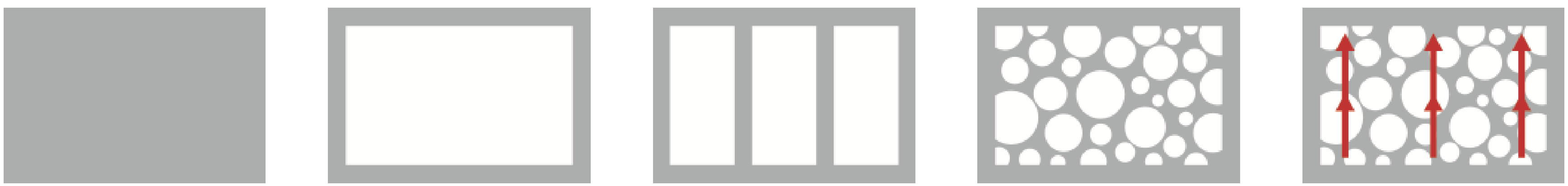
Internal structure evolution pattern

Internal structure evolution pattern

The pattern describes transformations obtained by complicating the internal structure of components.

It includes introduction of a void into a component, separation of a void into capillaries and pores and, finally, introduction of fields and forces into a void inside a component.

Internal structure evolution pattern



Solid component

Introducing a void

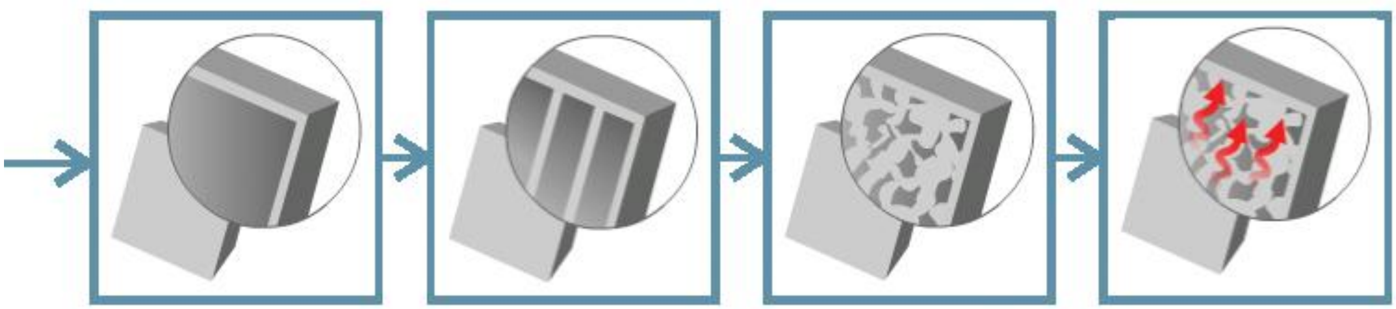
Forming several volumes

Separating space into many volumes

Introducing fields and forces

Transformation goal

• Reducing **the weight** of a system
• Increasing **compactness**
• Enhancing **resistance** to external action
• Making the arrangement of the system components more **rational**
•Improving **heat-insulating** properties
• Simplifying **control** of a system



Transformation goal

Transformations of this pattern are aimed at **optimizing** the parameters of a system component and a system itself.

These transformations provide resources for further enhancing the **coordination** of components in a system.

Transformation object

Any component of a system can be transformed provided it has spatial parameters.

Transformed are often objects which are in contact with the environment such as **housings, shells, casings,** etc.

It is exactly the internal structure evolution that provides a sufficient **strength** of such components and their **stability** to various external actions.

It is useful to apply internal structure transformations to components having an **unreasonably large size.** This allows a more rational use of the system space.

Initial version

A solid component

At the initial evolution stages, many system's components are made one-piece (solid).

Such components have no internal structure.

They may have a large weight and cost.

Solid components may occupy too much space.

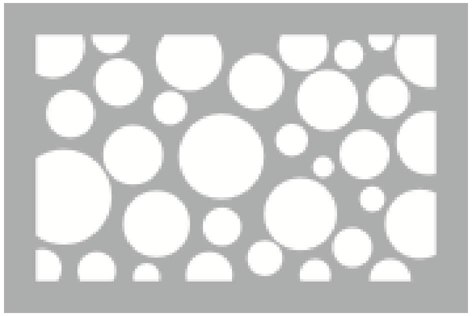
Introducing a void

Making a hollow inside a component improves
the operational parameters of a system.
Its insulating properties are improved.
The air filling the hollow is a good dielectric.
The heat-insulating properties are also enhanced
whereas the weight and cost are reduced.
The system can acquire elasticity
and enhanced resistance to external actions.

Forming several volumes

Forming several hollows (internal volumes) within a component improves its operational parameters.
It is possible to considerably reduce the component weight while preserving its strength.
Heat-insulating properties can also be improved.

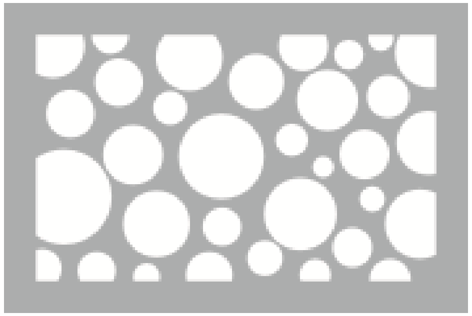
Structuring an internal volume (i.e. separating a hollow into smaller volumes) increases resistance to external action.
Damaging one of the volumes does not destroy the system because the remaining ones maintain its operation.



Separating space into many volumes

Space can be separated into many volumes by making
its structure porous, capillary or capillary-porous.
Pores may be open or closed.
Capillaries may be rectilinear or have a complex shape.
It is also possible to obtain special transformation versions for hollows,
for example, providing string-like
or column-like structures in a hollow. etc.

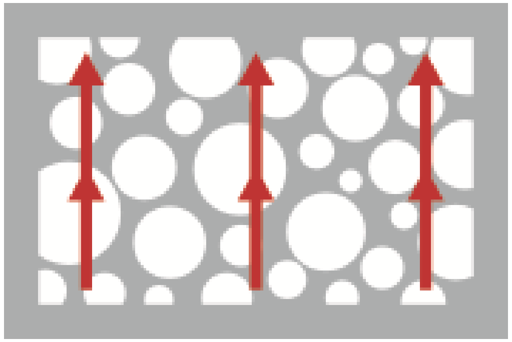
Transformations



Forming many volumes within a component
reduces the component weight.

Such transformation imparts new properties to a system.

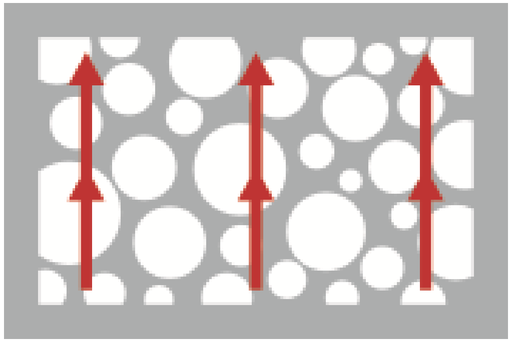
For example, it provides a necessary level
of heat conduction or heat insulation.



Introducing fields and forces

Forming an active structure within a component imparts new capabilities to a system.
This is mainly due to the use of fields:
magnetic, thermal, etc.
In this case, system parts interact not so much due to mechanical contact
as due to the field action on an object or another field.

Transformations

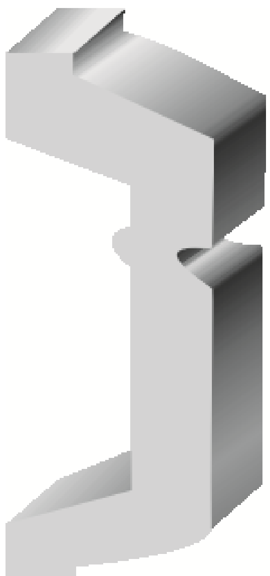


Active properties can be obtained not only at the expense of fields.
Various active substances can be added into a hollow.
To select them, you may use transformations
of the “Segmentation” pattern.
A component can be filled
with pastes, gels, liquids, foam, various gases, etc.

Combinations of various substances and substances
with fields may also be used.

Internal structure evolution pattern

An example. A car bumper



Bumpers of first cars were made solid.

They were formed of a thick metal strip.

Those bumpers were rigid enough.

Internal structure evolution pattern

An example. A car bumper

Then there appeared bumpers
having a hollow inside.

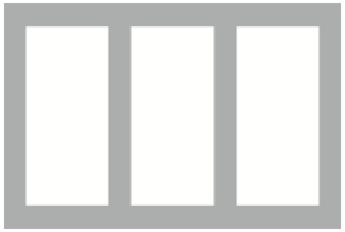
The hollow could be open or closed.

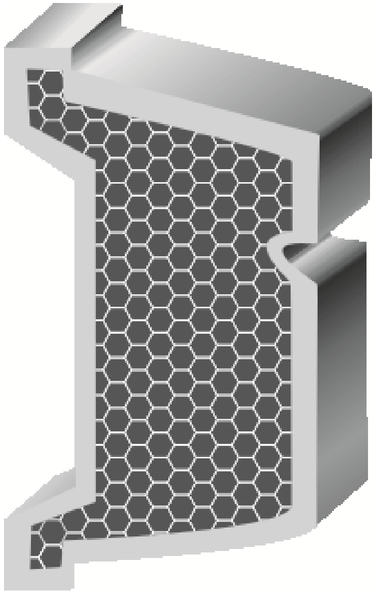
Such a bumper was deformed on impact,
thereby absorbing the collision energy.

In addition, the bumper with a hollow
had a lower weight.

Internal structure evolution pattern

An example. A car bumper





The next modification of a bumper had honeycomb filler in its hollow.

That is, space was separated into individual volumes.

Such a bumper absorbed collision energy even better.

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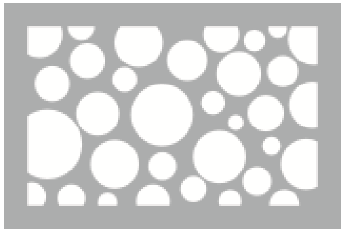

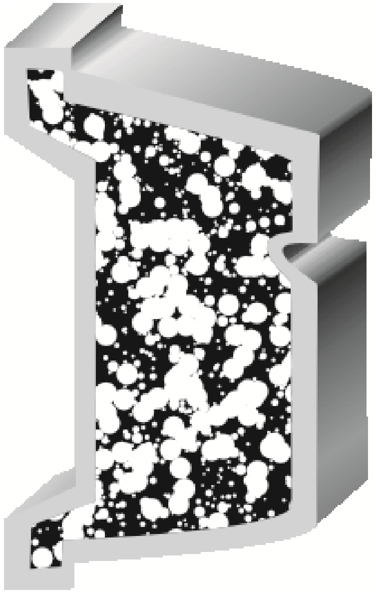

Modern bumpers are composed
of a plastic shell and porous filler.

The latter is a special shock-absorbing material.

On a weak impact, the shell only yields while
on a strong impact, the shell fails and the filler
absorbs the impact energy.

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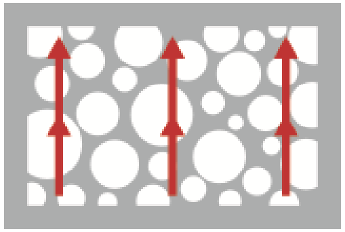
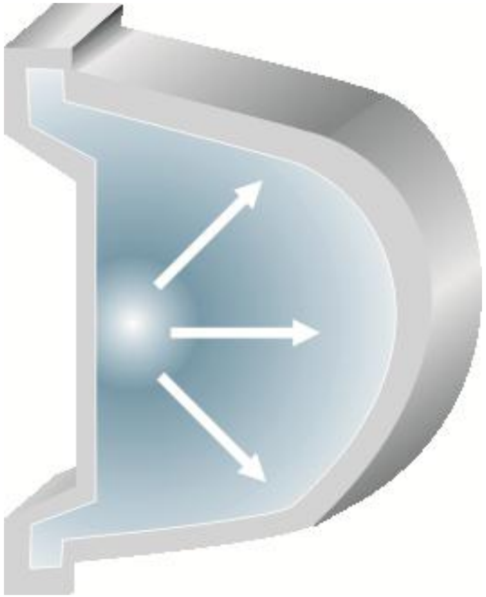


How can active properties be imparted
to the bumper's internal structure?



There are developments turning a bumper
into a kind of airbag.
A system of sensors monitors the speed of a car
at the front and the distance to an obstacle.
If the speed is high and the distance is small,
a command to activate protection is given.
The flexible bumper shell gets filled
with pressurized air and absorbs
the impact energy well enough.

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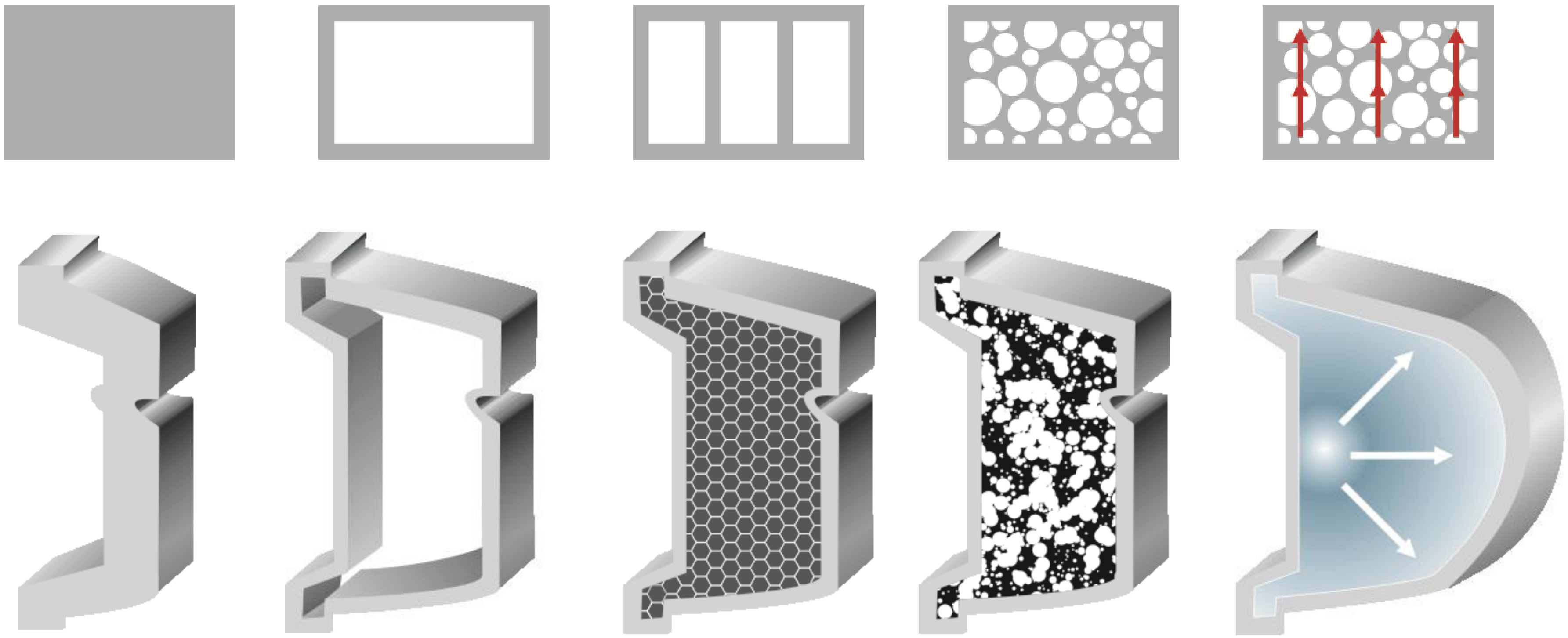
An example. A car bumper



The end of the lecture