

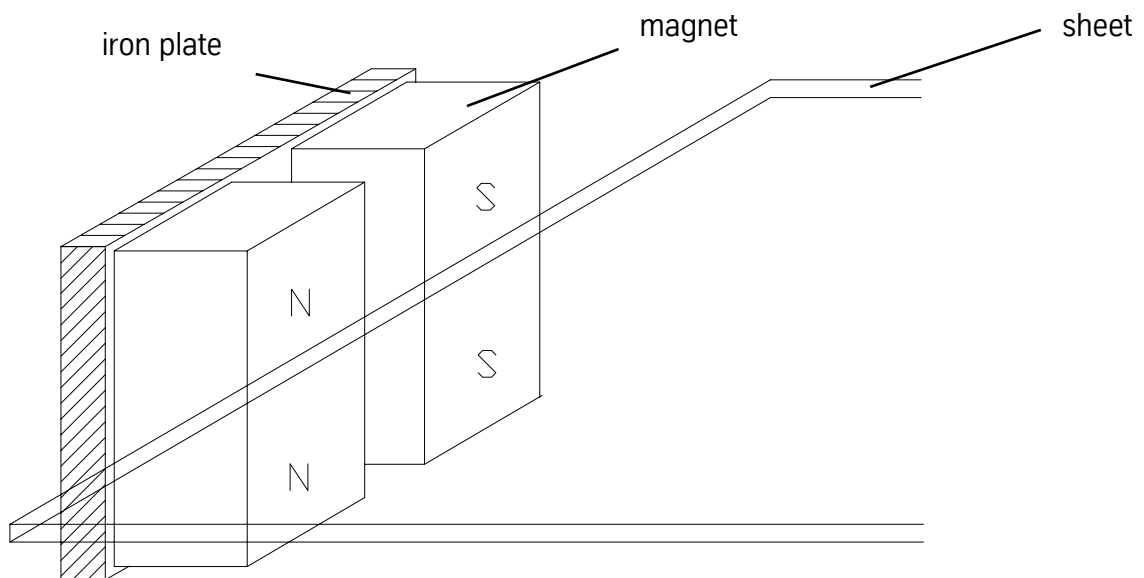
## Spreading Magnets

When piles of sheets of different thickness are unloaded, double sheets could occur despite the use of spreading magnets (fanners), and this all the more, the thinner the sheets. The effects of a spreading magnet -either according to the electromagnetic or the permanentmagnetic principle- are based on a magnetic flux admitted to the sheet so that magnetic poles of the same kind are generated in the sheet which then repel in the same way as two magnetic north or south poles would do. This repulsion effect isolates two sheets lying directly upon each other. This is especially required if the blanks were oiled before and have been under pressure for some time with the sheets showing a strong sticky effect. This cannot be avoided in the usual processes, because the sheets must be protected against corrosion until the following process stage begins. As a general principle two different kinds of spreading magnets are differentiated:

The purely **permanentmagnetic spreading magnetic system** and the purely **electromagnetic** one.

### 1. Permanentmagnetic Spreaders ( Fanners )

As the name already indicates, this kind of spreaders only consists of permanent magnets. The front view can be seen in **figure 1** and has the following arrangement:

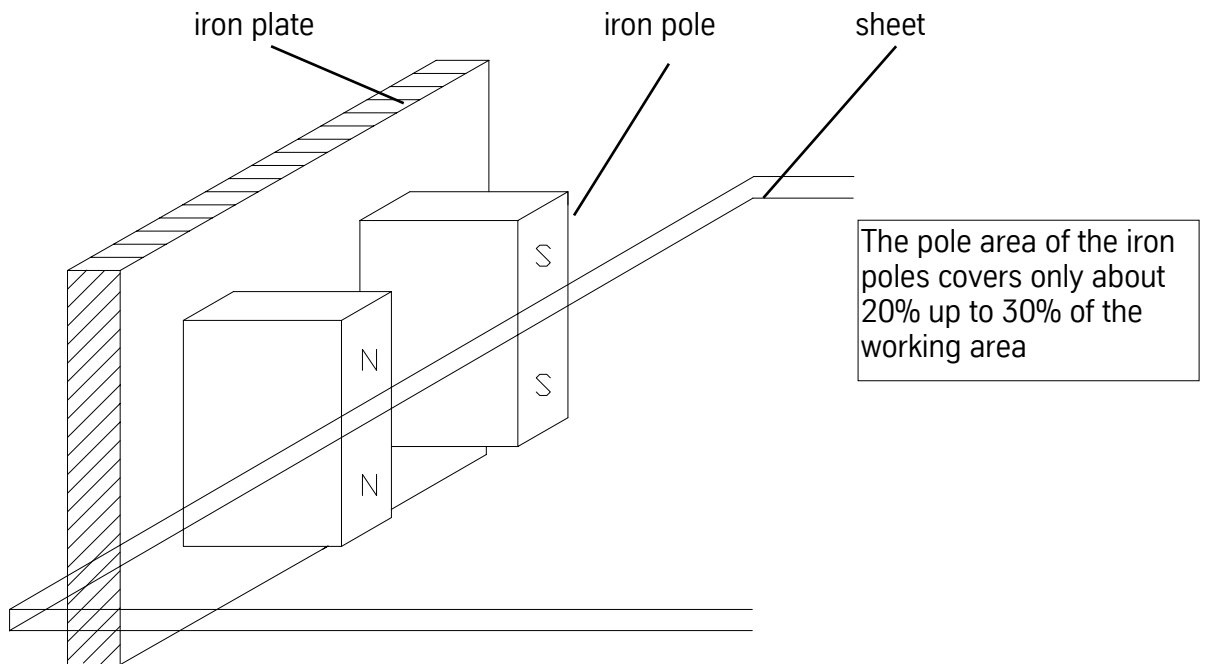


**Figure 1: Typical outline of a permanentmagnetic fanner**

The outline of the fanners can be seen. It represents an iron plate with permanent magnets sticking to them with the polarity specified; 'north' designates the north pole of the magnet which should be homogeneous on the complete area; 'south' designates the south pole of the other magnet. The sheet should stand perpendicularly on this area. The area of the magnets is covering about 90% of the working area.

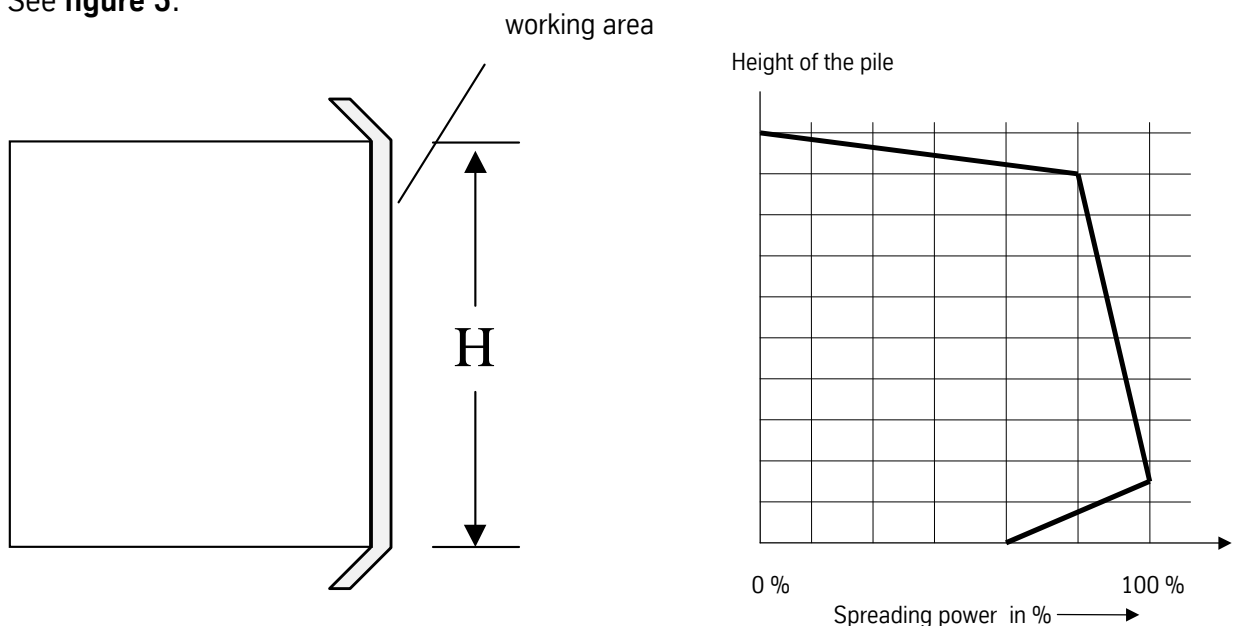
## 2. Electromagnetic Spreaders ( Fanners )

In case of electromagnetic spreaders the magnetic flux is not generated by permanent magnets, but by coils (solenoids). Depending on the arrangement (two- pole or three- pole) two or three coils are applied. The kind of operation is the same as with permanentmagnetic spreaders, however with some restrictions to be explained below. But first of all a principle drawing in **figure 2**:



**Figure 2: Typical outline of a conventional, electromagnetic fanner**

For the reason of better clearness the two selenoids - surrounding the iron poles each- are not shown. It has to be stated first that the spreading effect is not the same from the lower edge to the upper edge of the spreading magnet, because the end windings of the coils cause a thinning of the lines of electric field strength and thus a reduced magnetic flux. This becomes noticeable by a reduced spreading performance at the lower and upper ends of the system. See **figure 3**.



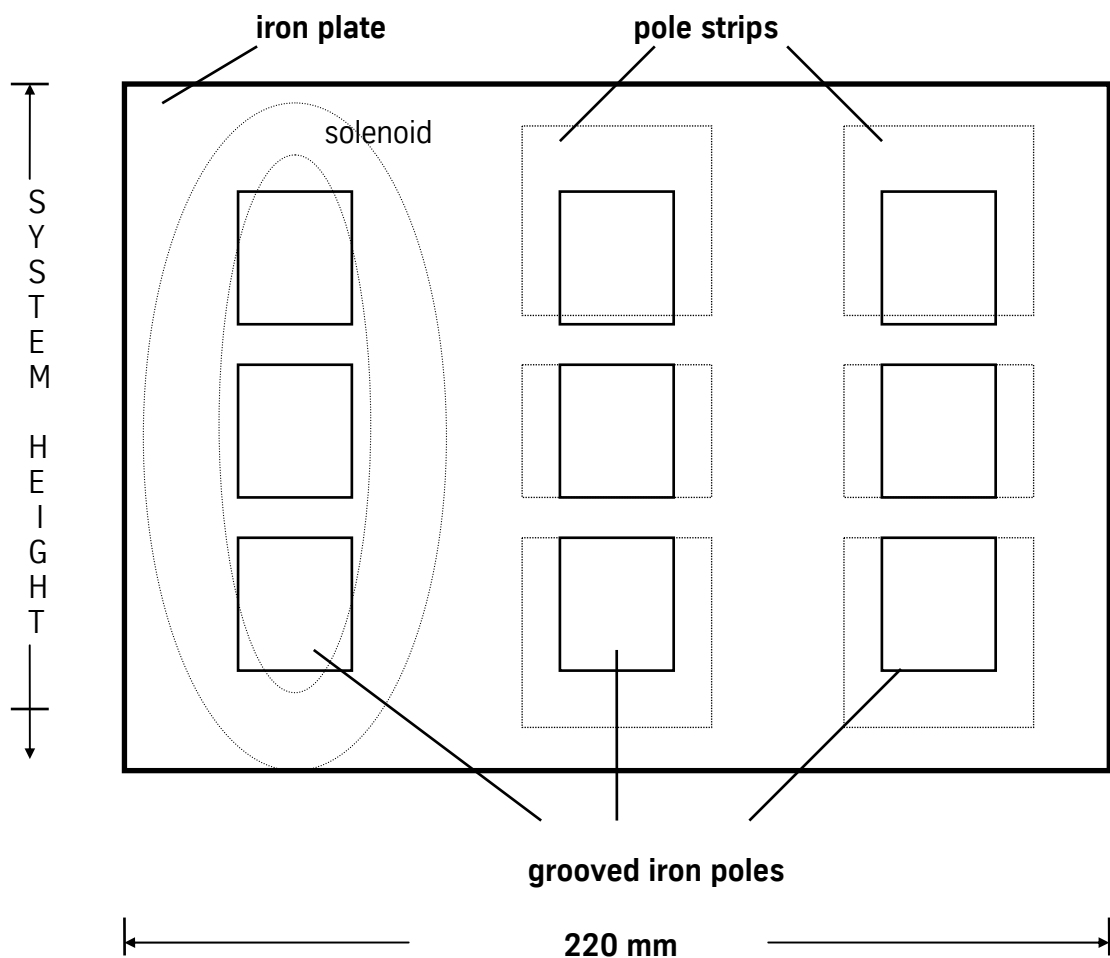
**Figure 3: Spreading power in dependence of the covered piling height**

In order to compensate this effect as far as possible, a iron strip is attached to the magnetic pole surrounded by the coil; this strip exceeds the end windings and extends the lines of magnetic flux to the lower edge of the system.

A further effect of the reduced spreading performance is to be seen in the fact that the sheets already lying on the pile have the same effect as a magnetic short-circuit and reduce the spreading performance in the upper part of the system. This phenomenon can be reduced by grooving the centre pole; thus the effect of the magnetic short-circuit is nearly eliminated (This method is protected by a patent and can be found under patent number: PS 36 15 186).

In case of permanentmagnetic spreaders the short circuit is of minor importance, because the relative permeability  $\mu_r$  is near 1 and thus the magnet is stable even in the upper part. The relative permeability at the iron poles is near 200 which makes the guidance of the lines of magnetic flux 'softer'.

An optimized electromagnetic fanner considering what mentioned above looks like **figure 4**:



**Figure 4: Optimized electromagnetic fanner**

### 3. Saturation

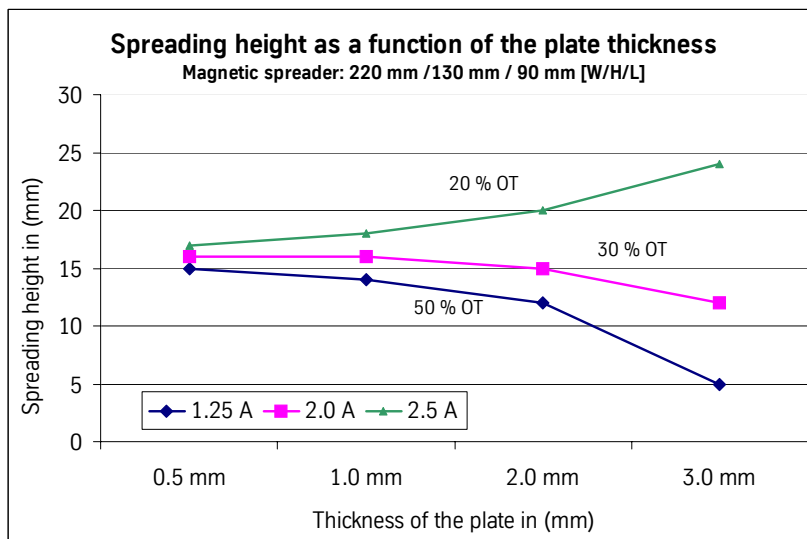
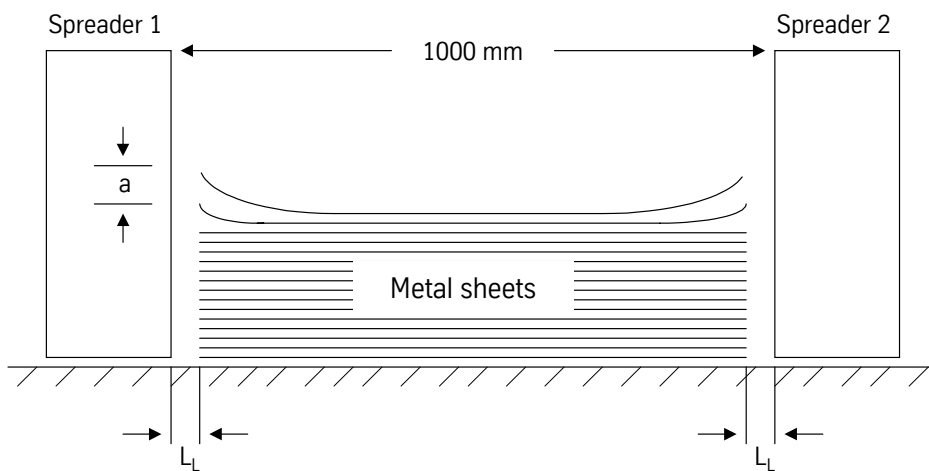
In case of thin sheets the problem of magnetic saturation occurs more strongly. This means that from a certain magnetic force the spreading effect cannot be increased considerably any more.

Below, the spreading effect is specified as the distance of the two upper sheets  $a$  in comparison to different sheet thicknesses  $T$ , related to the sheets with the

dimensions: 1000 mm \* 300 mm \*  $T$  mm ;  $T$  = thickness

electrical spreader, 3-pole 220 mm wide as seen above.

The specifications refer to a test arrangement - with the attractive forces compensated - according to the structure:



The current of the solenoids can be seen analogue to the magnetic power.

	0.5 mm	1.0 mm	2.0 mm	3.0 mm
1.25 A	15	14	12	5
2.0 A	16	16	15	12
2.5 A	17	18	20	24

**Figure 5: Spreading height of different thickness of metal sheets considered by different electrical power**

**Figure 5** shows the dependence of the sheet thickness. It can be seen that considerable difference as to the spreading height cannot be detected with a sheet being 0.5mm thick. The differences are not considerable up to sheets being 1.0 mm thick, since it is only 1 mm with the coil current being constant. In practice this should hardly be noticeable. In case of sheets being 2 or 3 mm thick the differences become noticeable. In case of a coil current of 2.5 A it can be noticed that the spreading height increases when the thickness of the sheet increases as well. This is a clear hint at the magnetic saturation with the thinner sheets. When the coil current is reduced to 1.25 A (to 50%), the dependence assumed already before can be seen clearly. The weight increasing with the thickness of the sheet causes a reduction of the spreading height.

#### 4. Trouble- Effects

Apart from the restrictions described there are some more points of trouble which are of major importance and affect the spreading function much more considerably.

##### 4.1 The Sticky Effect

Spreading magnets are applied to lift sheets lying above each other resp. to isolate the upper one in a pile from the one lying directly below. As the sheets lying below are slightly oiled before the piling to prevent early corrosion, the continuously increasing number of sheets also increases the pressure due to the own weight. These piles bound together like bundles are frequently put on pallets. The pressure on single sheets arising from that can easily amount to several tons, because the lower sheet of an average bundle of an area of 1 m<sup>2</sup> and a piling height of 300 mm is pressed by a weight of 2.3. tons of its own.

##### 4.2 The Formation of Burr

Due to natural wear cutting tools become blunt resulting in a larger amount of burr. Therefore the piling cannot be performed evenly; as a consequence the pile forms an inclined plane. Additional sheets piled lead to an increase of this effect. A more inconvenient characteristic of burr can be observed, when the blanks are not cut evenly, but look 'fringed'. This is the result of tools being so blunt that the sheets are not cut, but are more or less torn. The fringes resulting from that tend to be hooked on the sheet at the bottom. In such a case it is nearly impossible to spread the sheets, since there is a partially mechanically firm connection. Only the strong deformation of single sheets can loosen the hooking.

##### 4.3 Attractive Forces

Spreading magnets do not only spread ( fan ), but also have an attractive effect. They attract the sheets. On the one hand this effect is wanted for the alignment of the sheets, on the other hand it is not, when the blank leaves the area of the spreading magnets. In this case the spreading magnet tries to hold the sheet, though it is to be removed. The effect of alignment, of course, only occurs, if all spreading magnets are found on one side of the pile. The arising attractive force generates a high friction at the spreaders, which in turn weakens the spreading effect. Attaching the spreaders to opposite sides of the sheet bundle is often impossible due to construction. Thus, however, the clinging forces would be compensated considerably and therefore would add the spreading forces. Therefore electromagnetic spreaders, which can be switched off, as required, are frequently applied. Their performance, however, depends on the operating time and is not so effective in many applications.

## 5. Edge Covering

Furthermore the spreading height depends on the edge covering. That is the width of all spreaders applied to the sheet bundle in relation to the circumference of a sheet resp. the ratio in percent of system edge length and sheet edge length. Normally the spot where the spreading magnet is in contact with the sheet is the point where this sheet is magnetically saturated. This means that the spreading height can only be increased by increasing the number of spreading magnets applied so that the edge covering is increased as well. In order to be capable of comparing different systems the system width (as a last point) is also important, for the larger the magnetic pole pitch, the deeper the penetration of the magnetic field into the sheet. The width of the spreading magnets is, however, restricted due to design. Globally it can be stated that a spreading magnet with high attractive forces also has a high spreading performance.

## 6. Operating Time ( OT )

In order to be capable of comparing the performances of permanent- magnetic and electromagnetic spreaders it is compulsory to take the operating time of the electromagnetic spreader into account, for its spreading performance is especially dependent on the max. admissible housing temperature (e.g. 70 °C). The higher the temperature may be, the more heat can be radiated by natural convection (not considering additional forced cooling for reasons of costs). With copper varnished wire used for the coil the latter itself is not in danger, because it can stand temperatures of up to 140 °C; this does not apply to persons which might come into contact with the housing either accidentally or for reasons of operation. If the OT can be reduced, the density of current can be increased which increases the spreading performance. If the electrical spreader is to have an OT of 100 %, it can be stated at once that a permanent- magnetic spreader has a considerably higher spreading performance with dimensions being the same. Both types can be compared with an OT of approx. 20 % to 25 %. With the OT being 50 % the permanentmagnetic spreader shows advantages. Before coming to a decision in favour of one or the other type parameters apart from the spreading performance should be considered as well, because a lower spreading performance might sensibly be compensated by a further spreading magnet. If e.g. spreading magnets are only attached to one side of the sheet bundle (due to design), a higher spreading performance can normally not be noticed, because it is compensated by the increased attractive force, which means that the spreading height is not increased owing to friction.

## 7. Coil Design of the optimized fanner mentioned above

The max. conduction theta in A can be derived from the fieldnumeric calculation; it results in turn in the determination of the concrete coil data with the connected voltage specified:

### example:

conduction theta  $\Theta = 2200$  A for each solenoid

cross- sectional area of the coil space:  $1200 \text{ mm}^2$

first of all one single turn is assumed, so that  $I = \Theta$

$$U' = R * I = R_o * (L_m/A) * (\Theta / F_c)$$

with  $F_c$  =copper bulk factor and  $R_o$  = specific resistance of Cu

$L_m$  = mean turn length and  $A$  = cross section area

$$= 0.0175 \text{ mm} * \text{Ohm/m} * (0.266 \text{ m}/1200 \text{ mm}^2) * (2200 \text{ A} / 0.55)$$

$$= 0.01566 \text{ V}$$

chosen voltage =  $30 \text{ V}$ , so the number of turns is specified by

$$N = U/U' = 30 \text{ V} / 0.01566 \text{ V} = 1914 \text{ turns.}$$

This results in the required wire cross section

$$A_d = 1200 \text{ mm}^2 * 0.55/1914 = 0.345 \text{ mm}^2$$

and then a wire diameter of:  $\varnothing = \text{SQR}(4 * A_d/\pi) = 0.663 \text{ mm.}$

The standard series offers a wire diameter of  $0.67 \text{ mm}$  fitting very well to the wire diameter calculated. The max. current through the wire is as follows:

$$I_d = 2200 \text{ A} / 1914 = 1.15 \text{ A} \text{ with the density of current being}$$

$$j = 1.15 \text{ A} / 0.345 \text{ mm} = 3.33 \text{ A/mm}^2$$

This density of current shows that the electrical spreader may have an operating time of 50%, since otherwise the admissible housing temperature of  $75 \text{ }^\circ\text{C}$  would be exceeded. In case of an operating time of 100 % the density of current should not exceed  $2.5 \text{ A/mm}^2$ . As all 3 coils are to be connected serially, the connected voltage is approx.  $90 \text{ V}$  in the cold state. In order to have this current in the warm state as well, the voltage would have to be approx. 40 % higher, since the coils are heated up and the resistance is increased. So if a constant magnetic field resp. a constant spreading effect is required, a current regulator will have to be provided.

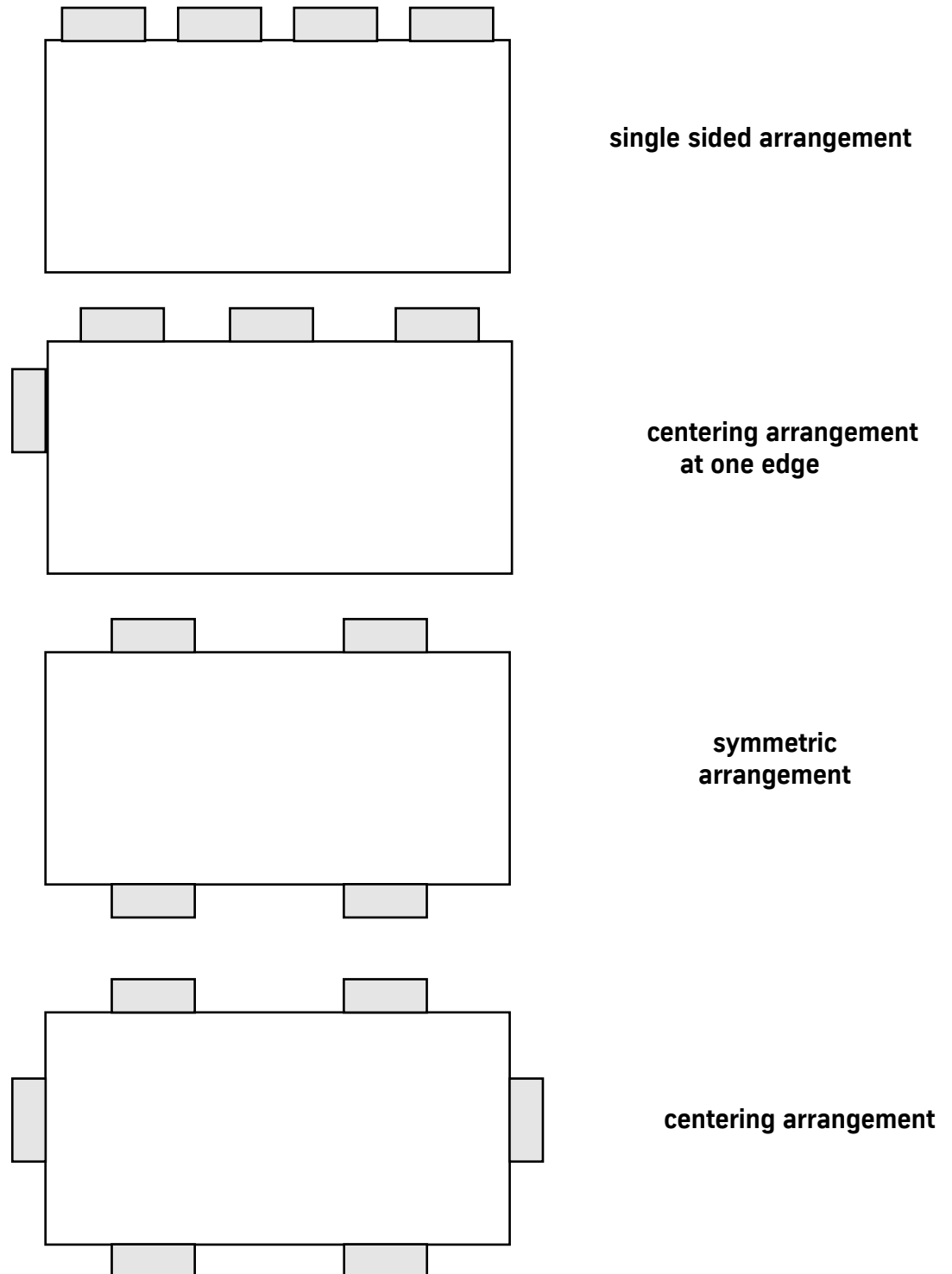
## 8. Dimensions:

Electromagnetic spreaders are in principle electromagnets with special designed poles. Their dimensions start with a width of  $100\text{mm}$ , whereas the system height, due to the special purpose, reaches from  $130\text{mm}$  up to  $600\text{mm}$ . The depth of the system or the thickness is restricted in normal case to less than  $100\text{mm}$ . The max. system width referring to a system with four poles can reach up to about  $400\text{mm}$ . In this case, the spreaders are able to fan sheet up to a thickness of  $8\text{mm}$ .

The dimensions of permanent magnetic spreaders are normally smaller, because of the tremendous attractive force, which can not be switched off. Due to this the max. system width will not exceed  $250\text{mm}$  by a system height of  $400\text{mm}$ . When the dimensions are getting smaller, there is no real choice than to take permanent magnetic spreaders. As a smallest dimension you can take a width of  $70\text{mm}$  with a height of also  $70\text{mm}$ . In this case you can even fan round shaped sheets like the lits of cans.

### 9. Different possibilities of positioning the spreading magnets

Due to the free space there exist different possibilities of positioning of the spreading magnets; these will be shown in the following **figure 6**. The attractive force of the magnets can be used to allocate a supplementary centering function:



**Figure 6:** Examples of different arrangements of spreading magnets