, drawing transformations in a diagram is still time-consuming and does not enable optimisation and immediate comparisons of various processes, especially if the system anticipates different ways of heat recovery from exhaust air.

All these reasons have led to an idea to produce a software program KLIMEN which removes all previously mentioned problems, and produces the results in the form of calculations, unit selection and schedules.

All calculations in this program are based on equations of conditions in the h-x diagram. Every point of transformation of the air humidity condition is calculated on the basis of temperature parameters (t) and humidity content (x). The equations are:

enthalpy	$h = c_{pL} \cdot t + x(c_{pD} \cdot t + r)$	[kJ/kg]
relative humidity	$\phi = (x \cdot p) / ((x \cdot p_s) + (0,622 \cdot p_s))$ ali	[%]
absolute humidity	$x = 0,622 \cdot \phi \cdot p_s / (p - \phi \cdot p_s)$	[kg/kg]
air density	$\rho = ((1+x)/(R_L + R_D \cdot x)) \cdot 1.10^5 / (t+273)$	[kg/m ³]

SYMBOLS:

t	- air temperature		[°C]
c_{pL}	- specific air heat	1,0	[kJ/kg.K]
c_{pD}	- specific steam heat	1,86	[kJ/kg.K]
r	- evaporative heat	2501,6	[kJ/kg]
p	- partial air pressure	1,0	[bar]
p_s	- partial steam pressure		[bar]
R_L	- gas air constant	287	[J/kg.K]
R_D	- gas steam constant	462	[J/kg.K]

On the basis of these equations the points of humid air condition for the entire process of transformation can be calculated, for the summer as well as winter season.

For a fixed air quantity heat and cooling capacity and the quantity of humidity are calculated with the following equations :

heat $Q = V \cdot \rho \cdot \Delta h$ [kJ/h]

humidity $m_v = V \cdot \rho \cdot \Delta x$ [g/h]

The diagrams below demonstrate transformations for the summer and winter operating season which are calculated after the entry of the appropriate data. Each diagram presents a different type of energy recovery.

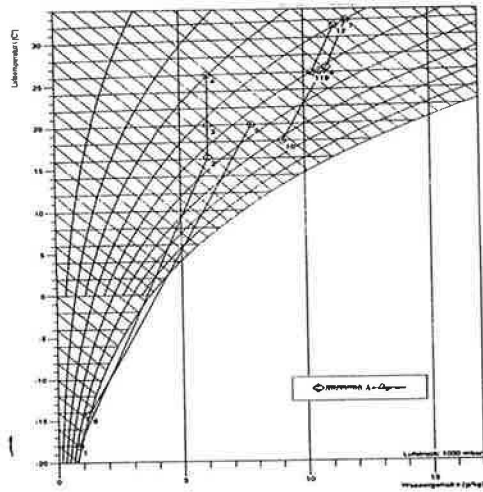


Figure 1: Air-conditioning with regenerative heat or cooling recovery from exhaust air

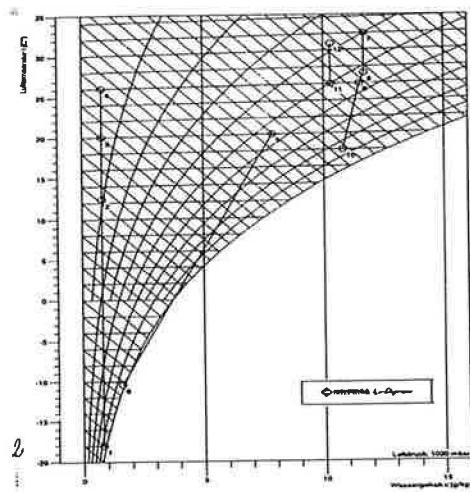


Figure 2: Air-conditioning with recuperative heat or cooling recovery from exhaust air

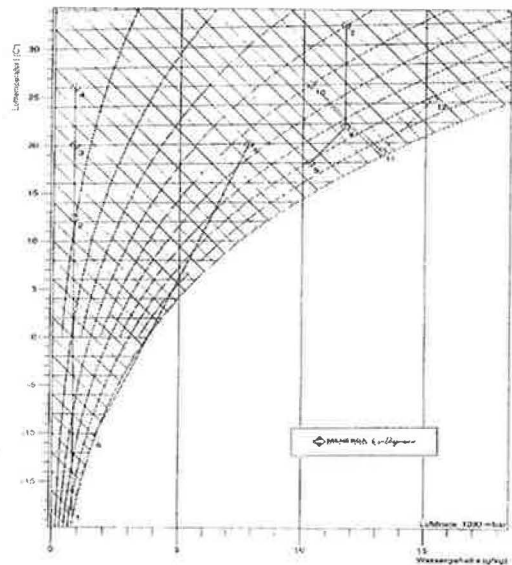


Figure 3: Air-conditioning with indirect adiabatic evaporative cooling

Figure 1 describes the transformation of humid air condition with the regenerative or cooling recovery from exhaust air for the summer and winter operating regime. The point of condition is numbered and it means :

Winter regime:

- points from 1 to 4 show the transformation of the outdoor air in winter,
- points from 5 to 6 show the transformation of the return air in winter.

From the point 5 to the point 6 and from 1 to 2 the regenerative heat transfer from exhaust air to the outdoor air is carried out. From the point 2 to 3 re-heating is necessary to make up for the air-change losses, and from the point 3 to 4 a compensation for heat loss is carried out.

Summer regime:

- points from 7 to 10 show the transformation of the outdoor air in summer,
- points from 11 to 12 present the transformation of return air in summer.

Between points 11 and 12, and 7 and 8 the regenerative cooling transfer from return to the outdoor air takes place. From the point 8 to 9 re-cooling is necessary to make up for the air-change losses and from the point 9 to 10 cooling capacity is needed for the removal of cooling loads.

The transformation of the air humidity condition with recuperative heat or cooling recovery from the exhaust air is described for winter and summer operating season in figure 2. Each point of condition is numbered:

Winter regime:

- points from 1 to 4 show the transformation of the outdoor air in winter,
- points from 5 to 6 show the transformation of the return air in winter.

From the point 5 to the point 6 and from 1 to 2 a recuperative heat transfer from return air to the outdoor air is carried out. From point 2 to 3 re-heating takes place owing to air-change losses and from point 3 to 4 a compensation for heat losses takes place.

Summer regime:

- points from 7 to 10 show the transformation of the outdoor air in summer,
- points from 11 to 12 show the transformation of return air in summer.

From the point 11 to the point 12 and from 7 to 8 the recuperative cooling transfer from the return air to the outdoor air is carried out. From the point 8 to the point 9 re-cooling is needed owing to the air-change losses and from 9 to 10 the cooling capacity for the removal of cooling loads is necessary.

The transformation of the air humidity condition with the recuperative heat recovery from the exhaust air in winter and with indirect adiabatic evaporative cooling and secondary re-cooling in summer is described in figure 3. Each point is numbered and means:

Winter regime:

- points from 1 to 4 the transformation of the outdoor air in winter
- points from 5 to 6 the transformation of the return air in winter

From point 5 to point 6 and from 1 to 2 the recuperative heat transfer from the return air to the outdoor air is carried out. From point 2 to 3 re-heating owing to air-change losses takes place and from 3 to 4 a compensation for heat losses occurs.

Summer regime:

- points from 7 to 9 the transformation of the outside air in summer
- points from 10 to 12 the transformation of the return air in summer

Between the points 10, 11 and 12 and between the points 7 and 8 the recuperative heat transfer from the outdoor air with simultaneous humidifying of the exhaust air is carried out. From points 8 to 9 re-cooling for the removal of cooling loads is necessary.

On the basis of given parameters and engineer's decisions and calculations, Klimen selects the most appropriate ventilation and air-conditioning units to which the regulation loop of heating and cooling coils may be assigned.

3 WORKING WITH KLIMEN

Klimen is an interactive program produced for Windows 3.1 and above. It enables the user to participate actively with his own suggestions. On the basis of all that Klimen produces the appropriate calculations, unit selection and schedules.

Help with instructions and suggestions from standards and schedules is available every active field.

In the main menu an engineer can decide for one of the three available languages (Slovene, Croatian or German). The selected language can also be changed later when project is finished.

The object that an engineer is working on must be divided into several *areas*. The *area* means that this is the air-conditioning area with one or more units of the same handling system of supply air.

One can choose between two fields, namely, "Air-conditioning in general" or "conditioning of indoor swimming pools".

3.1 AIR-CONDITIONING IN GENERAL

After the field has been selected, the window "air-conditioning area" (figure 4) has to be entered with basic data about the indoor and outdoor air condition, with data about supply-air temperature limitations, the selection of the air-handling system, the type of energy recovery, the unit type, the type of cooling and the unit modifications.

Figure 4: The window "Ventilation area"

Figure 5: The window "Room"

Under "rooms" (figure 5) all the rooms dealt with in this area are listed. At the same time in the window "units" the appropriate units are selected according to the type and quantity of air. The air quantity is a sum of total air amount in all rooms treated at that moment.

The geometric data about individual rooms, air exchanges, heat and cooling load for winter and summer operating season are entered in the window "rooms". If geometric data are not available, either the volume of the room or only the air quantity is sufficient. After data entry a button "calculation" must be clicked. In the window "calculated parameters" the capacity of the heating and cooling coils and the quantity of the required humidity are obtained.

In the window "unit" (figure 6) the units, which are enumerated in the window "air-conditioning area", can be combined according to the air quantity and dimensions. Further on, in this window the type of the heating coil and the type of regulation of heating and cooling coils are defined and basic parameters of regulation loops are also calculated.

With the button *options* the window for additional demands and additional equipment selected by an engineer is opened and these data are included in schedules. A window containing a picture of the selected unit, different schemes, forms etc., which are all enclosed in a printout, is opened with the *unit*.

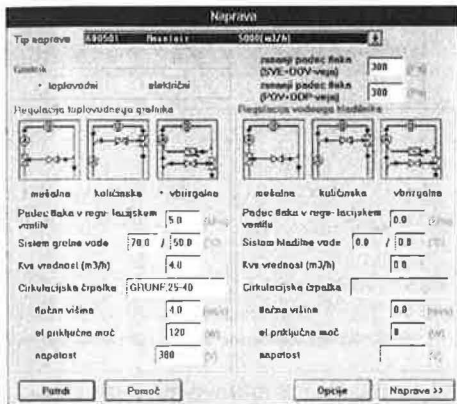


Figure 6: The window "Unit"

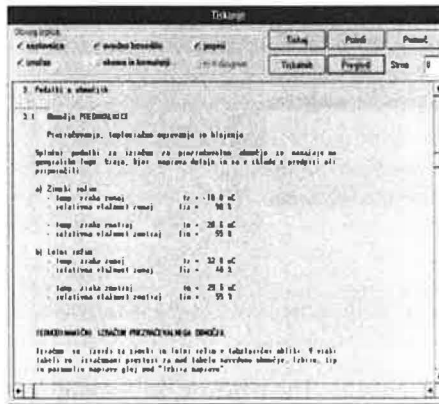


Figure 7: The window "Printing"

A review of all calculations, unit selection and schedules of units can be read through in the window "printing" (figure 7). An engineer can review individual air-conditioning areas. According to the user's wish, parts of the text that a user wants to read through or print can be indicated on the top of the window. A page number in the upper right corner can be automatically written on following pages or it can be re-written according to the user's wish.

3.2 AIR - CONDITIONING OF INDOOR SWIMMING-POOLS

Owing to specific calculations of ventilation, the program contains a separate field, "air-conditioning of indoor swimming pools".

Just as with air-conditioning in general, basic data about the outdoor and indoor air condition are inserted into the window "air-conditioning of swimming-pools" (figure 8). Further on, the name of the swimming-pool hall, the volume and the quantity of the evaporated water for all water attractions anticipated for that hall have to be inserted. In the

window "calculation of the evaporated water", the required data for all the swimmer pools and whirlpools in that hall are inserted. On the left window side all swimming- and whirlpools anticipated for that hall are enumerated, and below the appropriate unit air-conditioning and dehumidifying are listed.

The appropriate unit family, the characteristics of which are written in *help*, is set in the window "family of units".



Figure 8: The window "air-conditioning of swimming-pools"

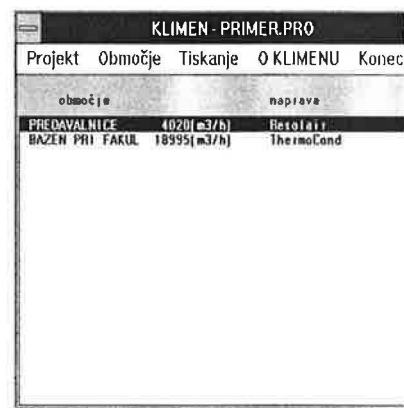


Figure 9: The window with a list of air-conditioning areas

The calculation of air-conditioning of swimming-pool halls is made after the recommendations SWKI - Nr. 85-1 (Lüftungsanlagen in Hallenbädern), German VD according to the latest technological achievements in this field.

After the calculations are finished, all air-conditioning areas are listed in the window "KLIMEN" (figure 9) from which all the main menus can be selected. The selected area is opened by a double click on that area.

The advantage of KLIMEN is that allows the user to change type of the unit, type of energy recovery from exhaust air, type of heating and cooling, etc., at all stages of the project. Therefore, it is possible to carry out different variants of the process in the shortest time possible in order to achieve the most economical and rational energy consumption.

4 THE RESULTS

The results obtained by this program can be printed out or saved in the text-file for later use in other word-processors. The first part of a printout is a title-page containing information about the project. Then, the calculation of ventilation or air-conditioning follows and that the unit selection, the schedules of selected units, schemes and forms follow.

The pages are numbered automatically or equipped with optional page openings so that they can be combined into texts of other projects.



5 CONCLUSION

The software package Klimen has been designed on the basis of knowledge and experiences of a group of experts in the field of ventilation and air-conditioning. Working with this program is similar to the traditional working on a project, however, Klimen allows the user to include his own creative solutions. In comparison with traditional planning and designing time-savings here are enormous, especially if taking into account precise and accurate calculations and immediate results even when data are changed. The results are printouts of calculations, of unit selection and schedules including all technical data.