FISITA WORLD AUTOMOTIVE CONGRESS

F2014-LWS-044

The Russian Federation
Nizhny Novgorod State Technical University named after R.Y. Alekseev
Nanotechnology and Biotechnology Department
www.nntu.ru/nbt

# The Modeling of Gasoline Permeation thought New Polymeric Materials

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# Cooperation between NNSTU and GAZ
# Governmental support of R&D

NNSTU – the best traditions of Soviet and Russian engineering school


GAZ – Russian producer of LCV

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Contract №02.G25.31.006 from 12.02.2013
Governmental Regulation №218 from 09.04.2010

# OUTLINE

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- Introduction
- Theoretical background
- Modeling
- Mathematical model verification
- Conclusion

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# Metal vs Plastic… Why?

**Driven by the need to reduce weight and improve fuel efficiency!**

# INTRODUCTION

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| | Advantages | Disadvantages |
|---|---|---|
| **Metal** | High temperature resistance<br>Solidity | Price<br>Corrosion<br>Conductive<br>Weight |
| **Plastic** | Price<br>Low corrosion<br>Lighter weight<br>Vibration/sound damping<br>Easily forming | Soft<br>UV-corrosion |

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# Fuel tank

## Key word is “safety”:

- evaluate the real-world environment that will impact the product,
- chemical exposure or contact solutions,
- temperature ranges,
- shielding,
- forces (including worst-case scenarios)
- FUEL PERMEABILITY!

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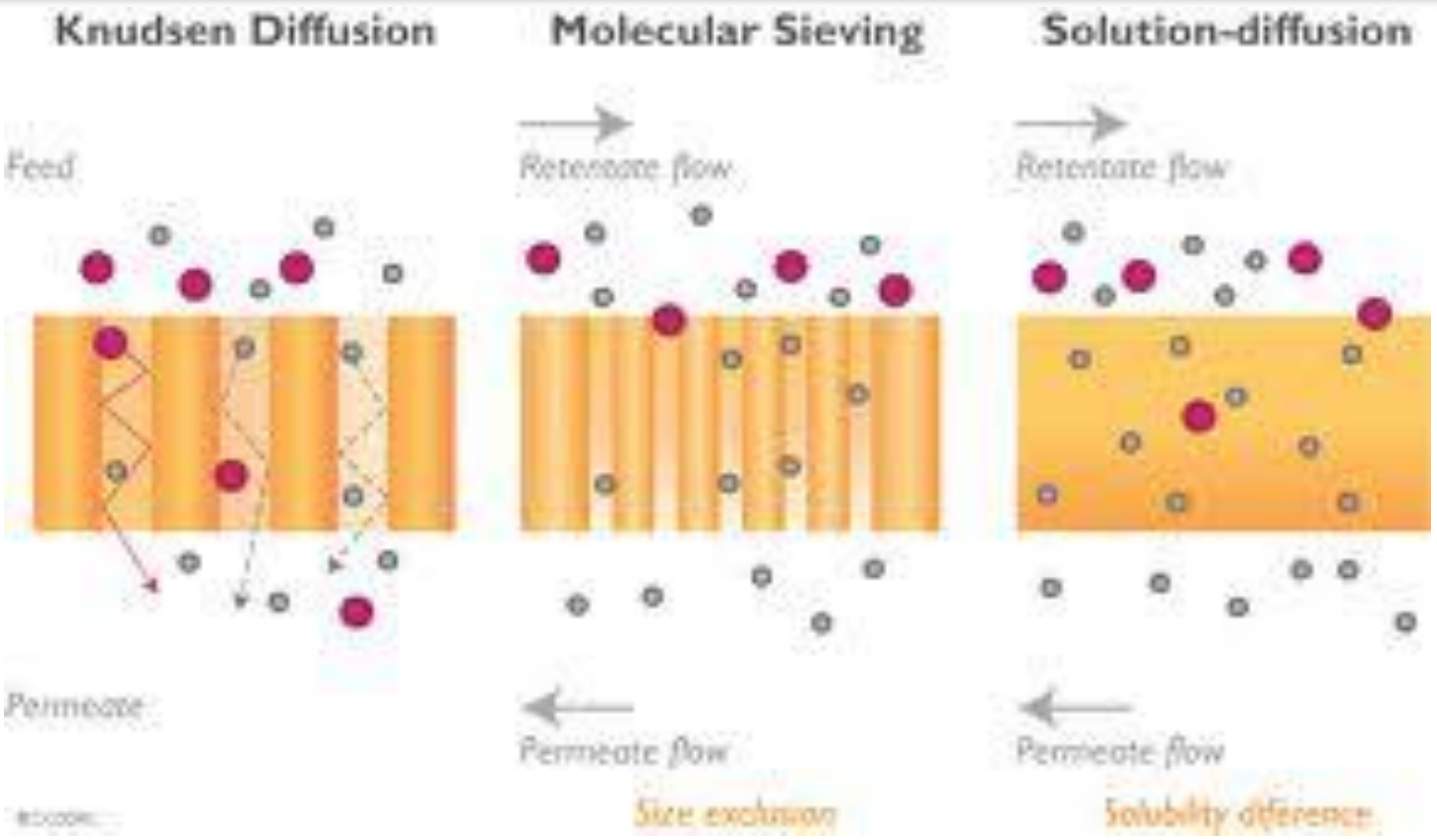
# THEORY




**Permeability of vapour and liquids may leads by different mechanisms. The most common mechanisms are diffusion-solution model and Knudsen flow**

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# MODELING



$$J = -D\frac{dC}{dl} = -D\frac{\Delta C}{\Delta l}$$

$$C = S\,P$$

$$J = D\,S\,\Delta P/l$$

$Pe = S\,D$ – ***permeability***

$$D = D_0 \exp\left(-\frac{E_d}{RT}\right)$$

$$S = S_0 \exp\left(-\frac{H_s}{RT}\right)$$

$$Pe = Pe_0 \exp\left(-\frac{E_p}{RT}\right)$$

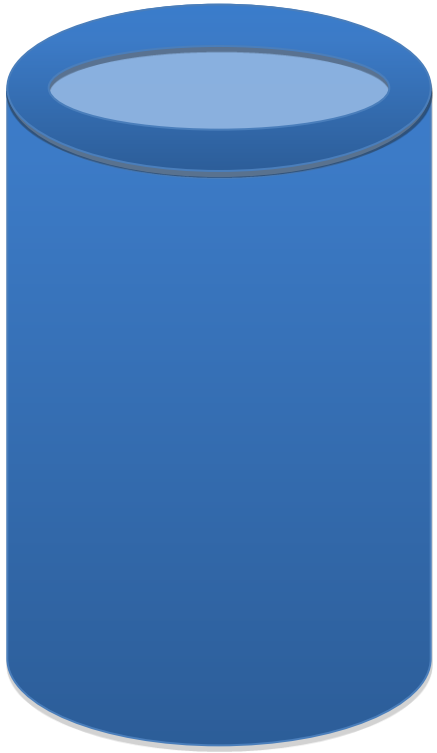
$$E_p = E_d + \Delta H_s$$

# MODELING



For the fuel evaporation thought the polymeric is calls pervaporation.

Pervaporation is membrane process in which the permeation of certain components through a polymeric film from a liquid feed mixture into a vapour phase is combined with the evaporation of these components.



The diffusion equation in cylindrical coordinates:

$$\frac{\partial C}{\partial t} = D\left(\frac{\partial^2 C}{\partial t^2} + \frac{1}{r}\frac{\partial C}{\partial r} + \frac{\partial^2 n}{\partial z^2}\right)$$

# MODELING



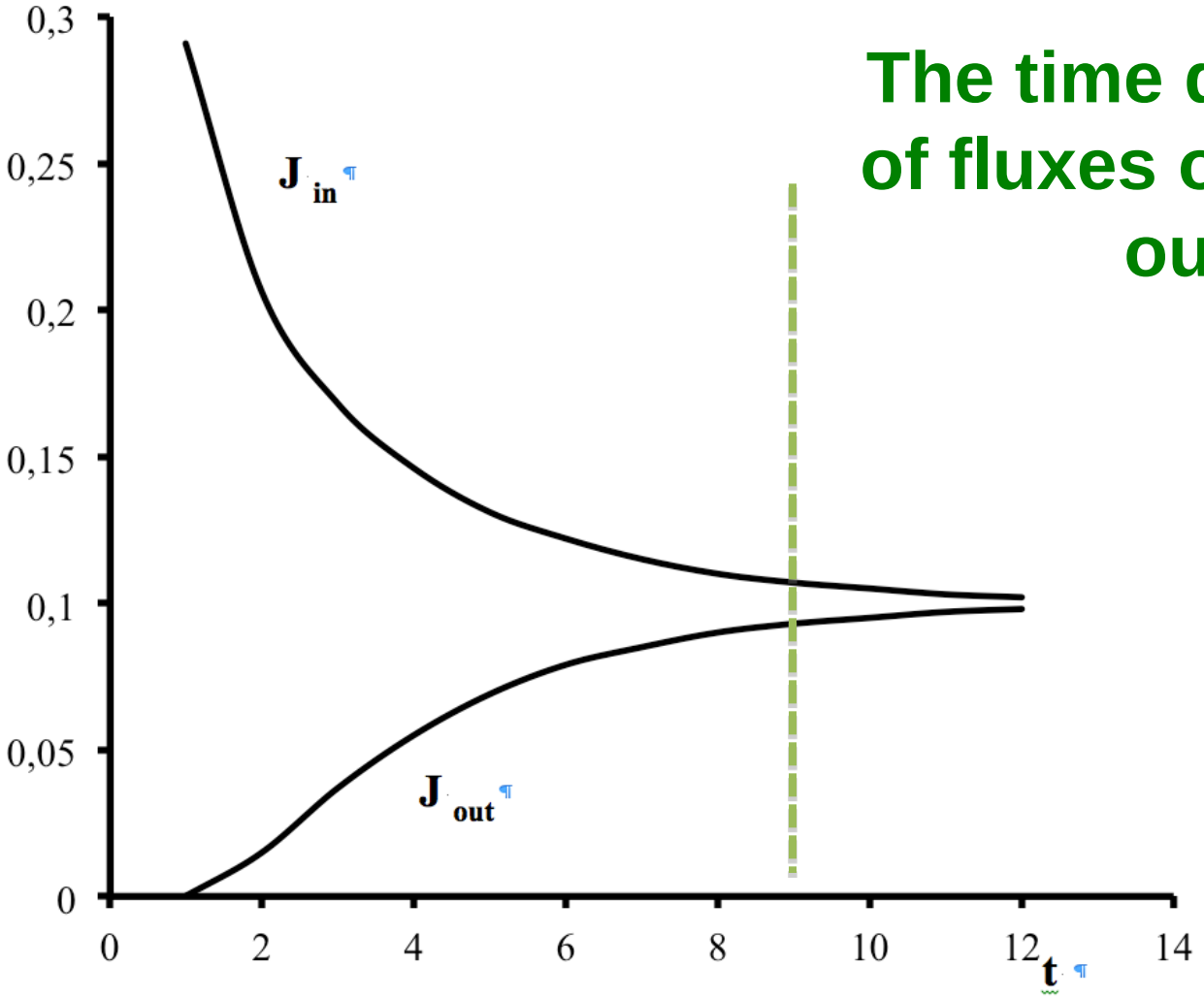
$$J_z = D\frac{\Delta C}{l}2\pi r l\tau$$

$$J_r = D\frac{\Delta C}{\Delta \ln r}2\pi l\tau$$

$$(\tau\, l^2/D) << 1$$

Monte Carlo Method
Molecular Dynamic

# MODELING




## The time dependence of fluxes on input and output

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# VERIFICATION



$$J_z = D\frac{\Delta C}{l}2\pi r l\tau$$

$$J_r = D\frac{\Delta C}{\Delta \ln r}2\pi l\tau$$

$$(\tau\, l^2/D) << 1$$

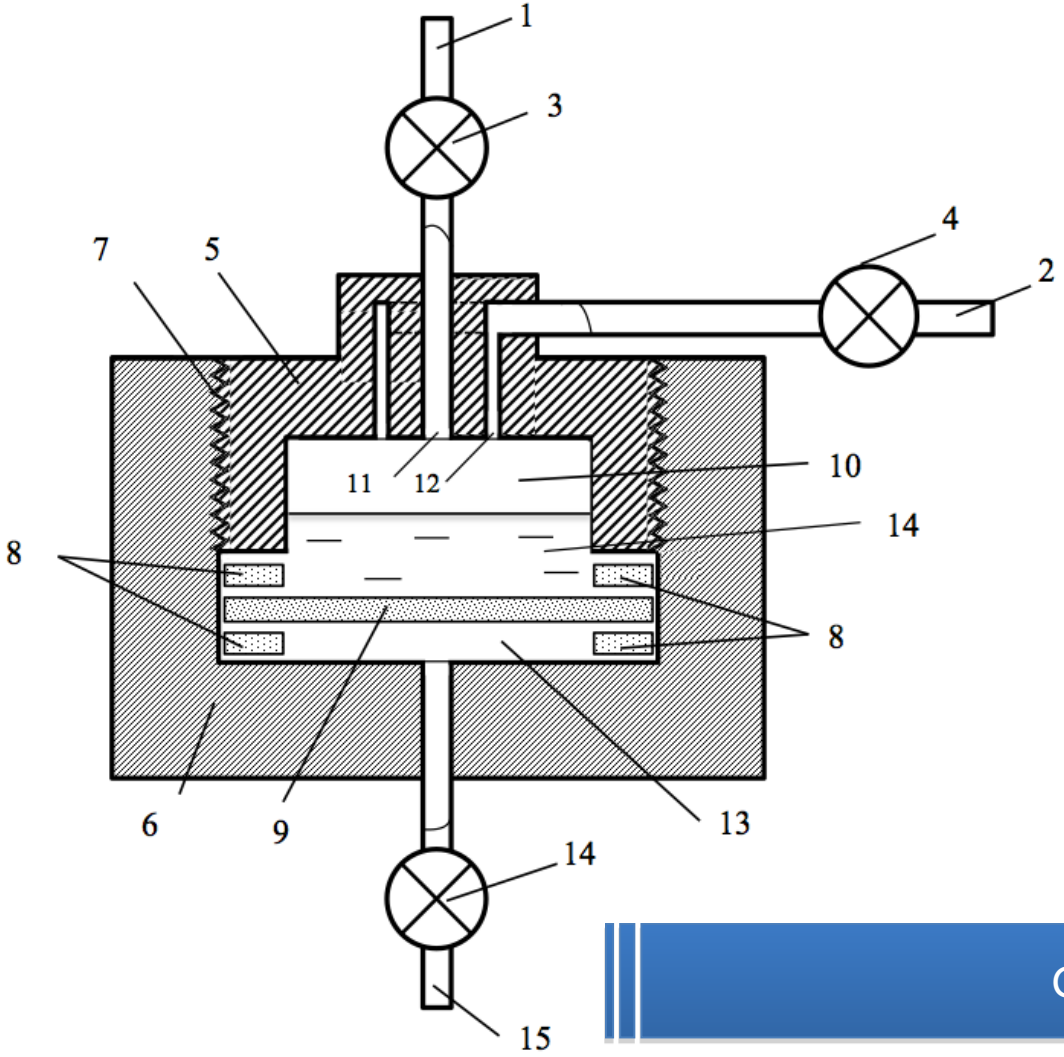
$$J = \frac{3{,}83 \cdot 10^{-4}}{t + 7{,}66}$$

**In the surface layer of the PTFE the concentration *C* is equals to the equilibrium concentration of the component in PTFE at the normal condition (P=1 bar).**

**In the longitudinal direction with a concentration of l=0 and $J_c$ =0. Assumed that at the initial concentration corresponded equilibrium solubility, i.e. permeation process has reached a steady state.**

# VERIFICATION

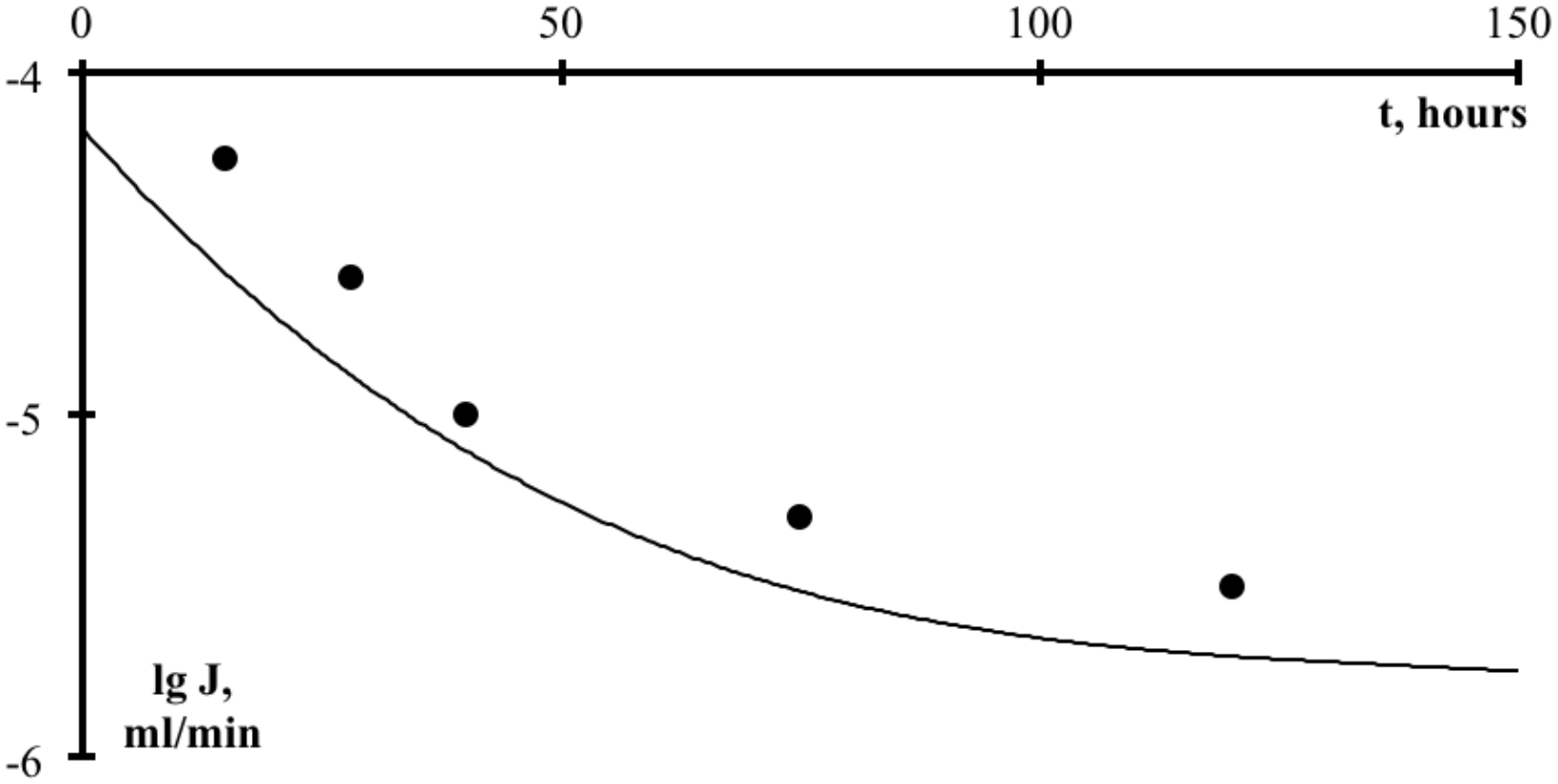





## Testing module

GC/MS

# VERIFICATION




The experimental results (dots) and calculation by obtained equation

**A slight deviation of the experimental data from the calculated due to the fact that in the calculations was considered homogeneous polymer and $D$=8.8·10$^{-12}$ m s$^{-2}$.**

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# CONCLUSION



The new approach for testing new polymeric materials was observed. The comparison theoretical and experimental data shows applicability of this procedure for automobile industry, especially developing of light commercial vehicle.

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## Thank you for kind attention!

### Welcome with your question…

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