

Test Facility for Screening and Evaluating Candidate Materials for Advanced Microturbine Recuperators

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Outline

- *Background*
 - *Advanced Microturbine Recuperators*
 - *Previous approach for material evaluation*

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- ***Microturbine Test Facility***
 - *System Overview*
 - *Preparation of test specimens*
 - *Sample holder*
 - *Test Campaign*

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 - *System Overview*
 - *Preparation of test specimens*
 - *Sample holder*
 - *Test Campaign*
- ***Future Work***

Background

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The U.S. Department of Energy and U.S. microturbine manufacturers are working together to develop the next generation of advanced microturbines.

- *\$500 per kW*
- *Fuel to electricity efficiency 40-45%*
- *Fuel flexibility*
- *Several years between overhauls.*
- *Single-digit NOx emissions.*

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- ***In most designs, microturbine recuperators are responsible for a significant fraction of the overall efficiency.***

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- *Most of today's compact recuperators are manufactured with 300 series stainless steels which are used at exhaust-gas temperatures below about 675° C. At higher temperatures, these materials are susceptible to **creep deformation** and **oxidation** which lead to structural deterioration and leaks, reducing the effectiveness and life of the recuperator.*

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- ***Need to screen and evaluate sets of candidate materials.***

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Background

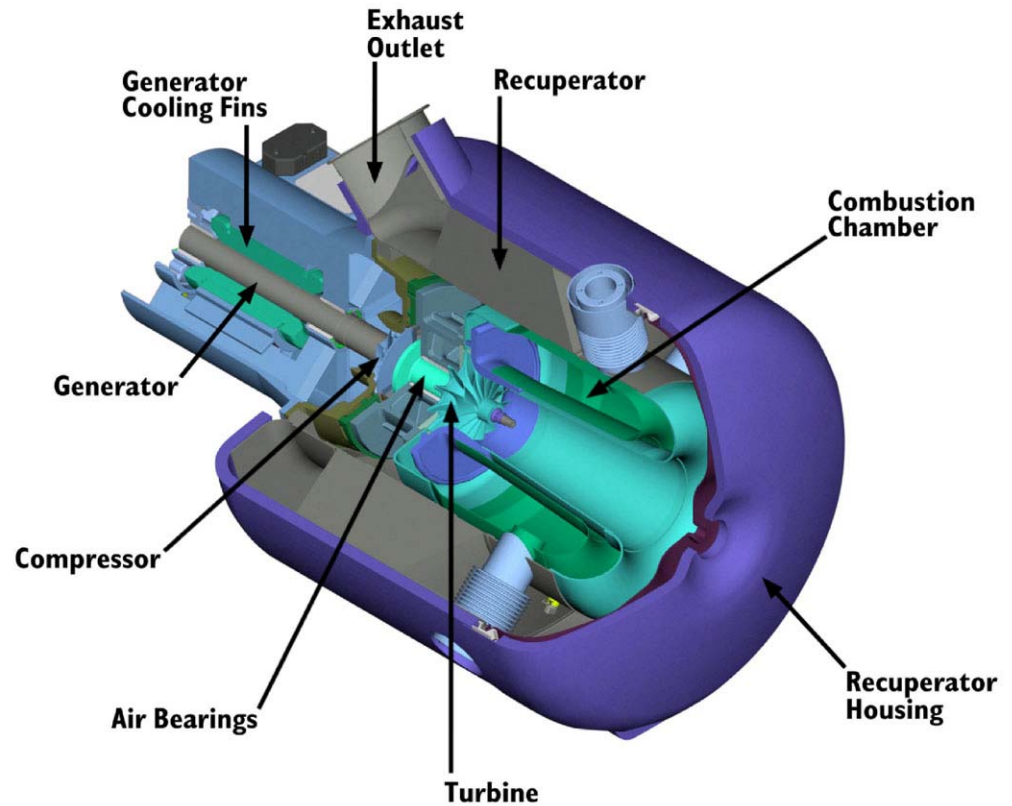
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- *Relations among stress, temperature and environment?*
- *Effect of manufacturing parameters on durability and reliability?*

Microturbine Test Facility

Microturbine Test Facility



Microturbine Test Facility



Annular Recuperator

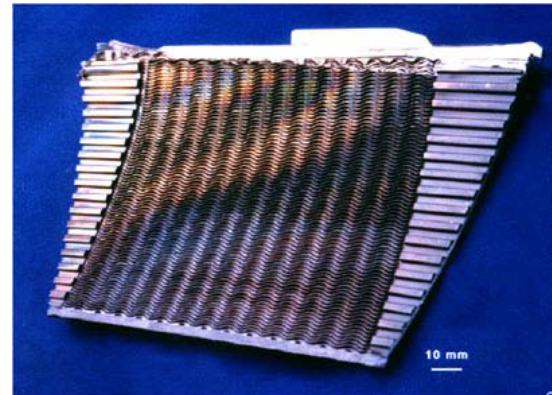
The recuperator is about 45.7 cm in diameter, and is comprised of 169 air cells.



Annular Recuperator

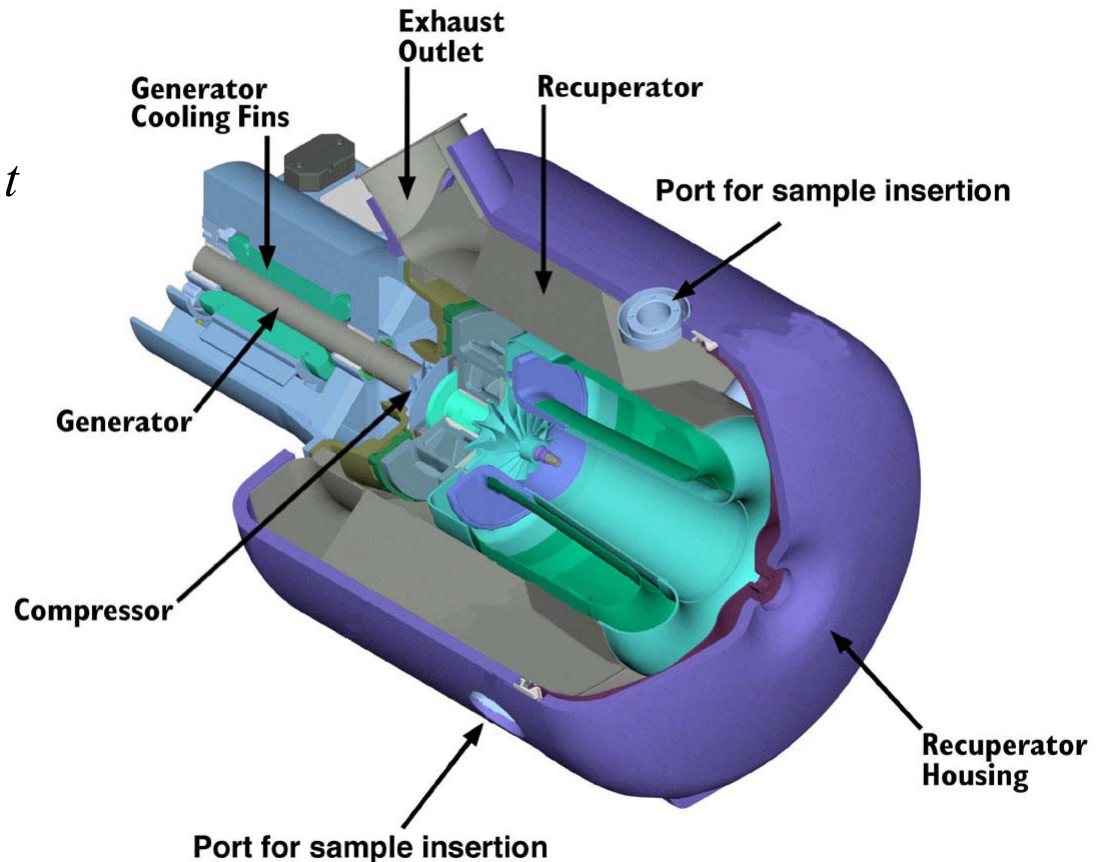
The recuperator is about 45.7 cm in diameter, and is comprised of 169 air cells.

Each air cell is fabricated by welding individual fin-folded 347 stainless steel sheets that were 100 μm in initial thickness.



Modified 60kW Capstone Microturbine

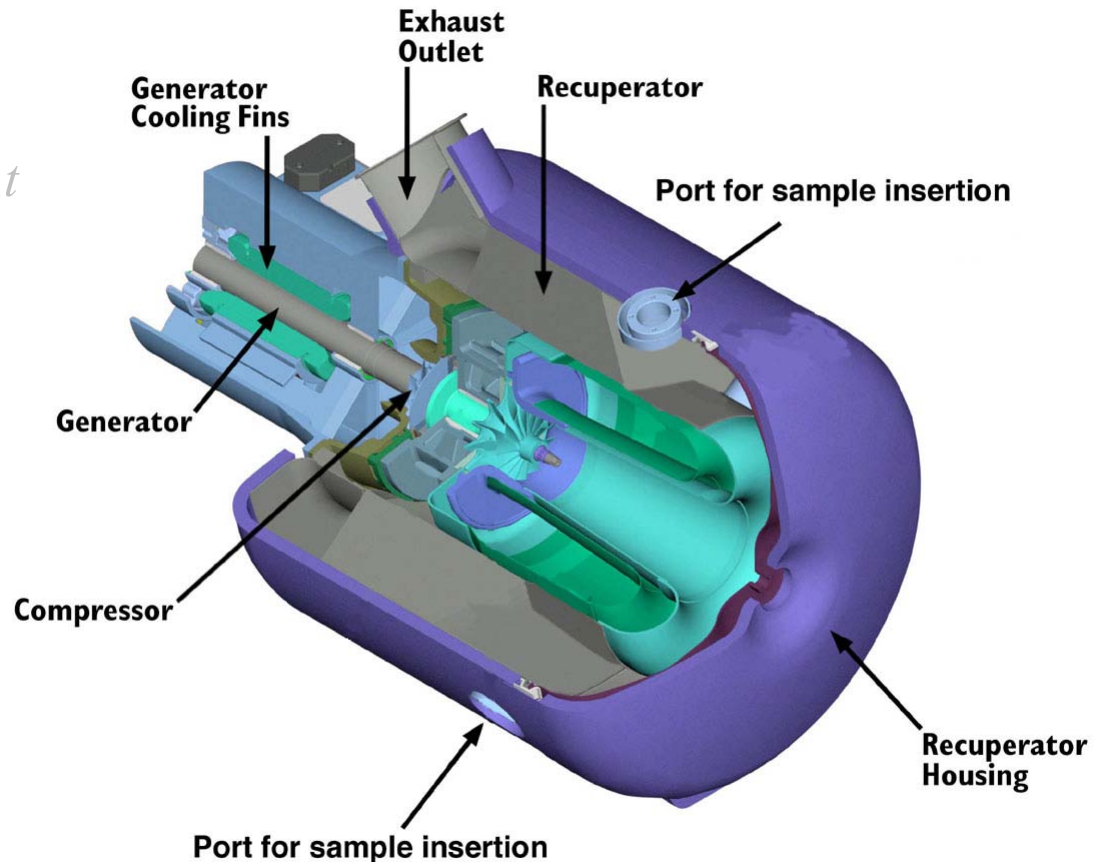
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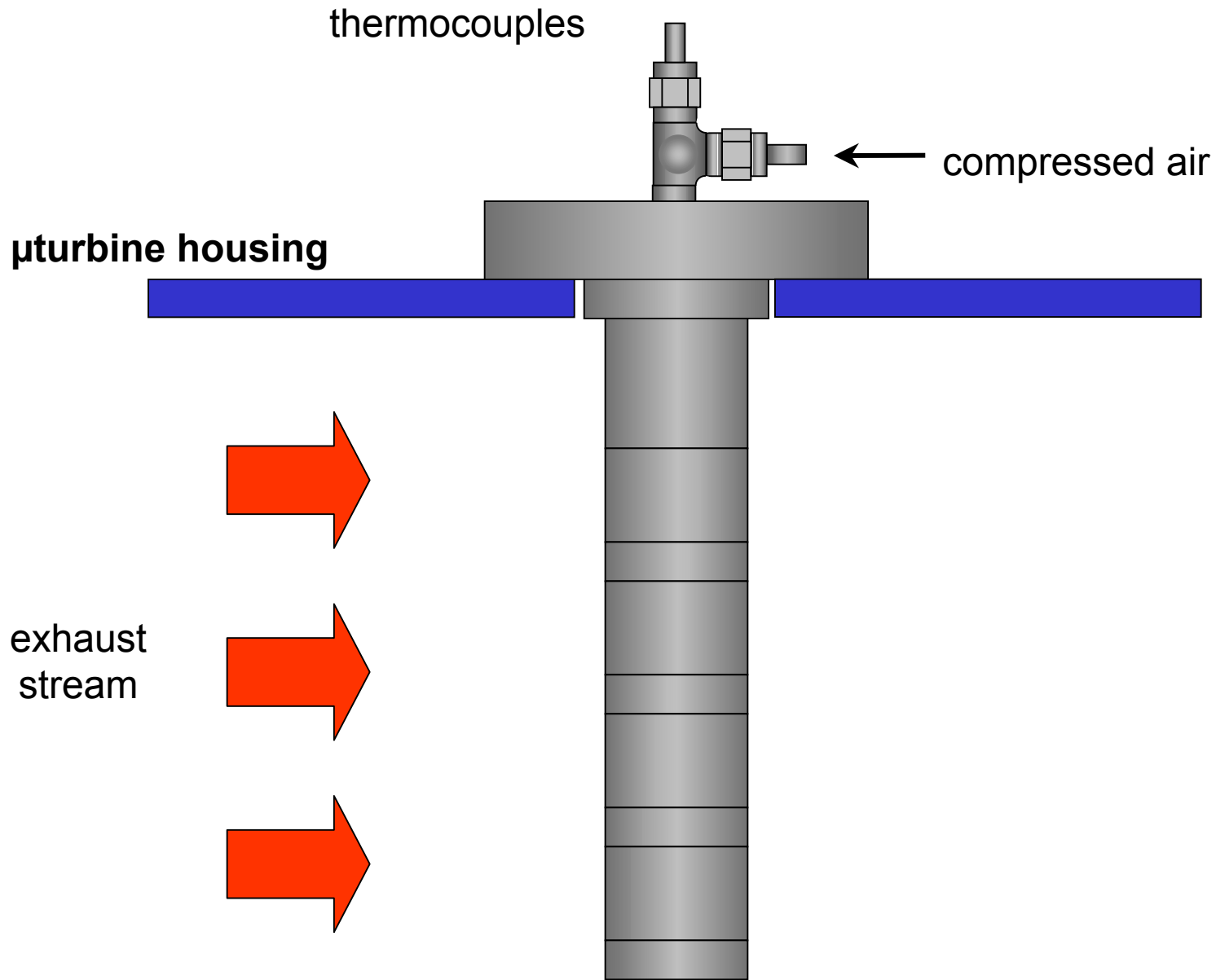
Six different sample holder bosses were welded around the pressure vessel that encloses the turbine. These sample holder bosses vary in diameter from 24 to 90 mm

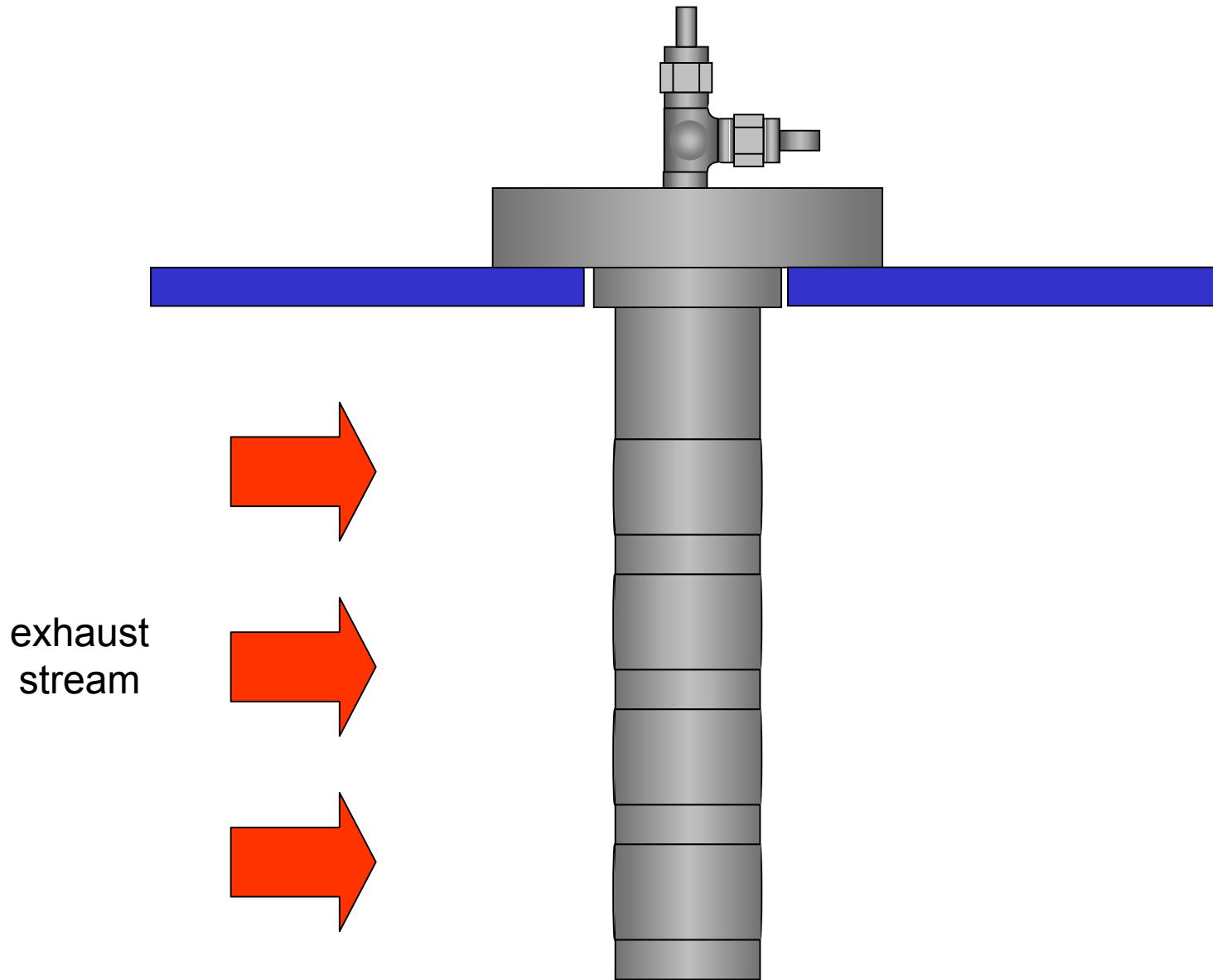


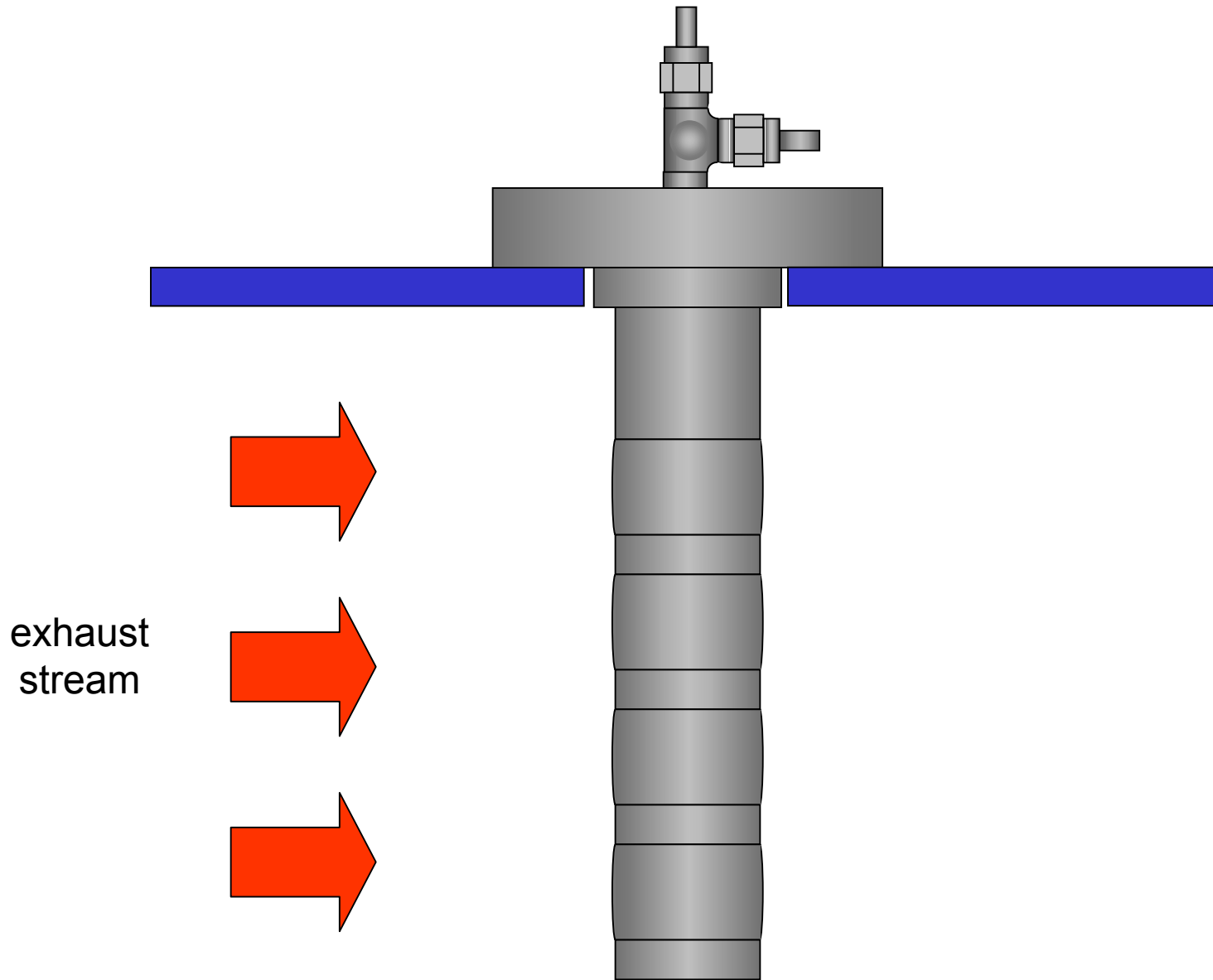
Sample Holder



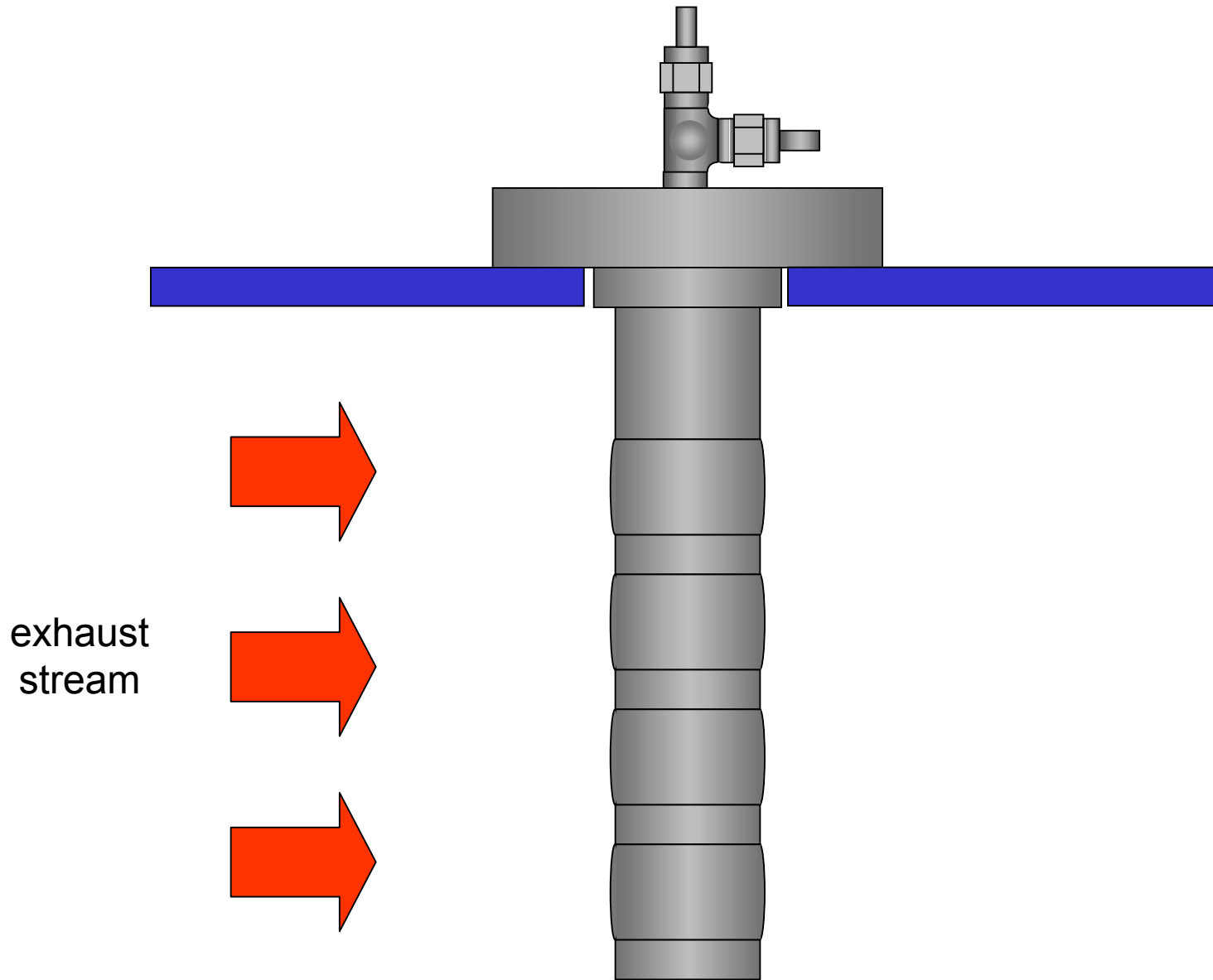
- *Ability to investigate the effect of mechanical stress on materials at a location upstream of the recuperator.*



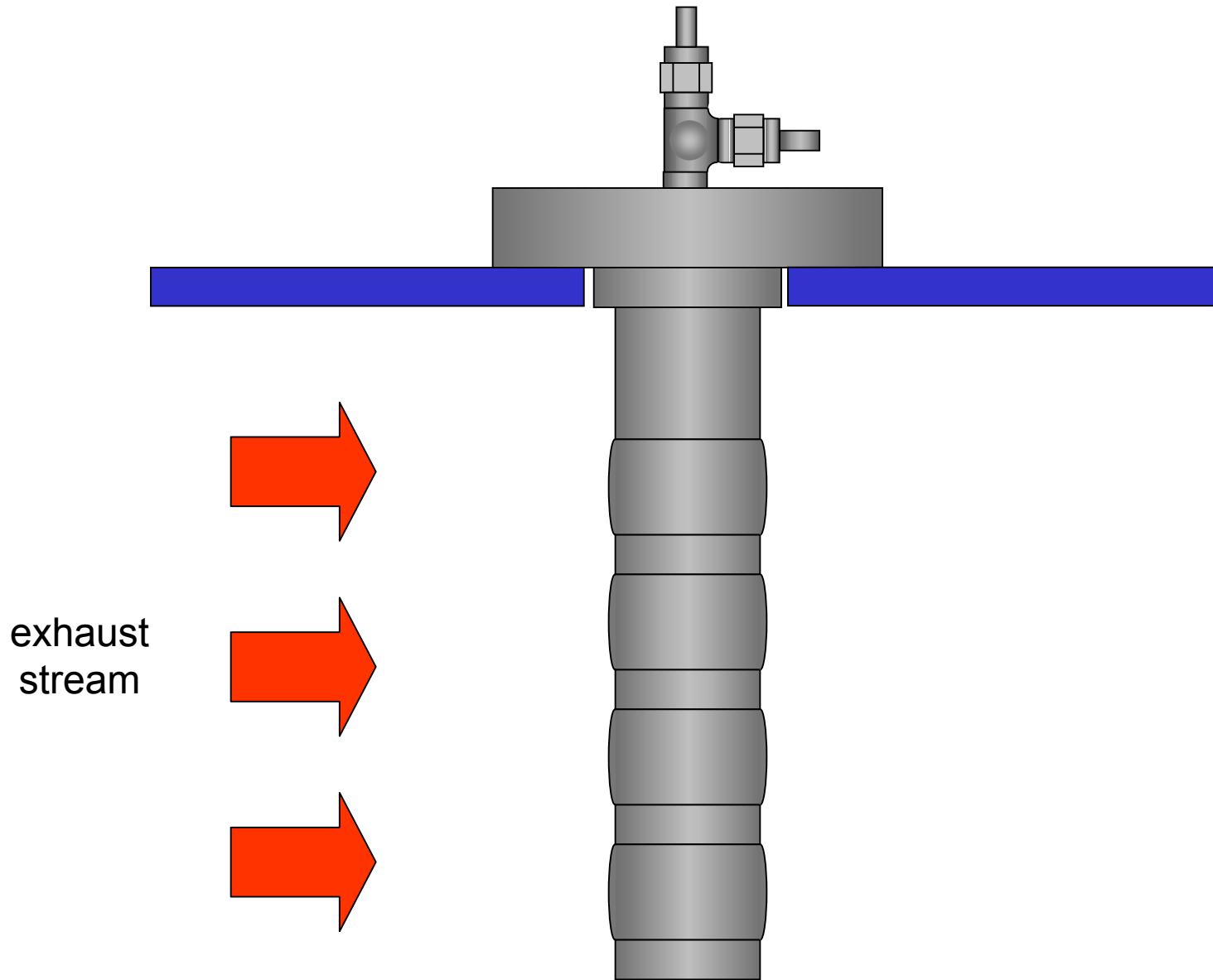


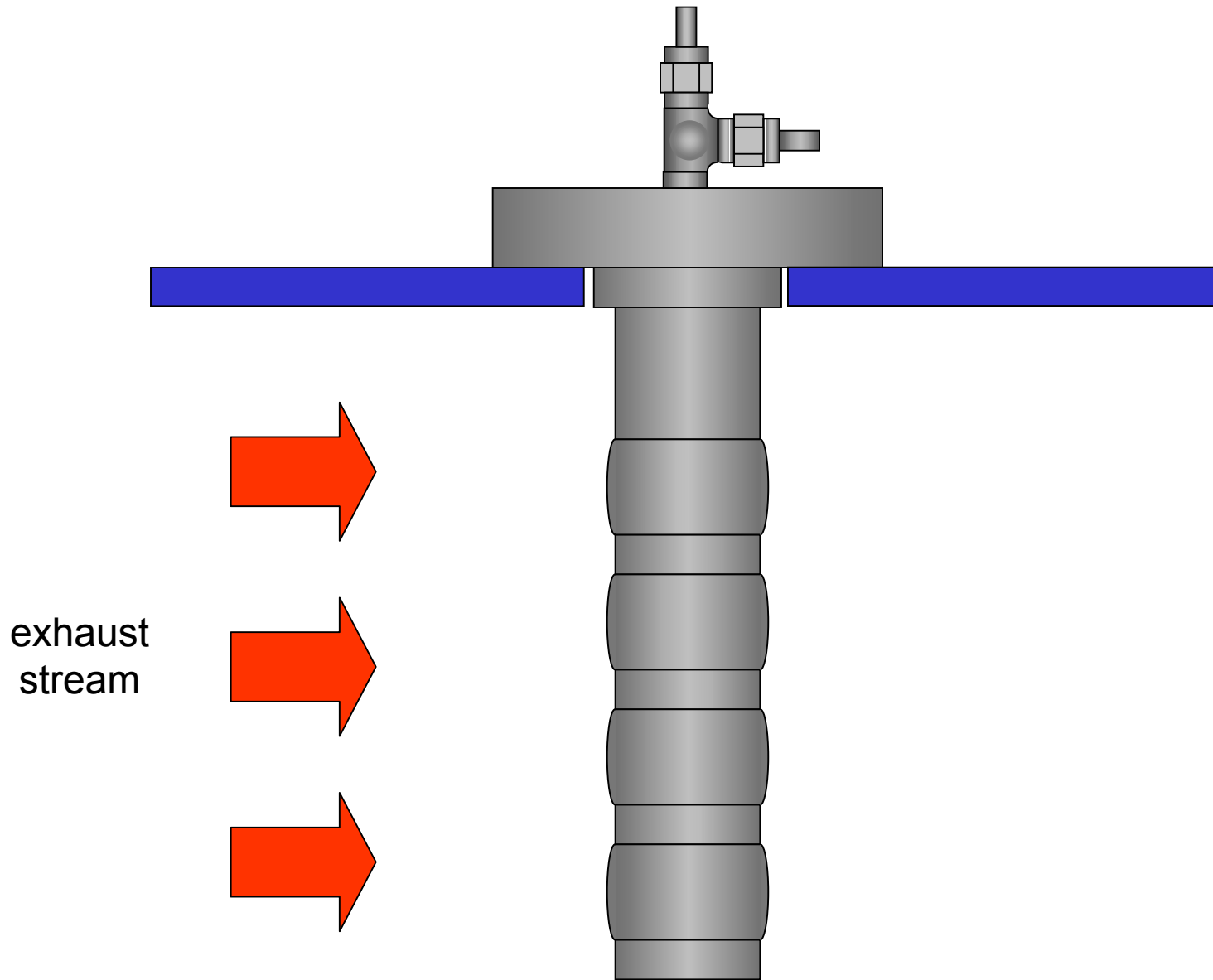


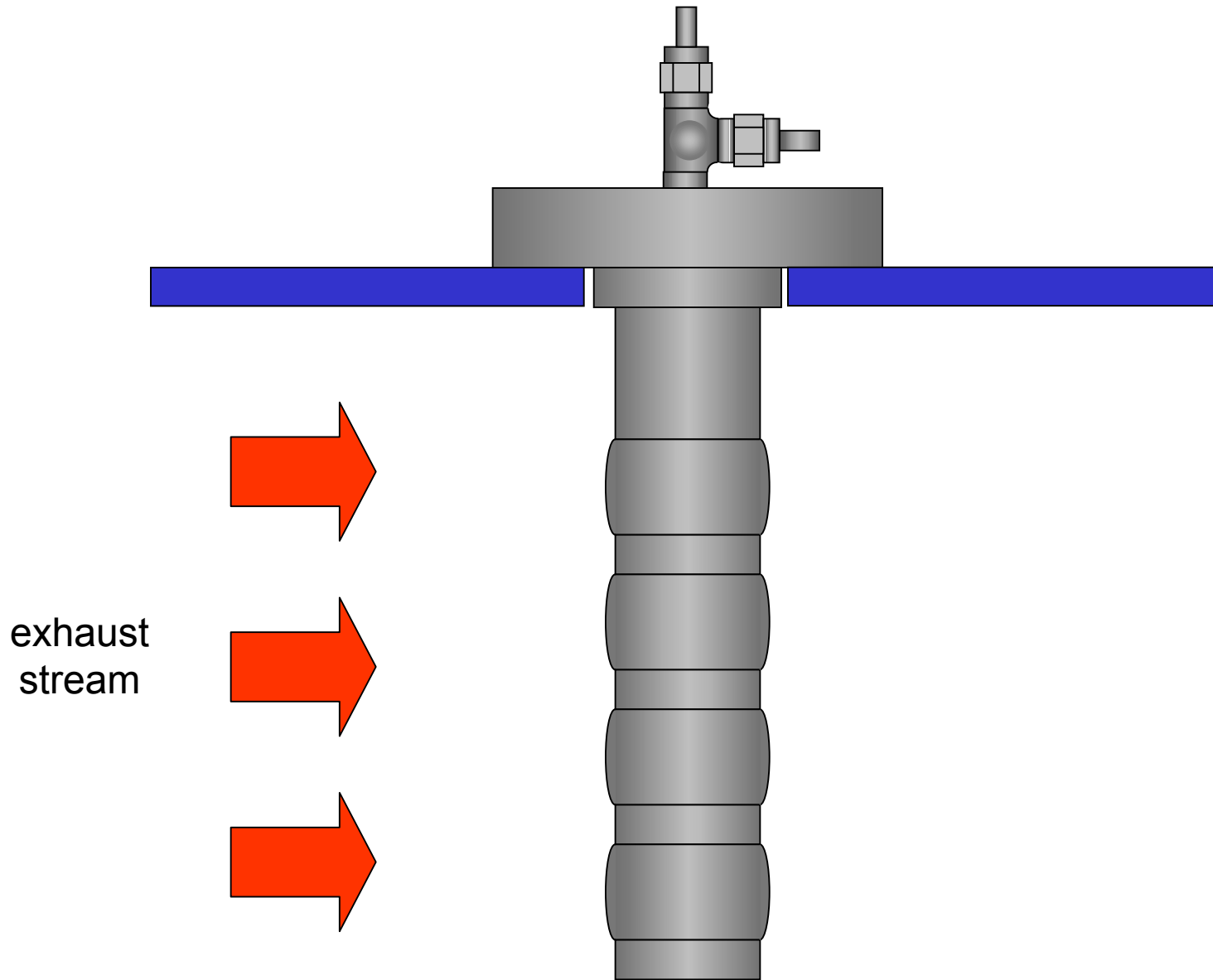
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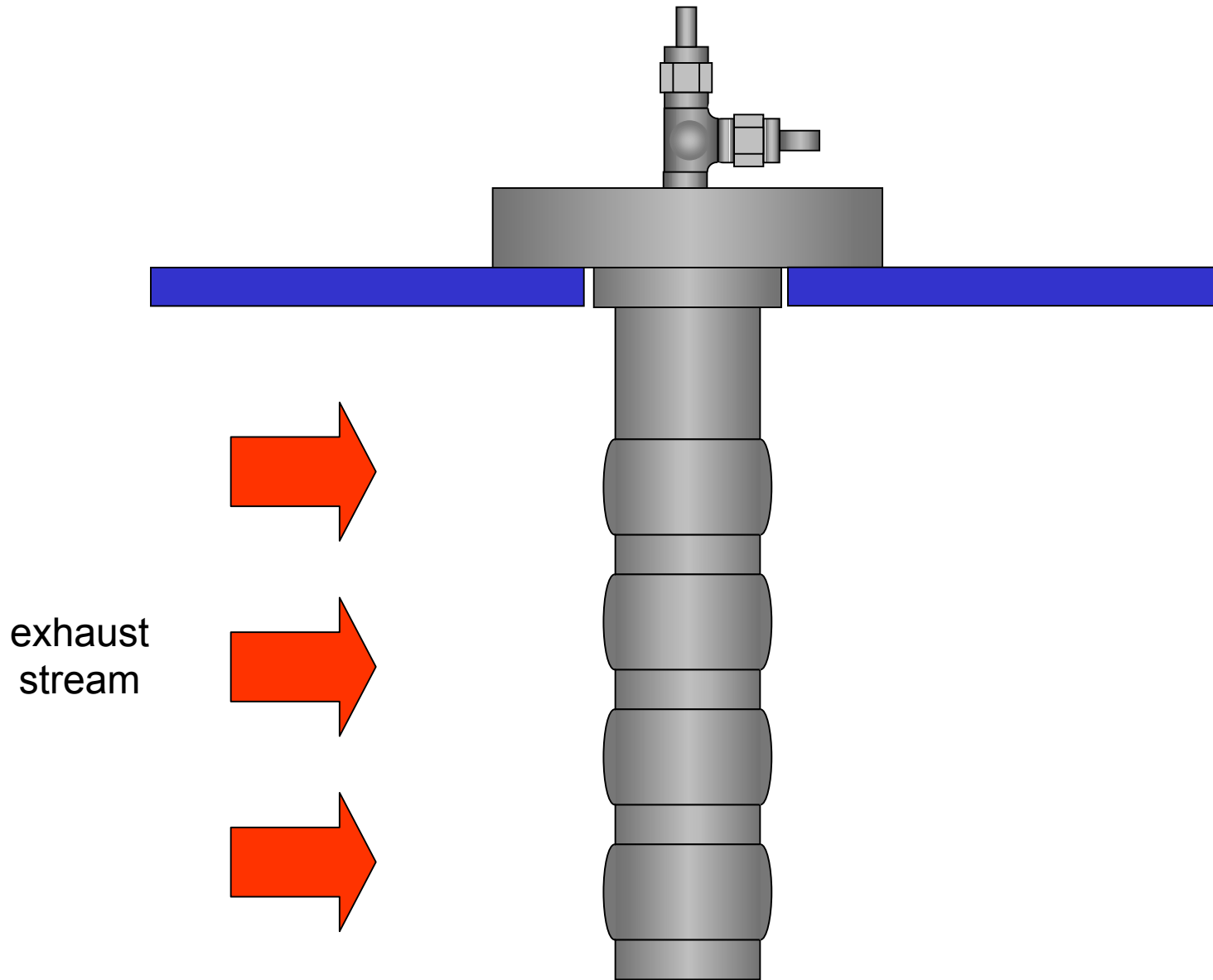


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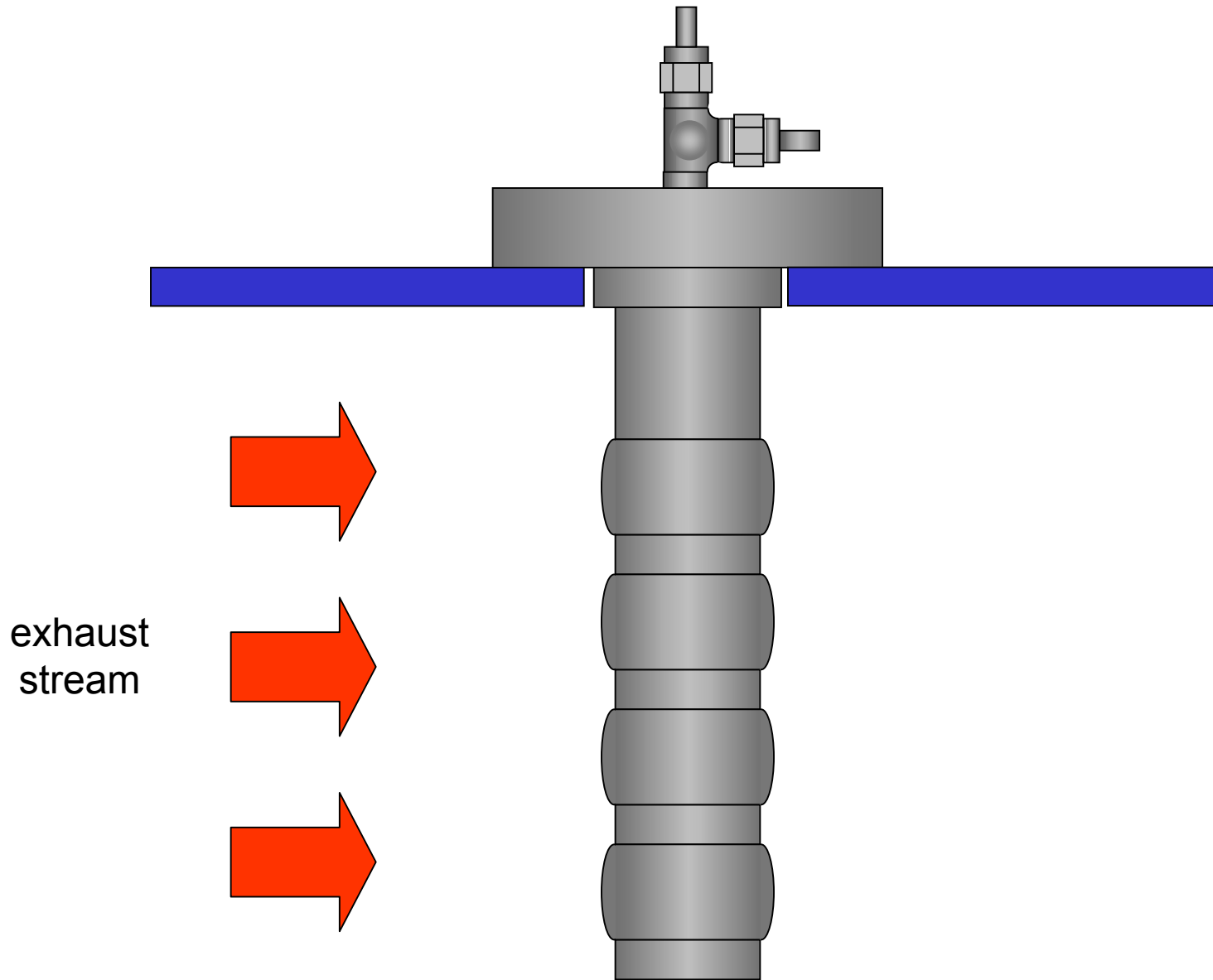






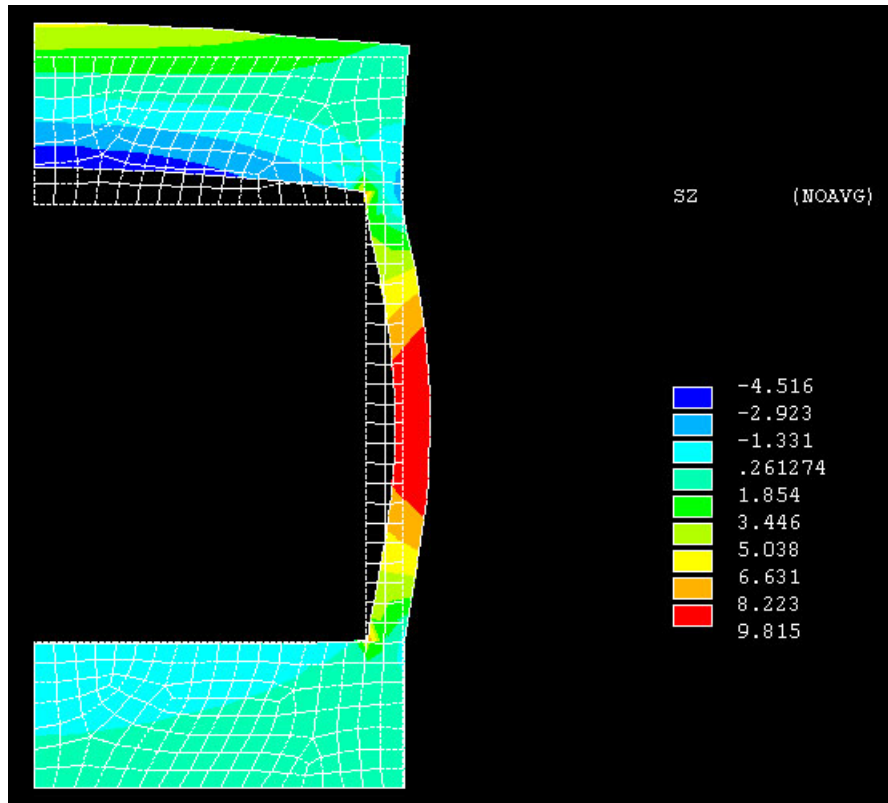


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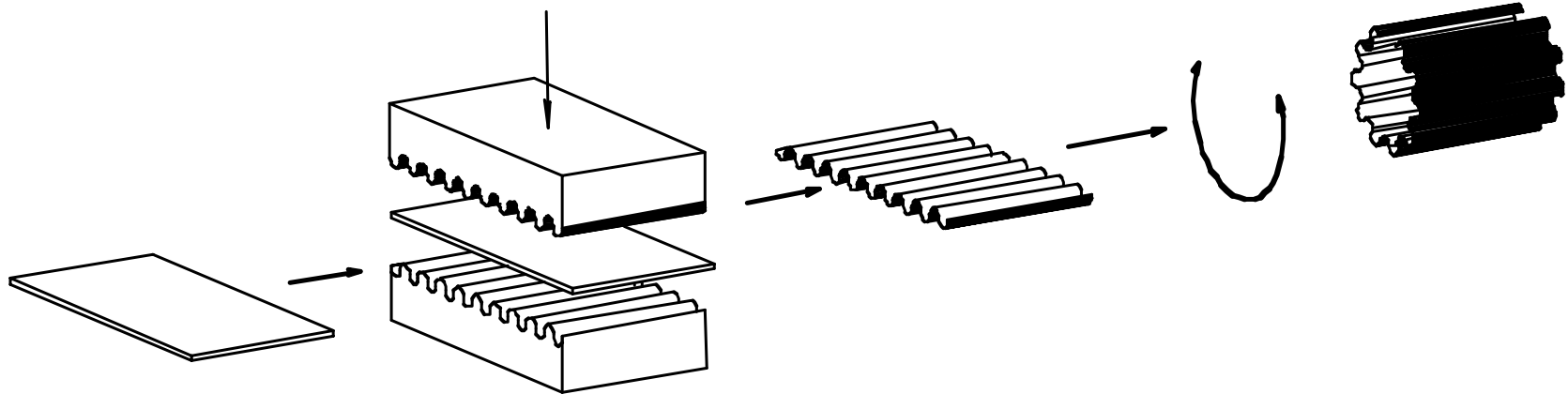
Stress Analysis



Sample Holder

- *Ability to investigate the effect of mechanical stress on materials at a location upstream of the recuperator.*
- ***Ability to screen potential manufacturability and weldability problems.***

Sample Preparation



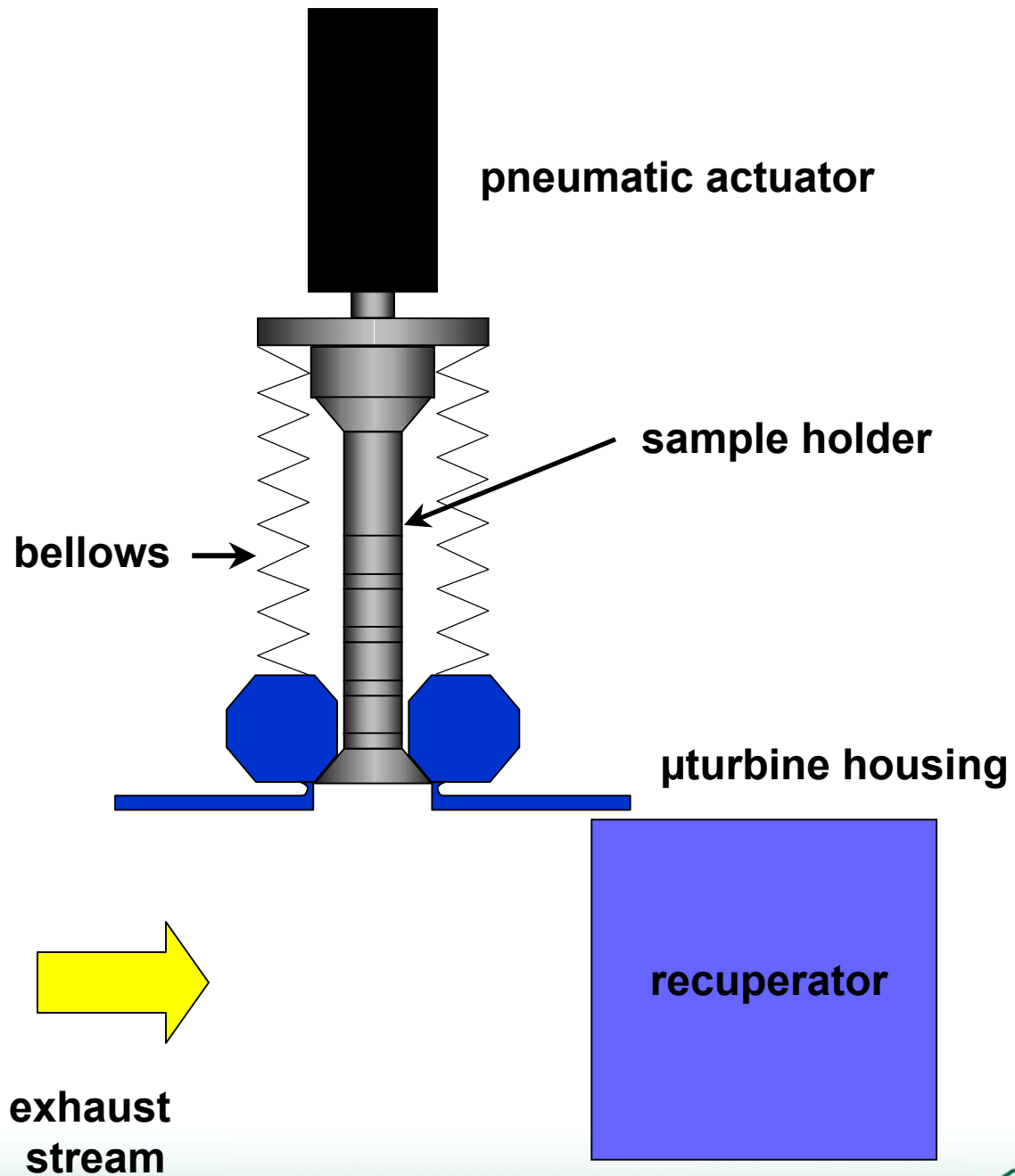
Sample Holder

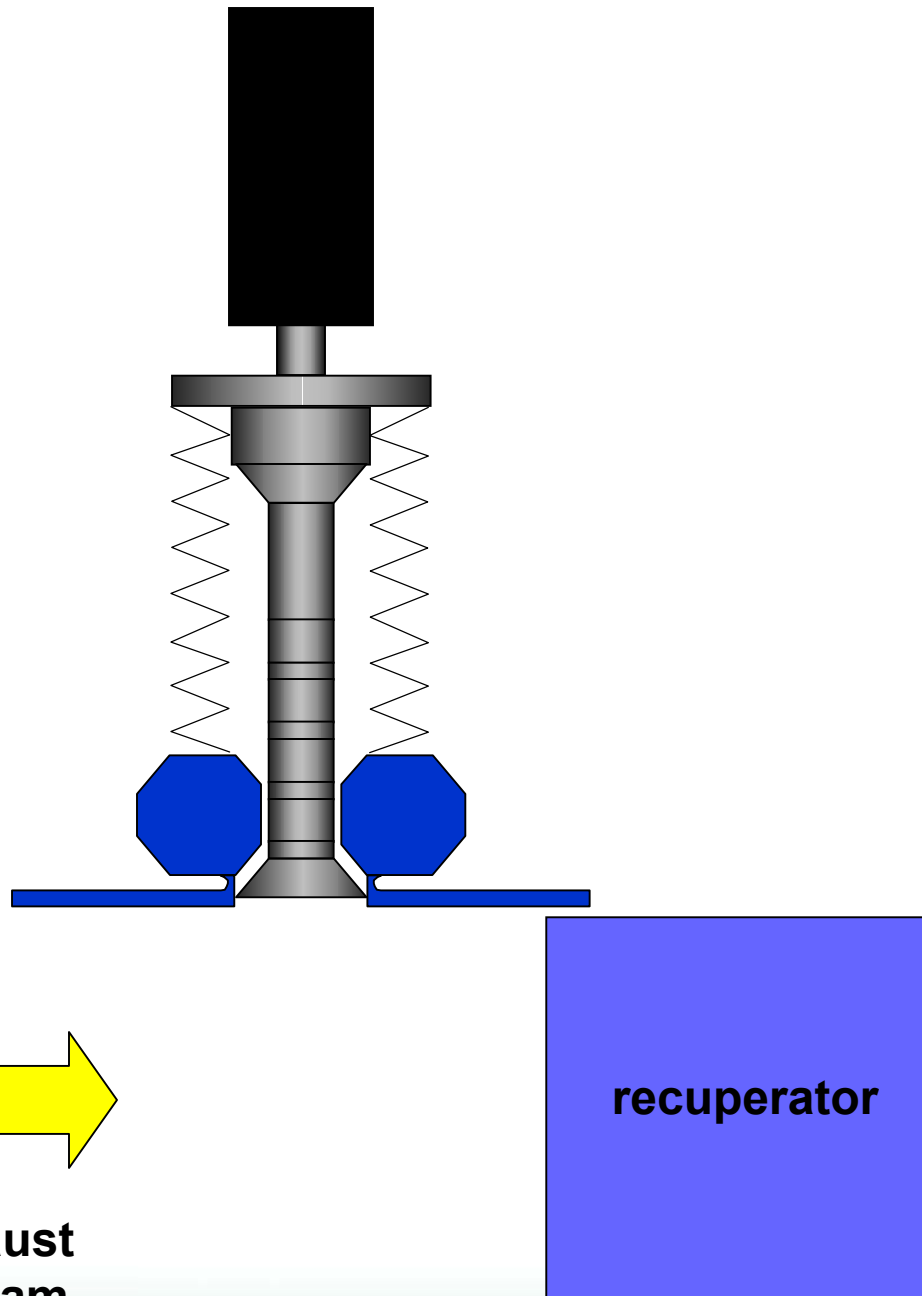


Sample Holder

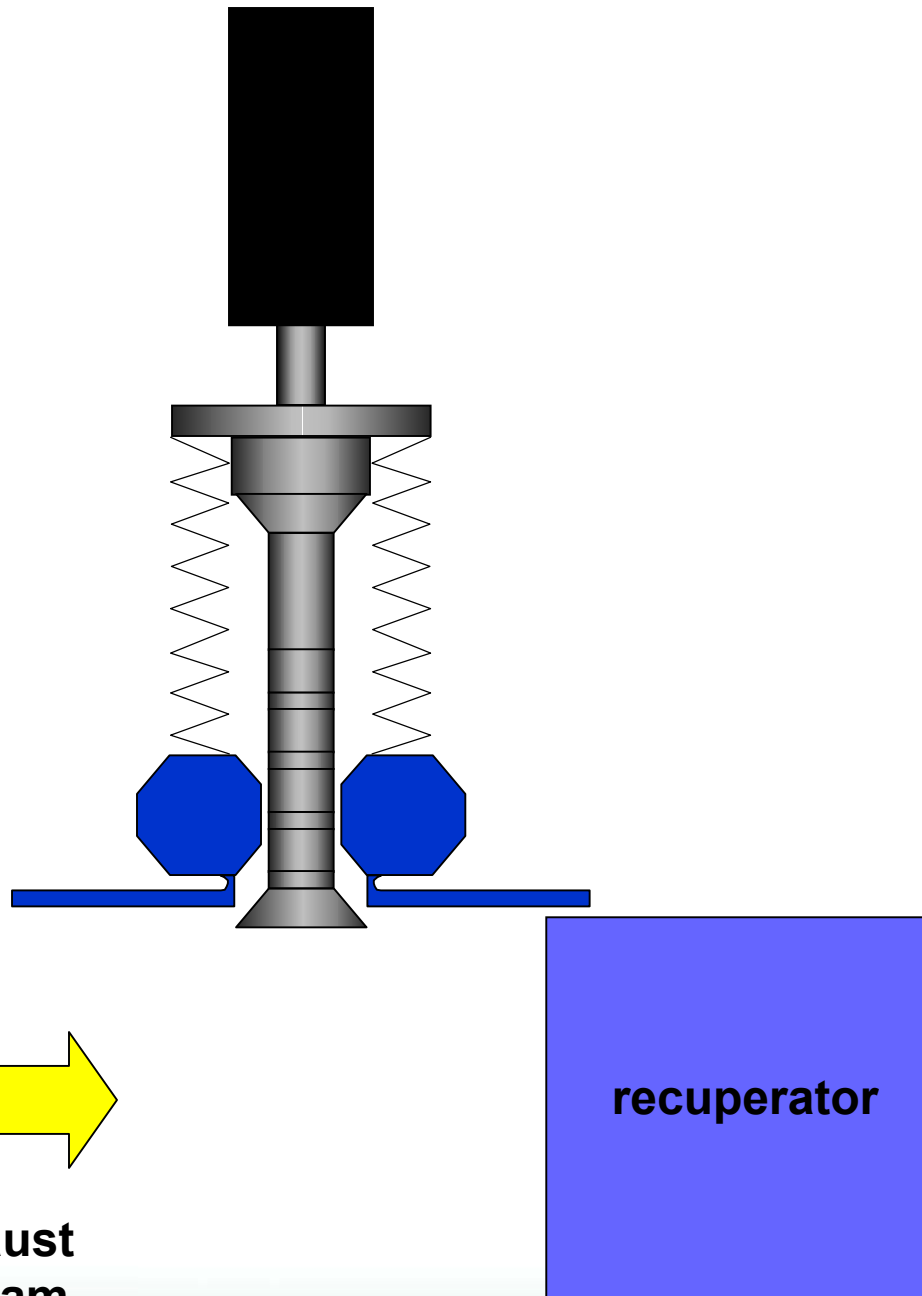
- *Ability to investigate the effect of mechanical stress on materials at a location upstream of the recuperator.*
- *Ability to screen potential manufacturability and weldability problems.*
- ***Potential to investigate the effect of various microturbine operating modes.***

Intermittent Operation



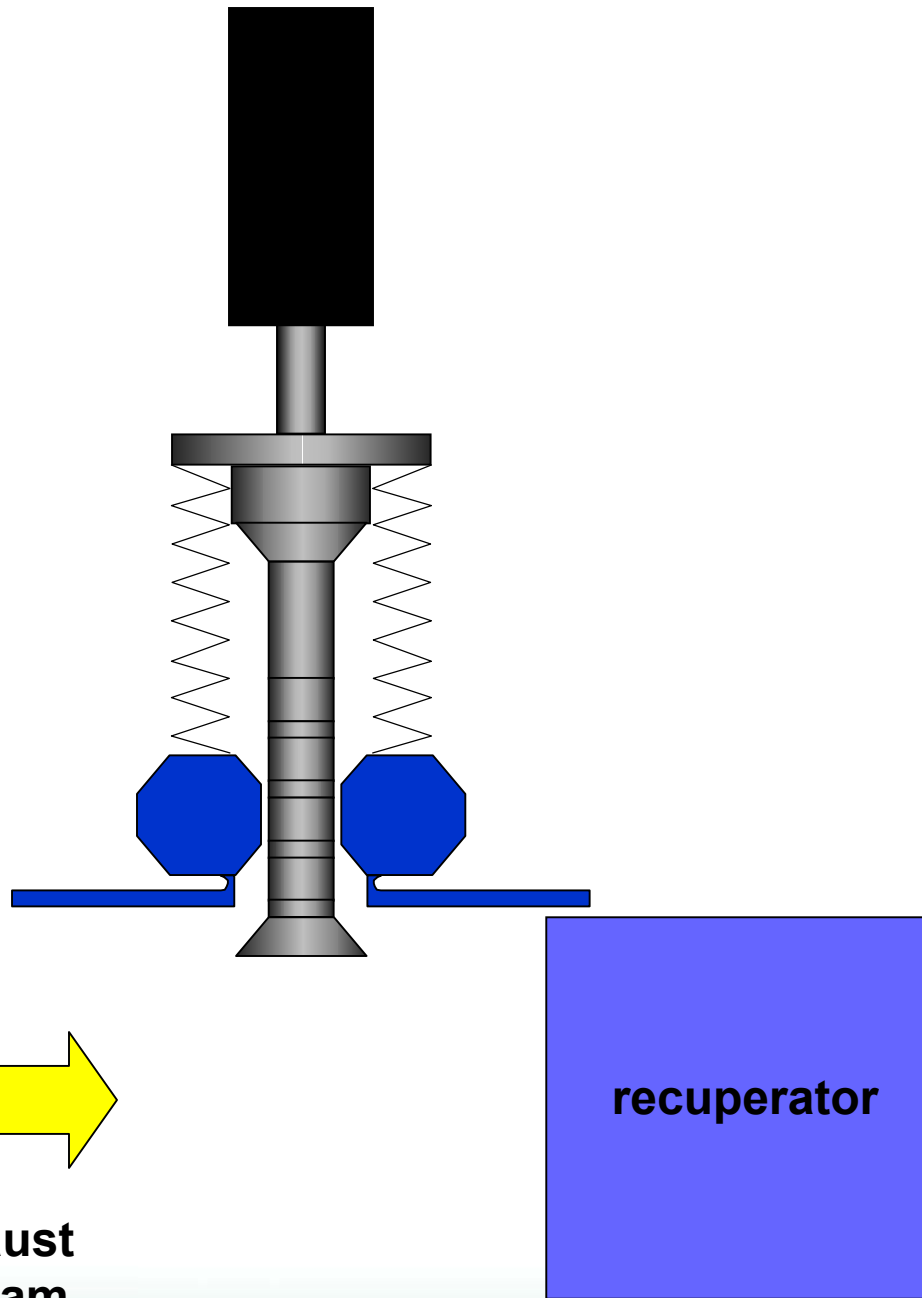


**exhaust
stream**



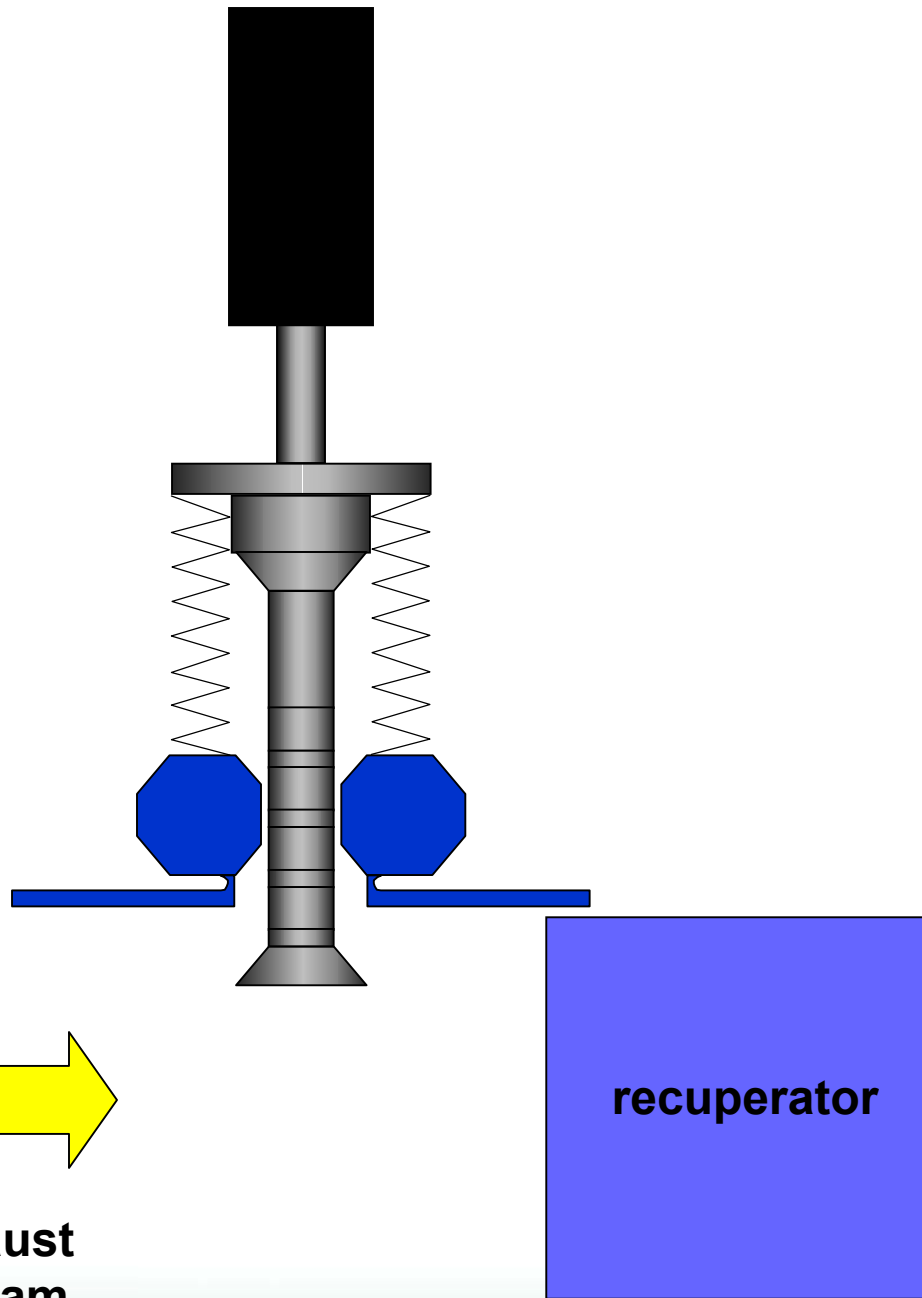
**exhaust
stream**

recuperator



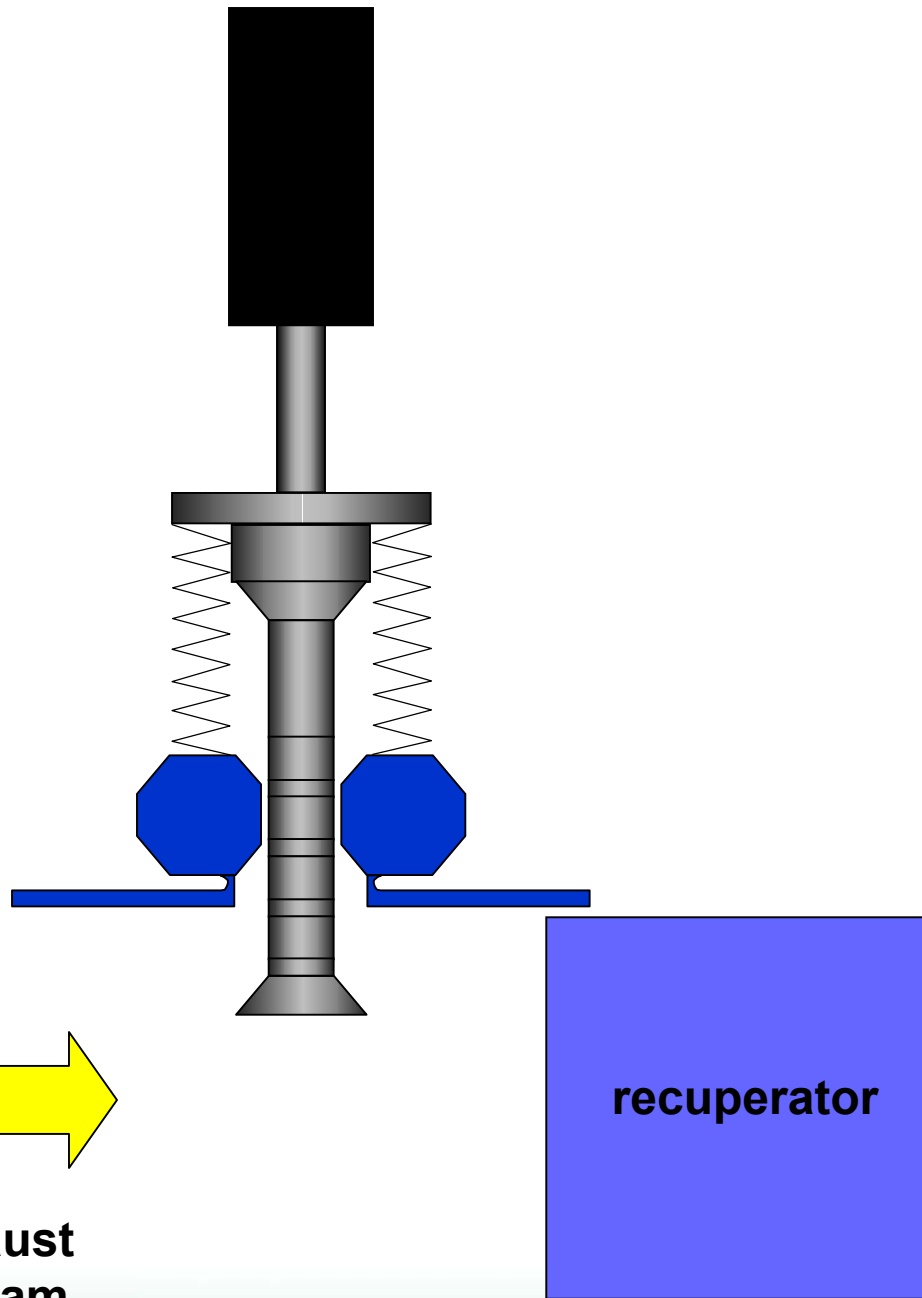
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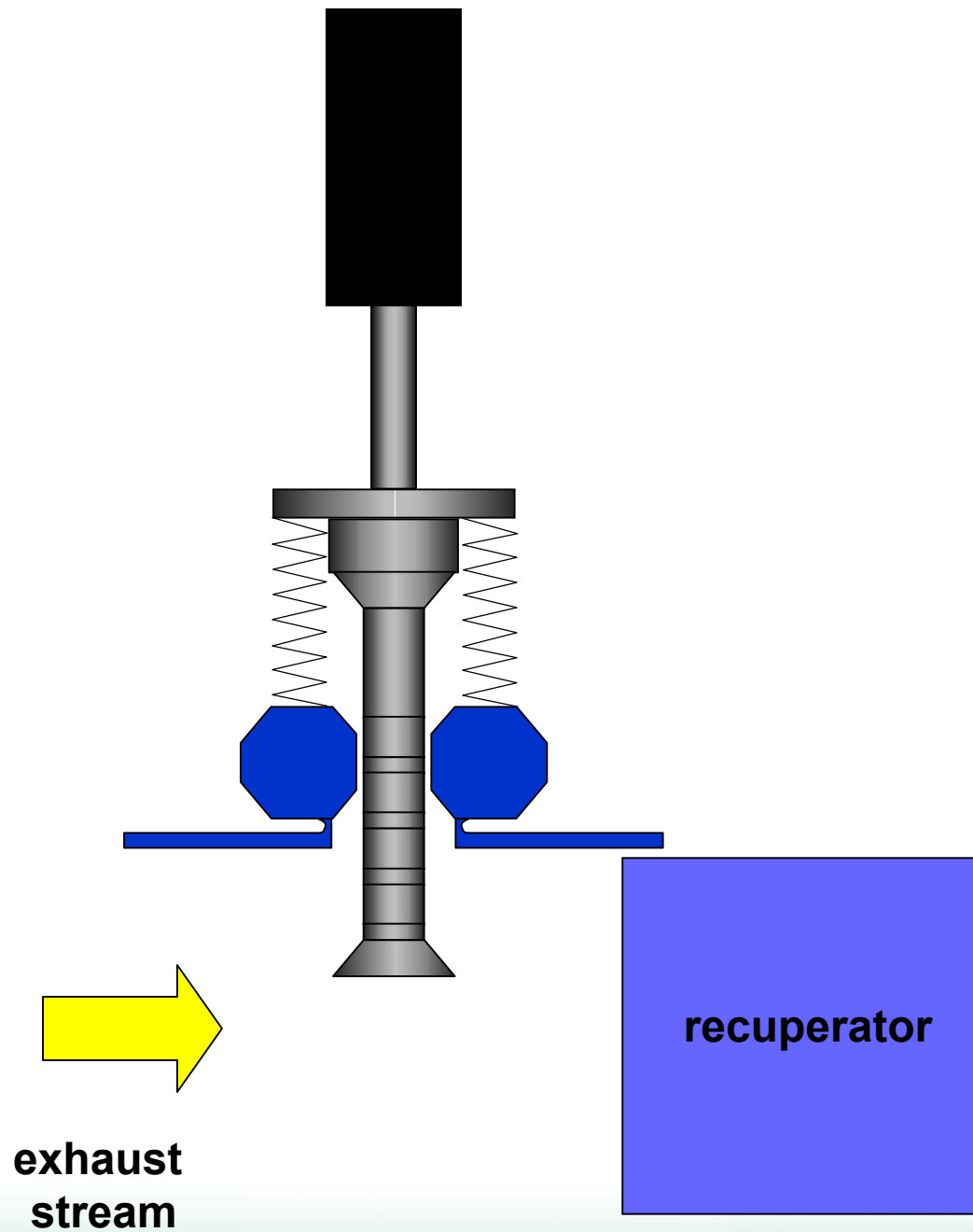
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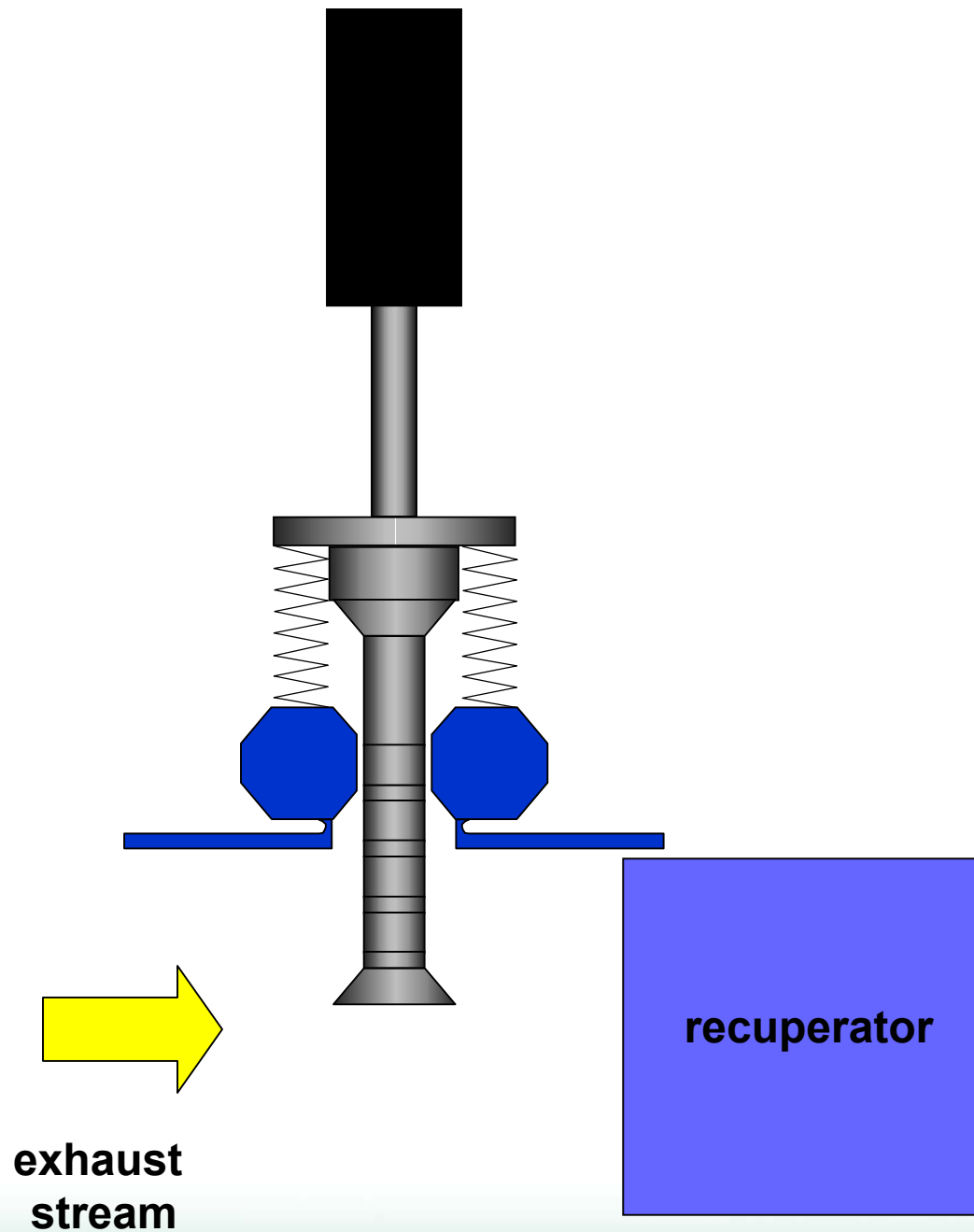
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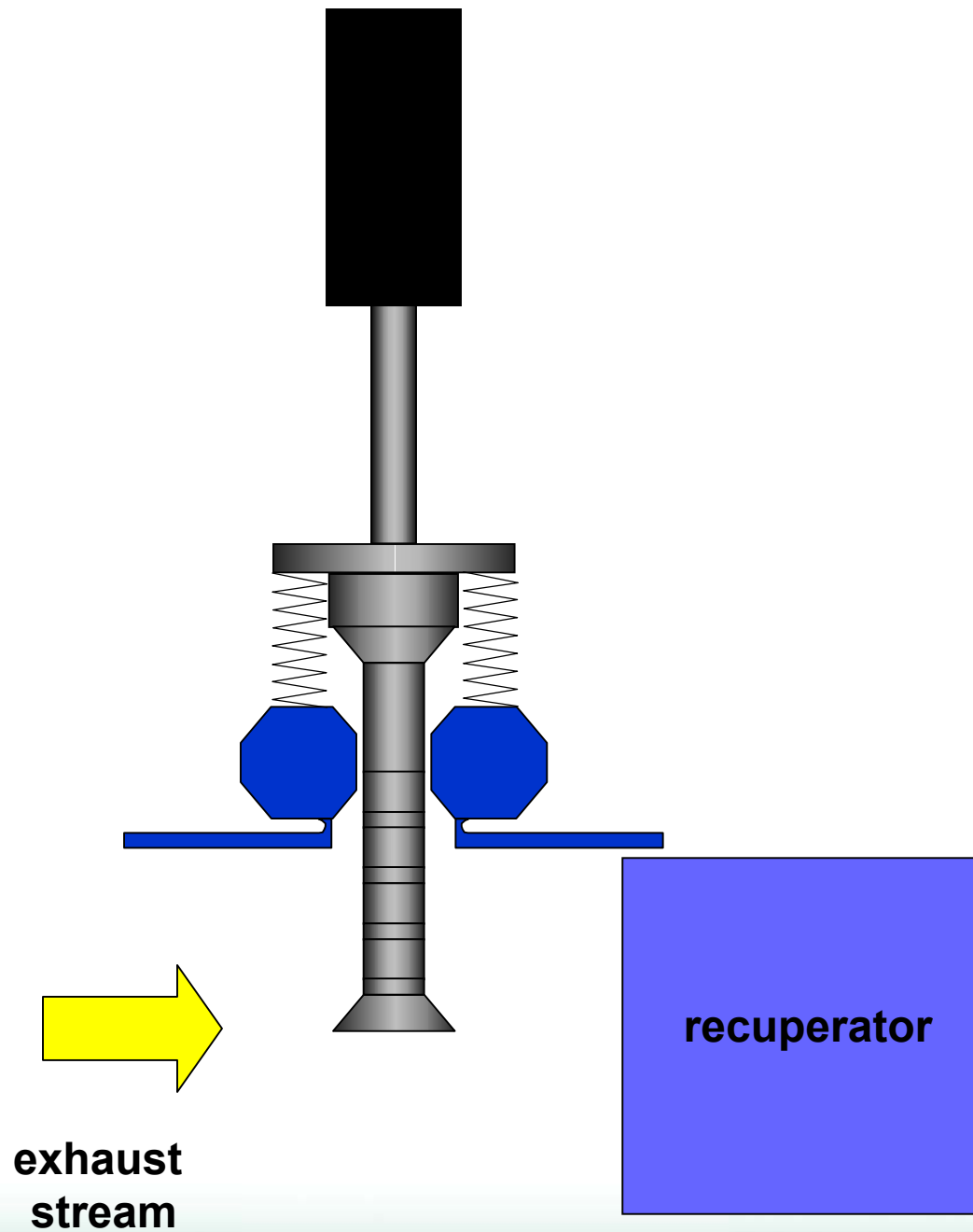


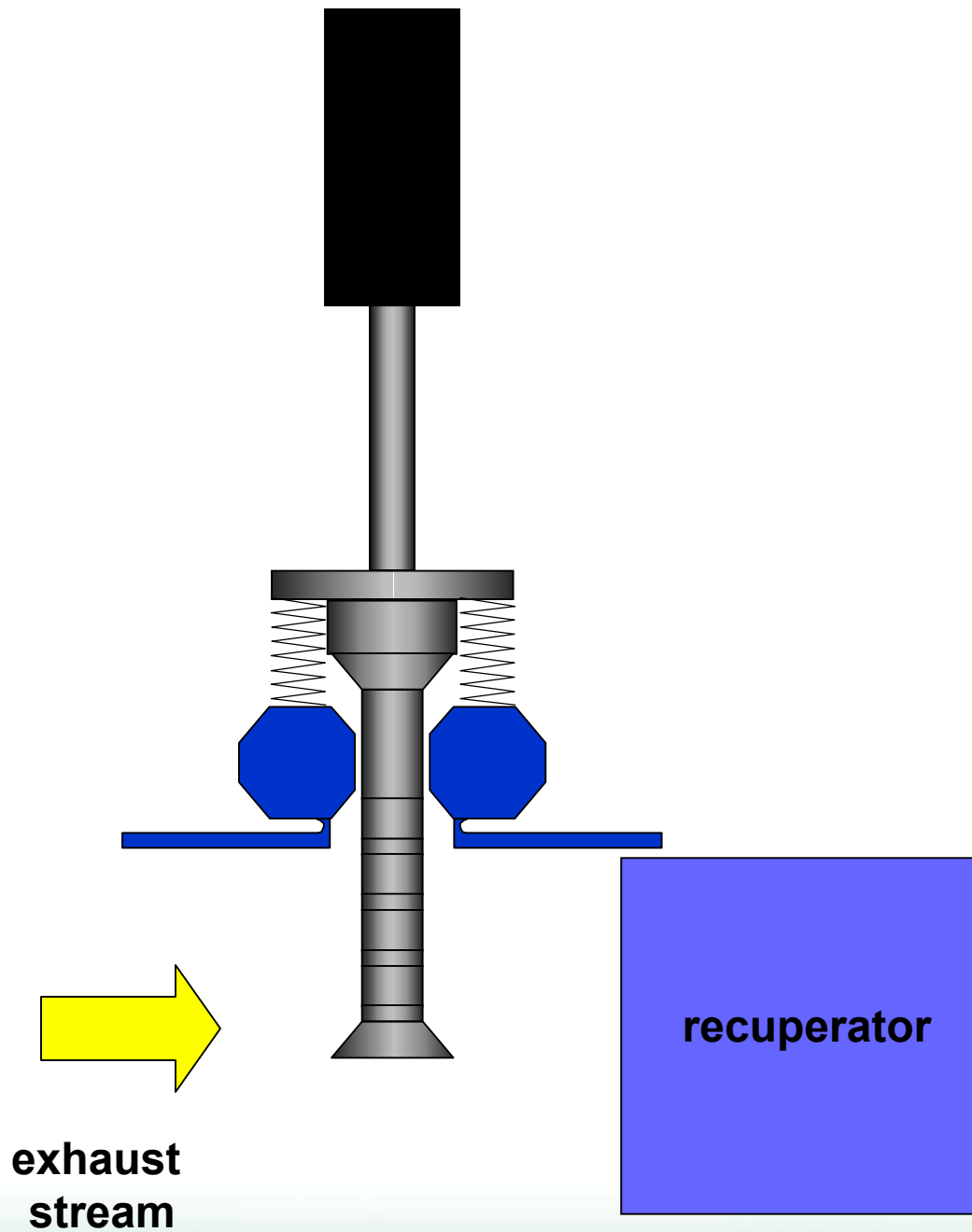
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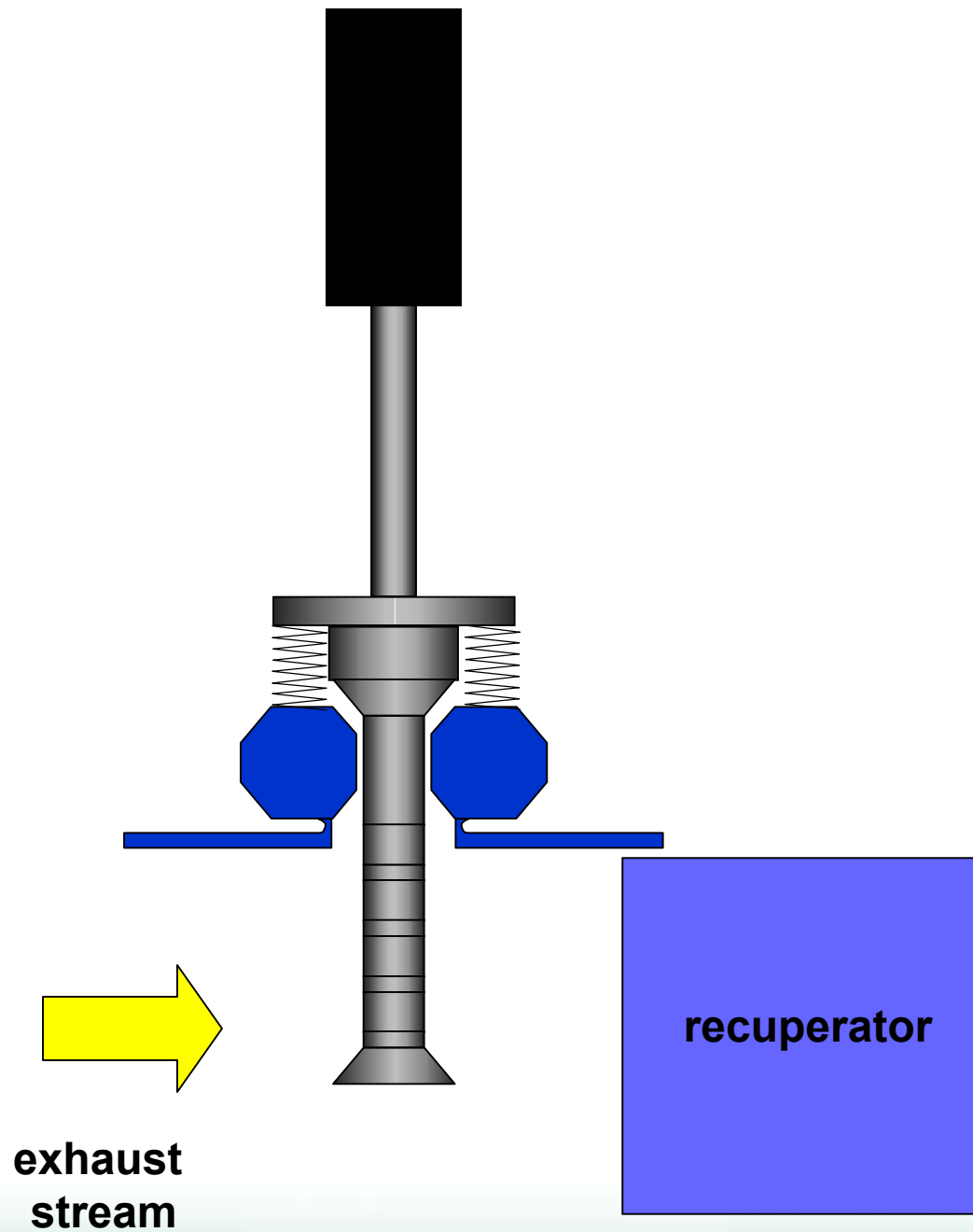
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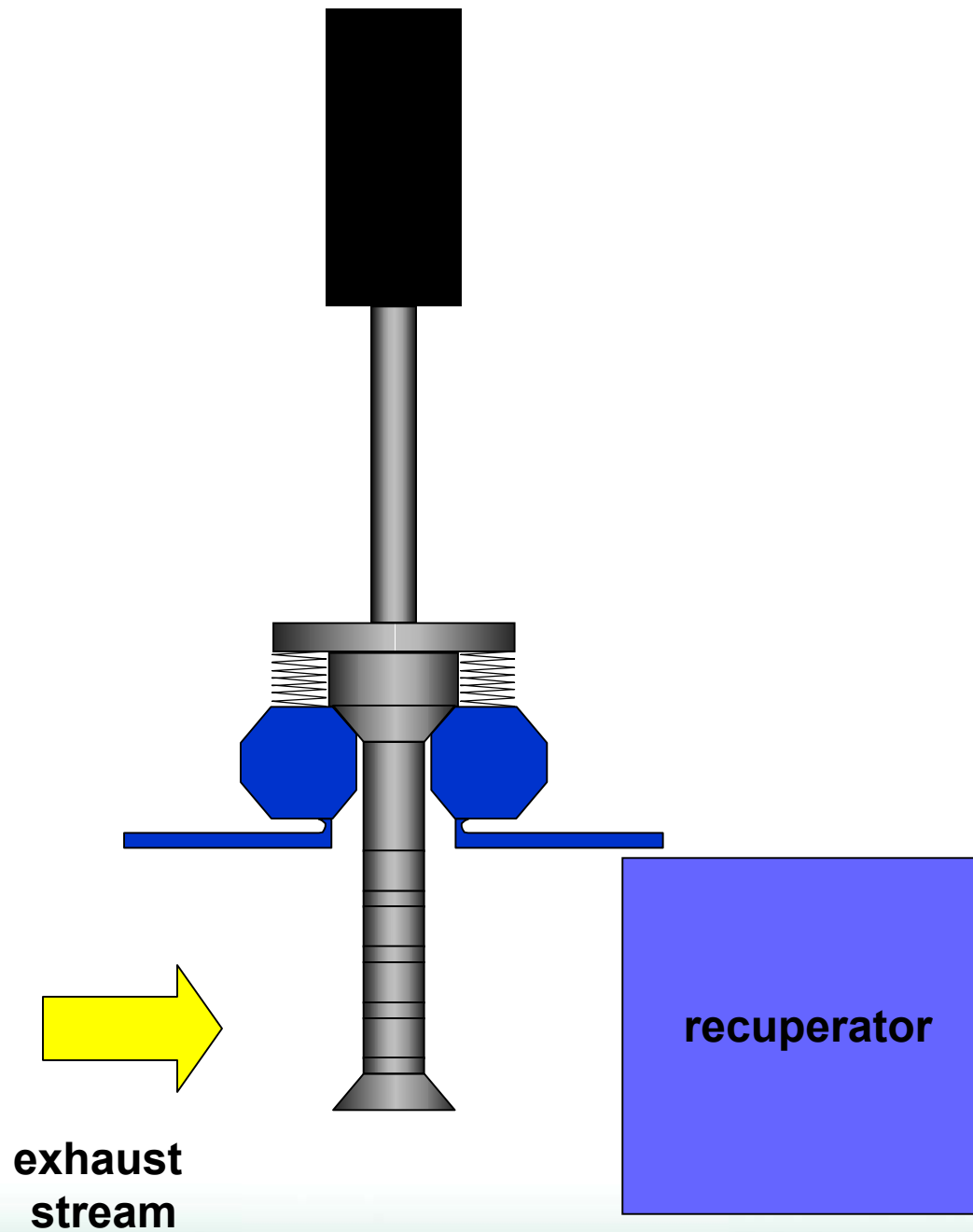


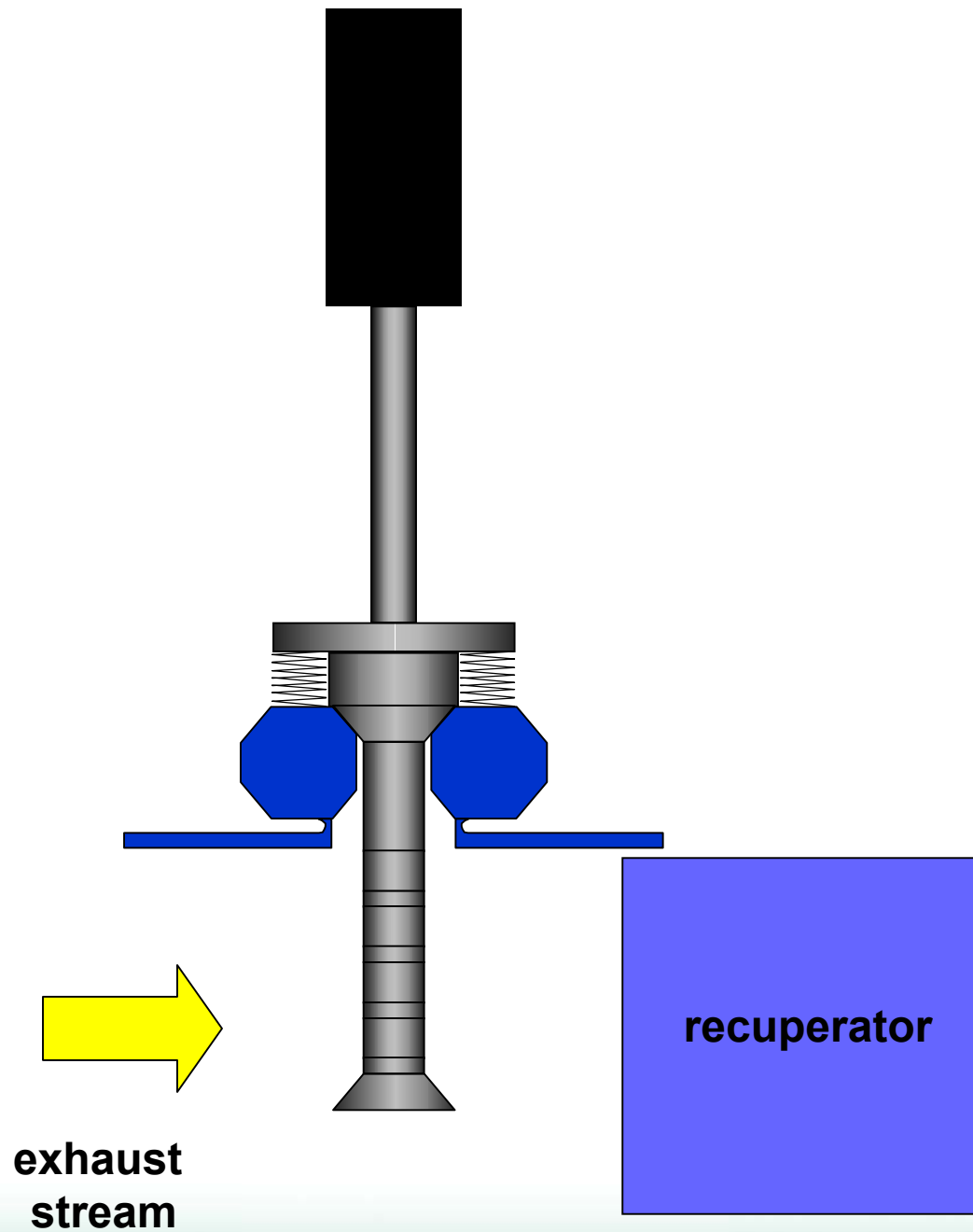


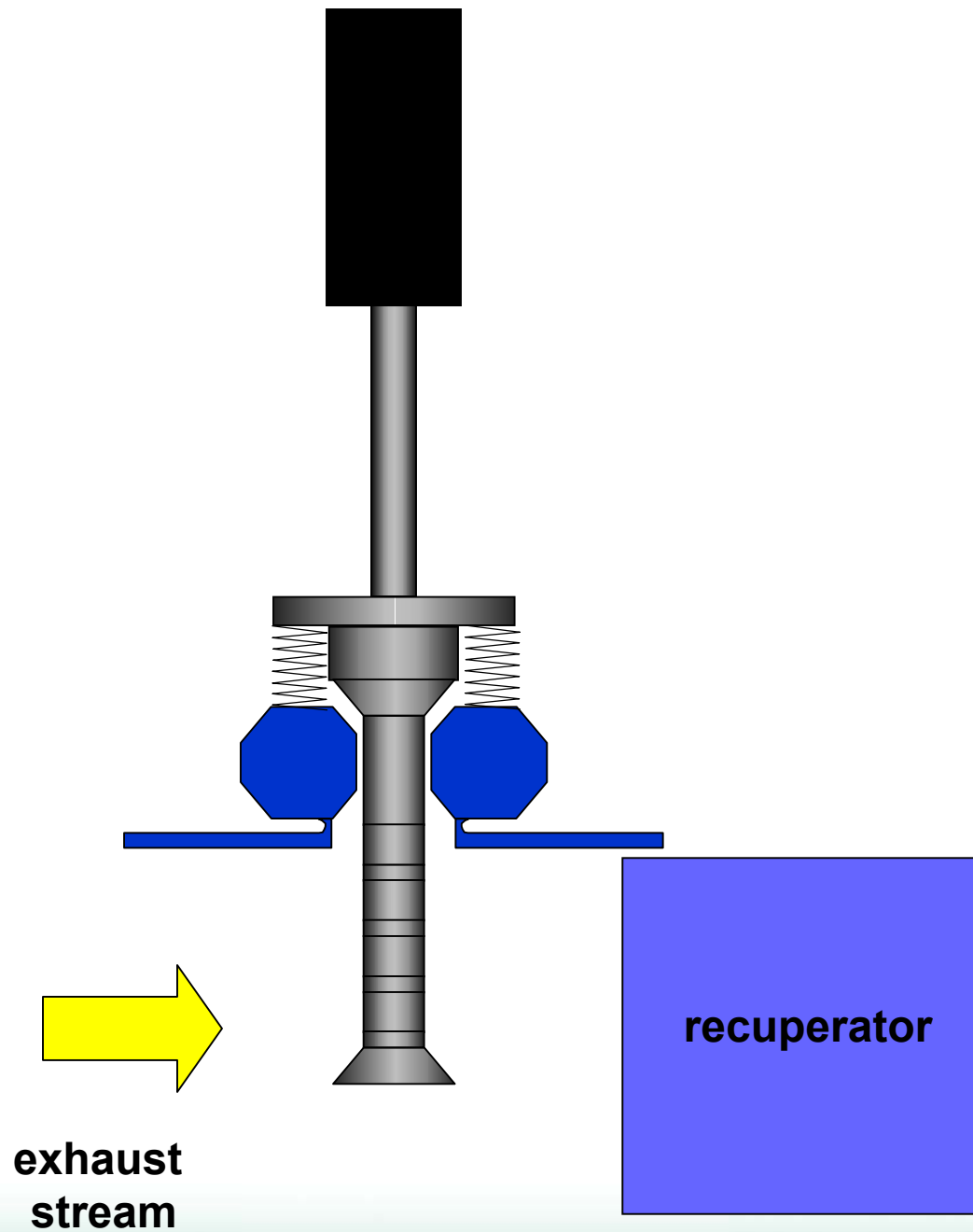


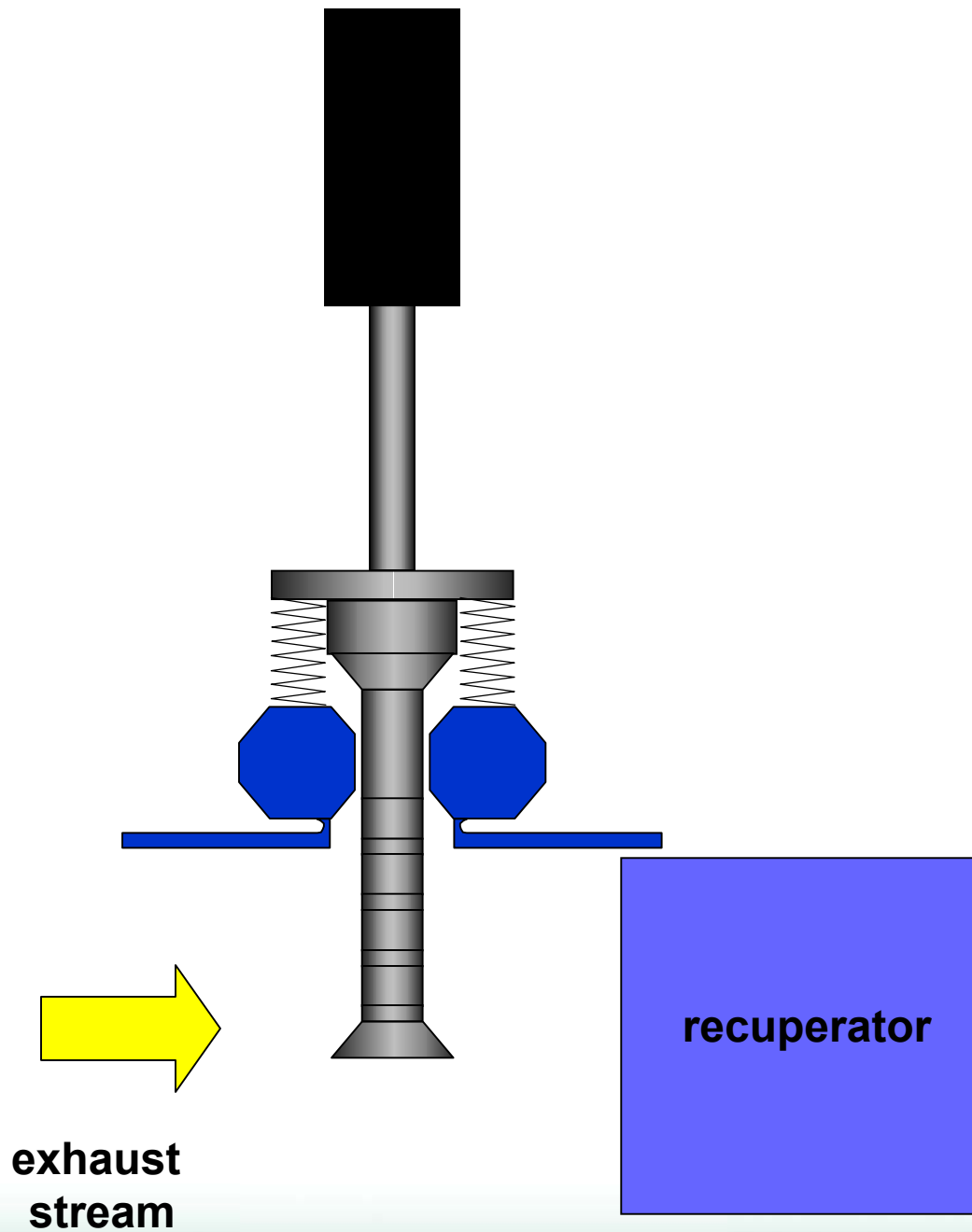


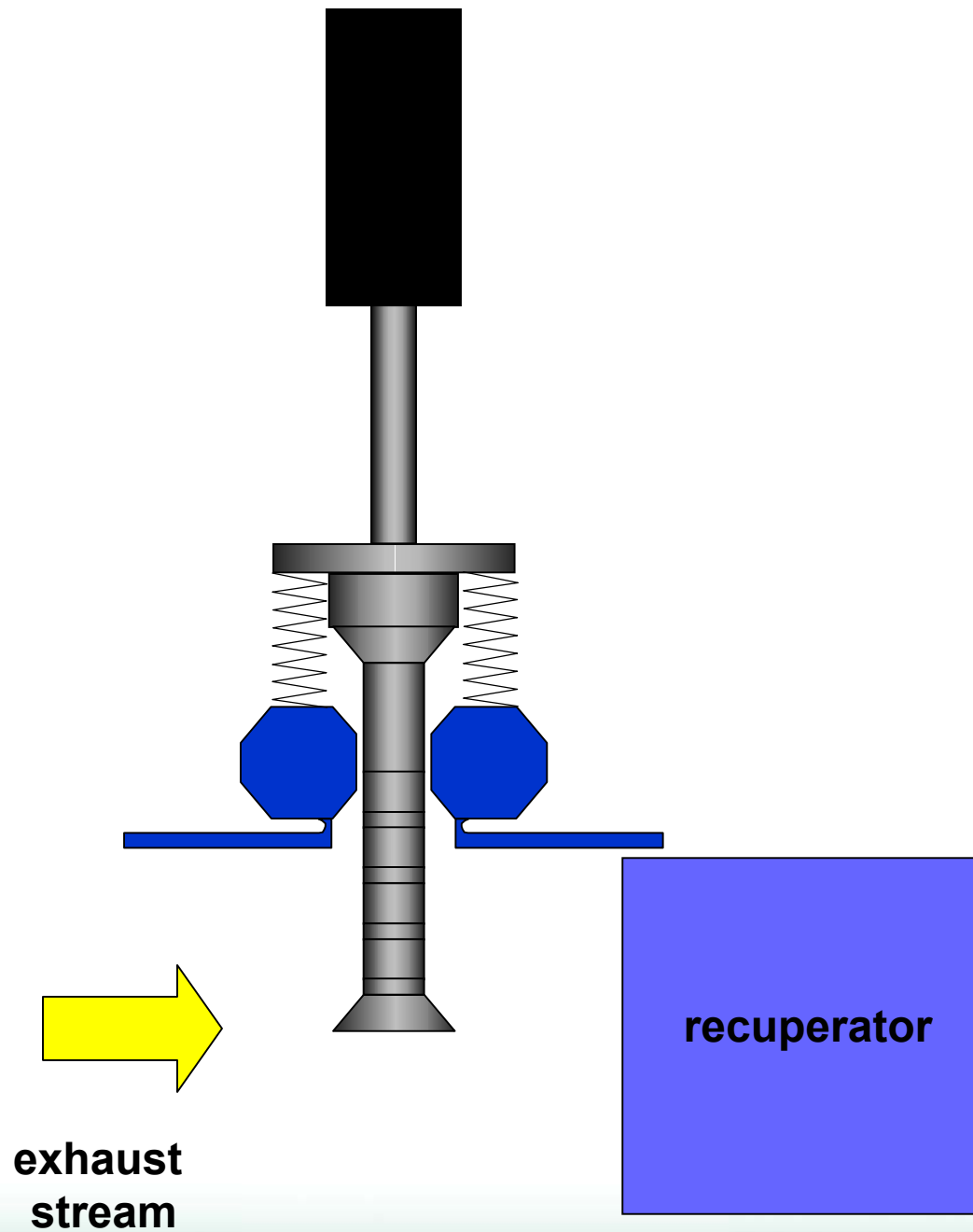


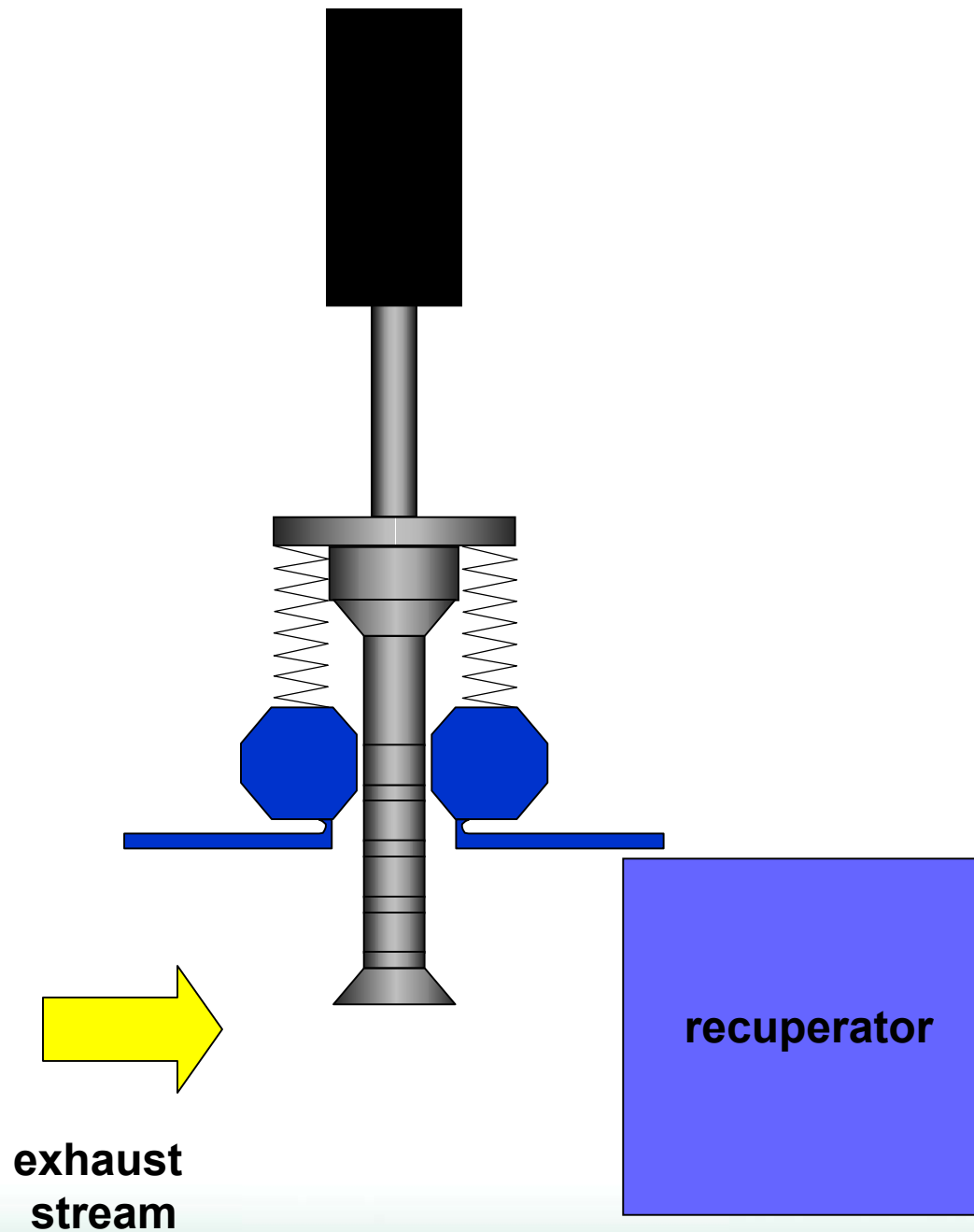


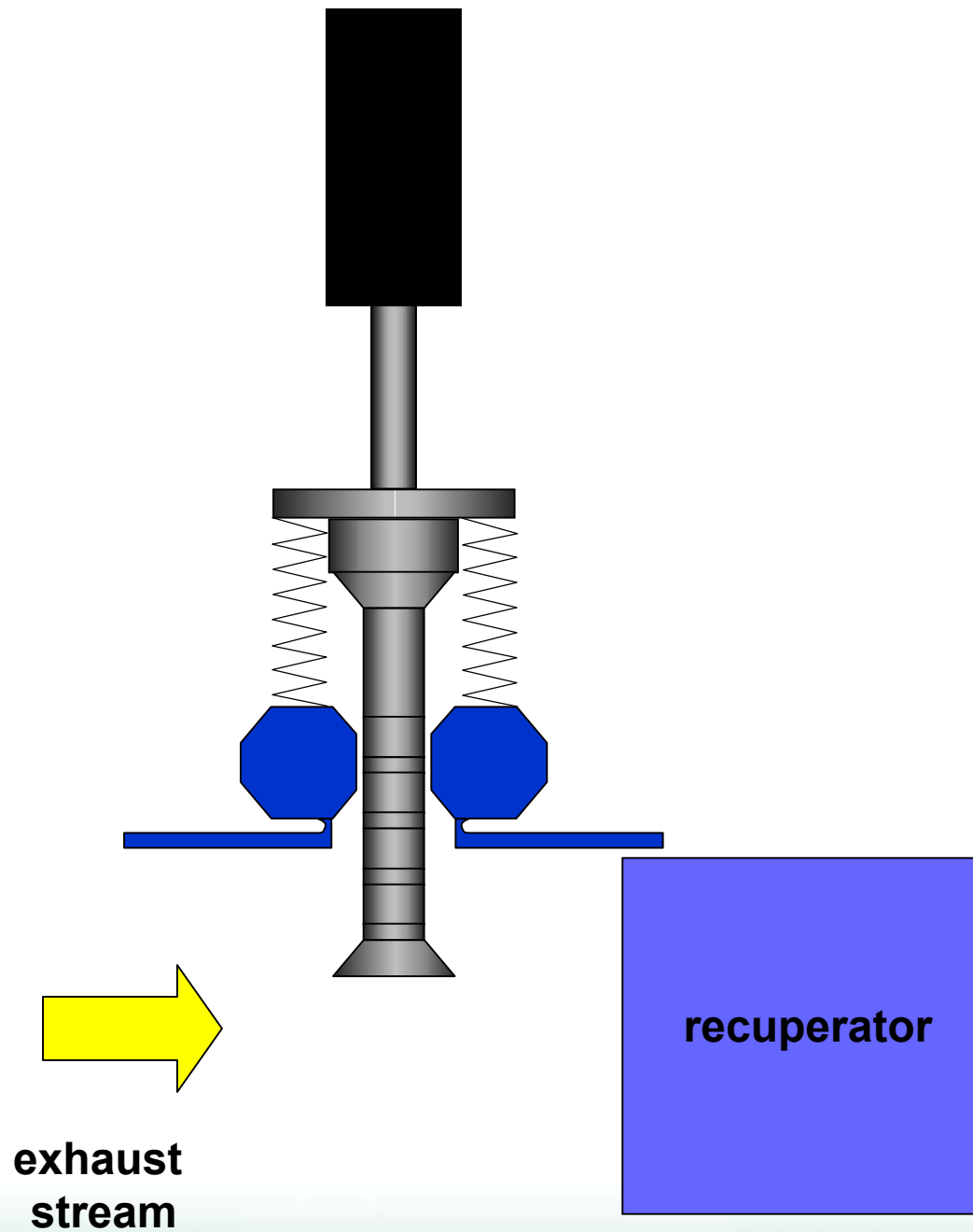


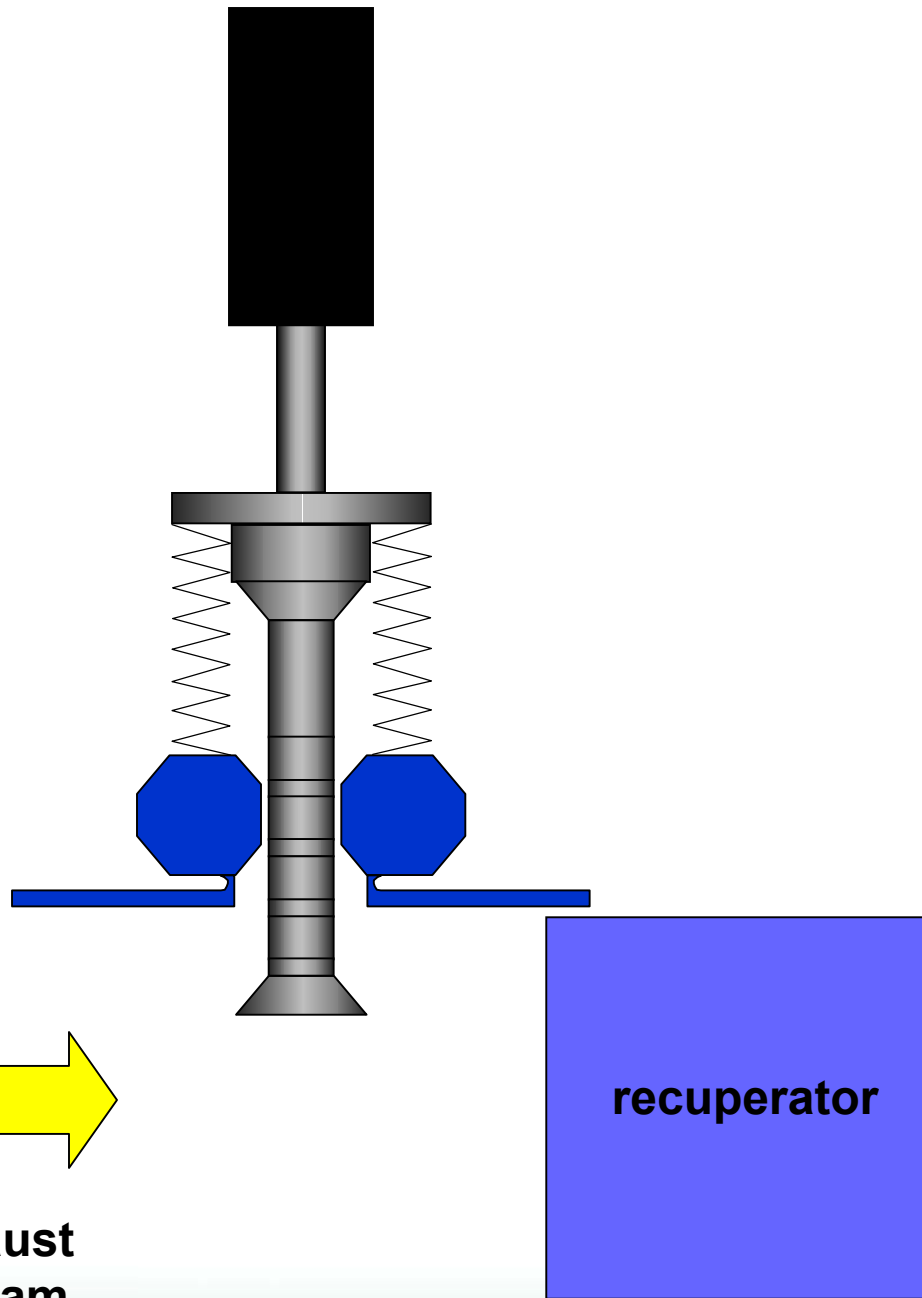






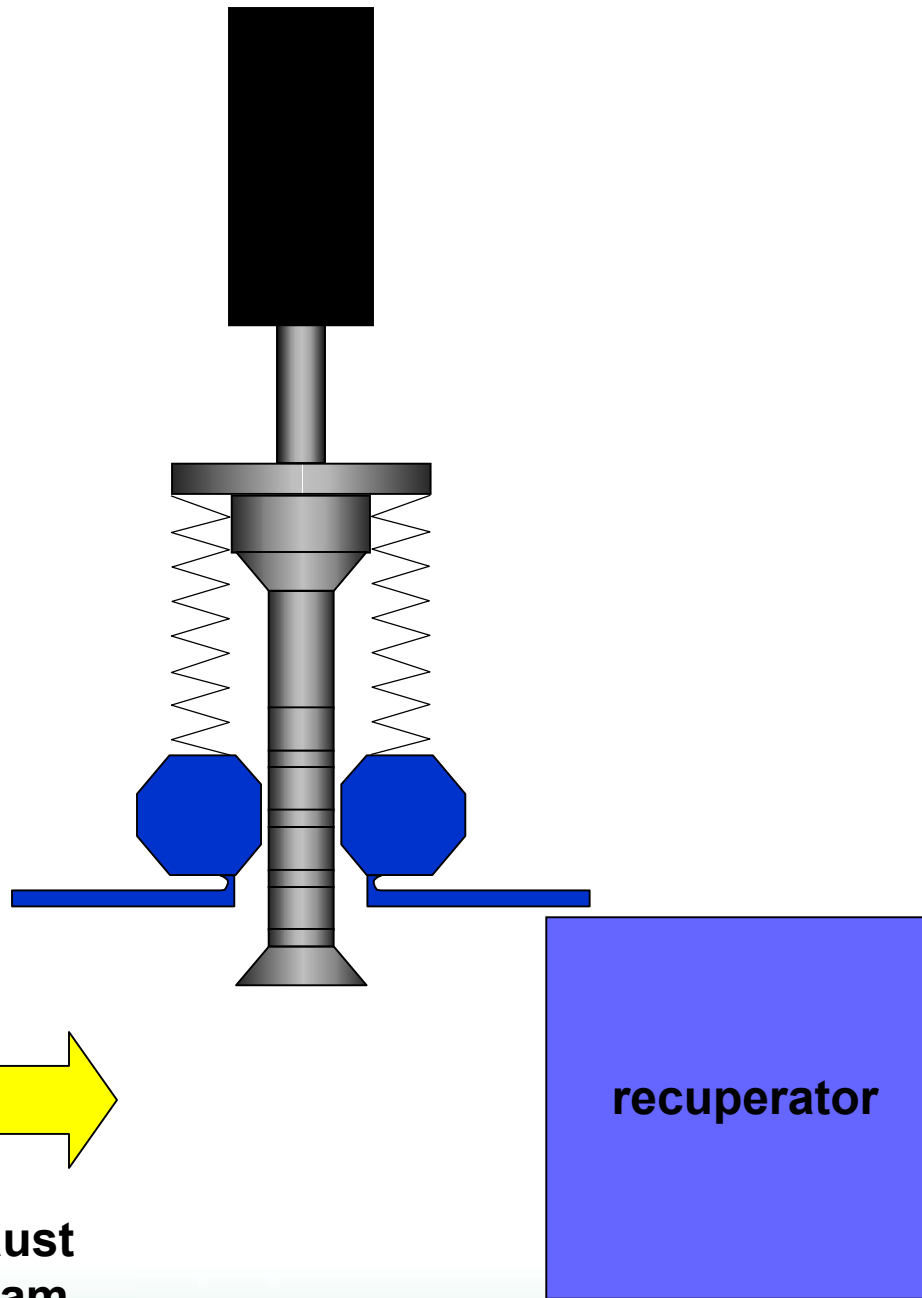






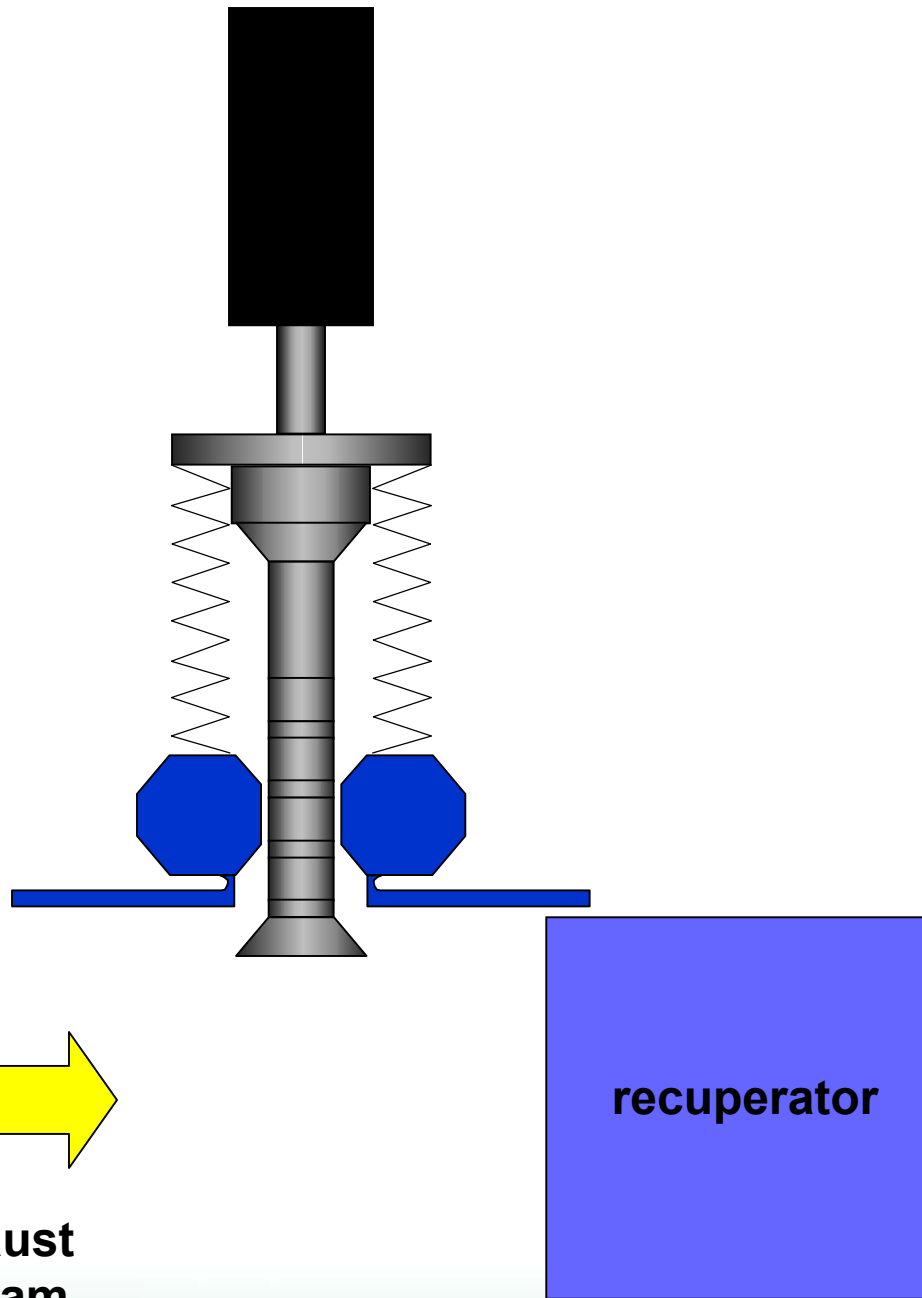
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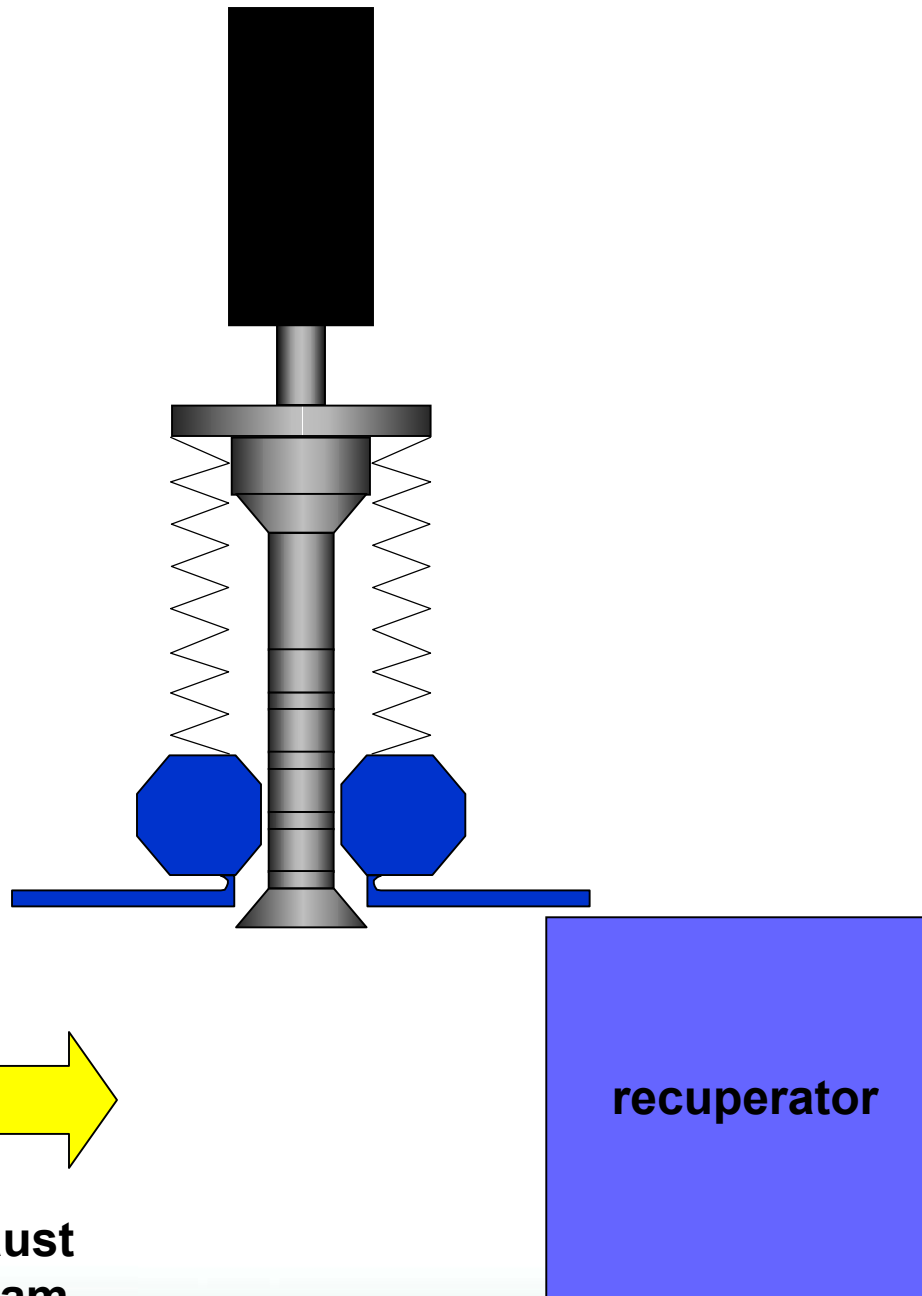
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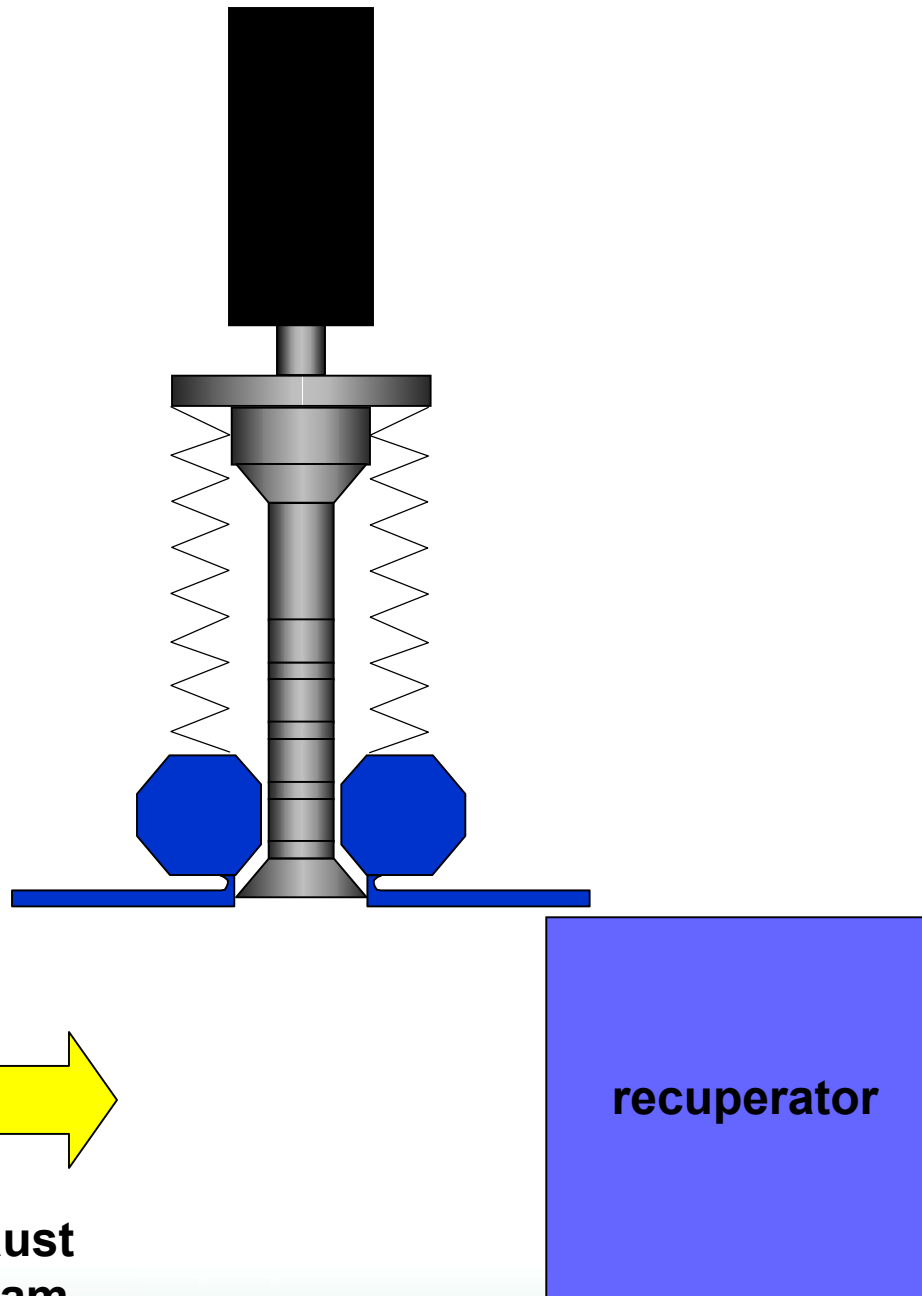
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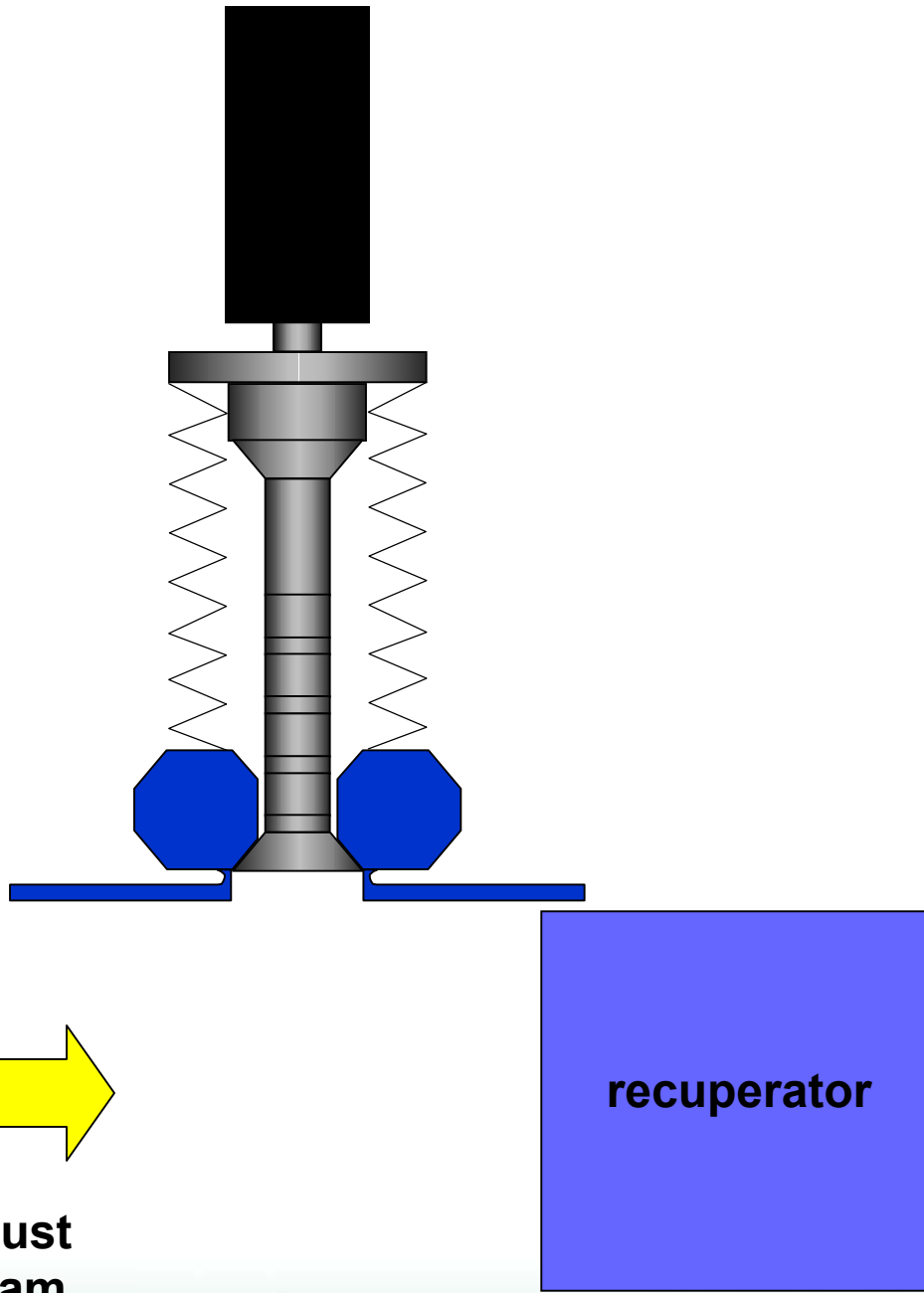
recuperator



**exhaust
stream**

recuperator





**exhaust
stream**

recuperator

Materials to be Evaluated

Initial screening and evaluation tests will be carried out with the following materials:

- *Haynes 120*
- *Haynes 214*
- *Haynes 230*
- *Special Metals-625 LCF*
- *Special Metals-Alloy 864*
- *modified 803, and*
- *modified stainless steels*

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- *Enable determination of the relationship among stress, temperature and environment, and their effect on durability and reliability of materials.*
- *Testing methodology useful to identify potential problems associated with manufacturability and weldability.*
- ***Evolution of material properties will be established through thorough characterization.***