

Introducción a la Ingeniería de Procesos Metalúrgicos y de Materiales

Dr. J. Bernardo Hernández Morales

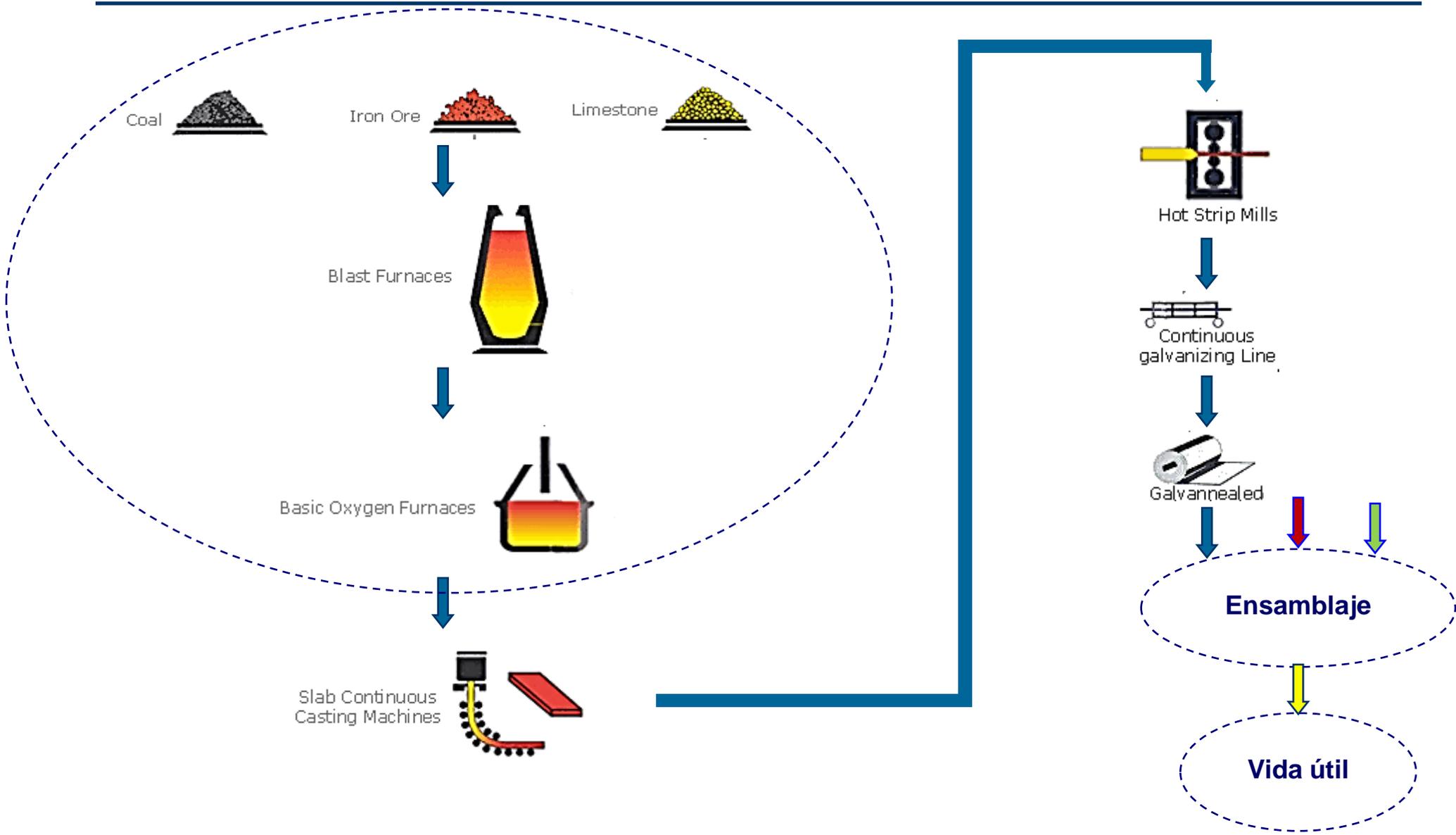
**Depto. de Ingeniería Metalúrgica
Facultad de Química, UNAM**

Semestre 2017-1





Procesos de obtención de materiales y de manufactura de componentes ingenieriles



Procesos de obtención de materiales y manufactura de componentes ingenieriles

- **Procesos de obtención de materiales**
 - **Cambios químicos**



<http://www.mechel.com/production/metallurgy/rolled/billets/r26150/>

- **Procesos de manufactura de componentes ingenieriles**
 - **Cambios físicos**



<http://www.tortilladoras.com.mx/engranos.shtml>

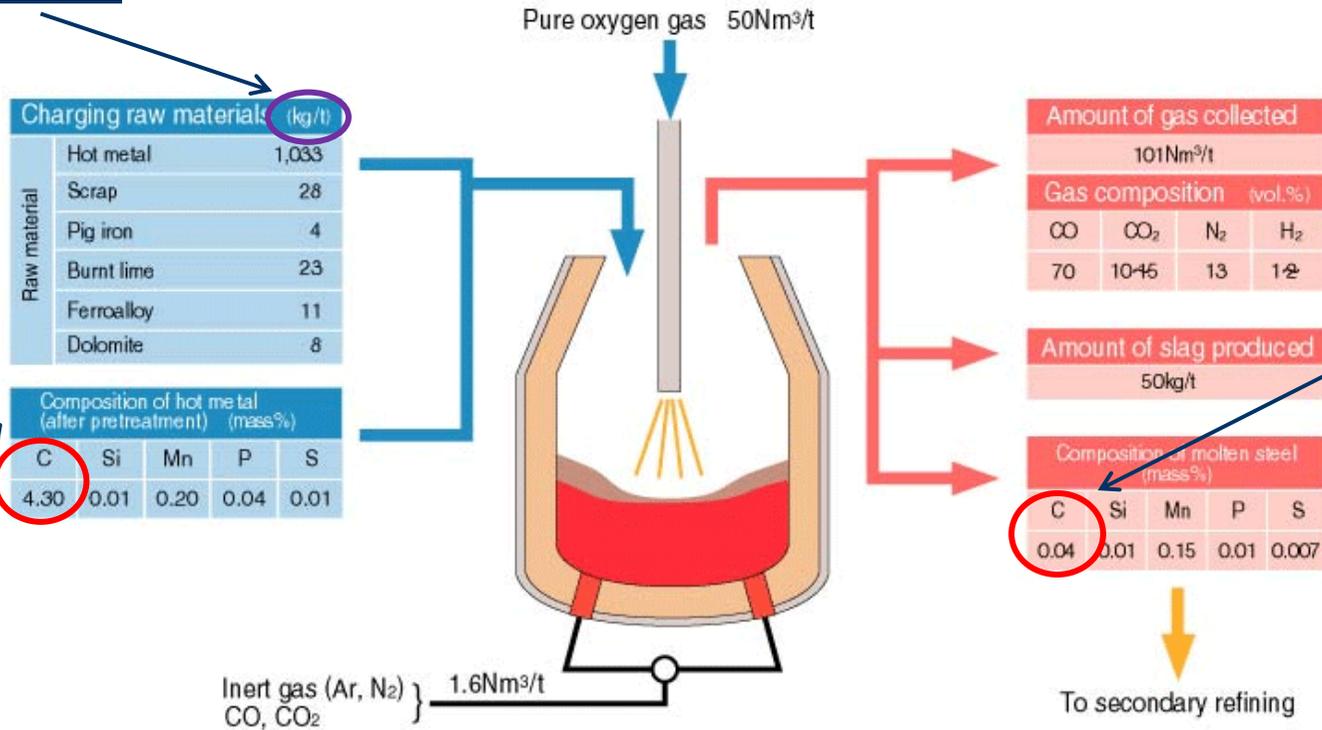
Introducción a la Ingeniería de Procesos Metalúrgicos y de Materiales

- **Balances macroscópicos de materia**
- **Balances macroscópicos de energía térmica**
- **Balances macroscópicos de energía mecánica**
- **Balances microscópicos de momentum**

Cálculo de cargas (Balances macroscópicos de materia)

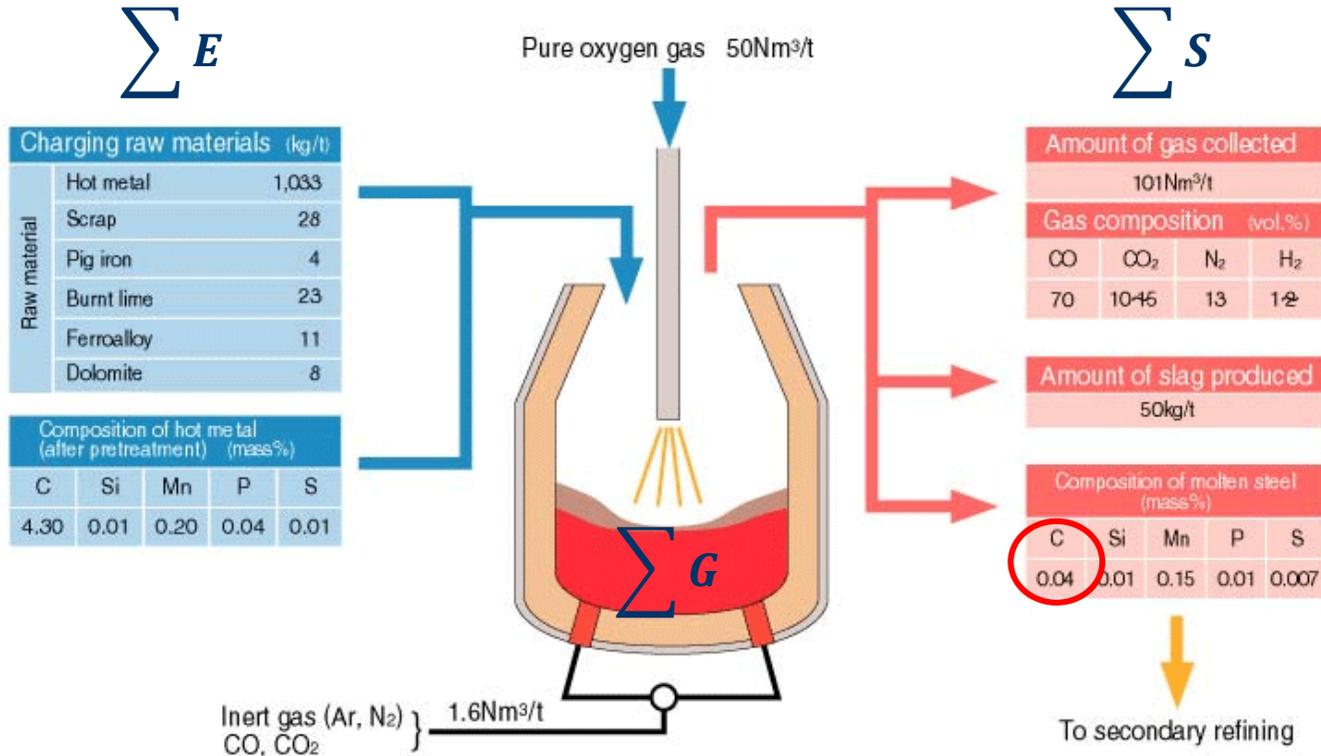
Bottom Stirred BOF Operation Example

Objetivos de cálculo



Objetivos de cálculo

Bottom Stirred BOF Operation Example



© 1997-2002 KAWASAKI STEEL 21st Century Foundation
© 2003 JFE 21st Century Foundation

En edo. estacionario: $A = 0$



Cálculo de requerimientos térmicos (Balances macroscópicos de energía térmica)

Cálculo de requerimientos térmicos

Objetivos de cálculo

T de salida de los gases

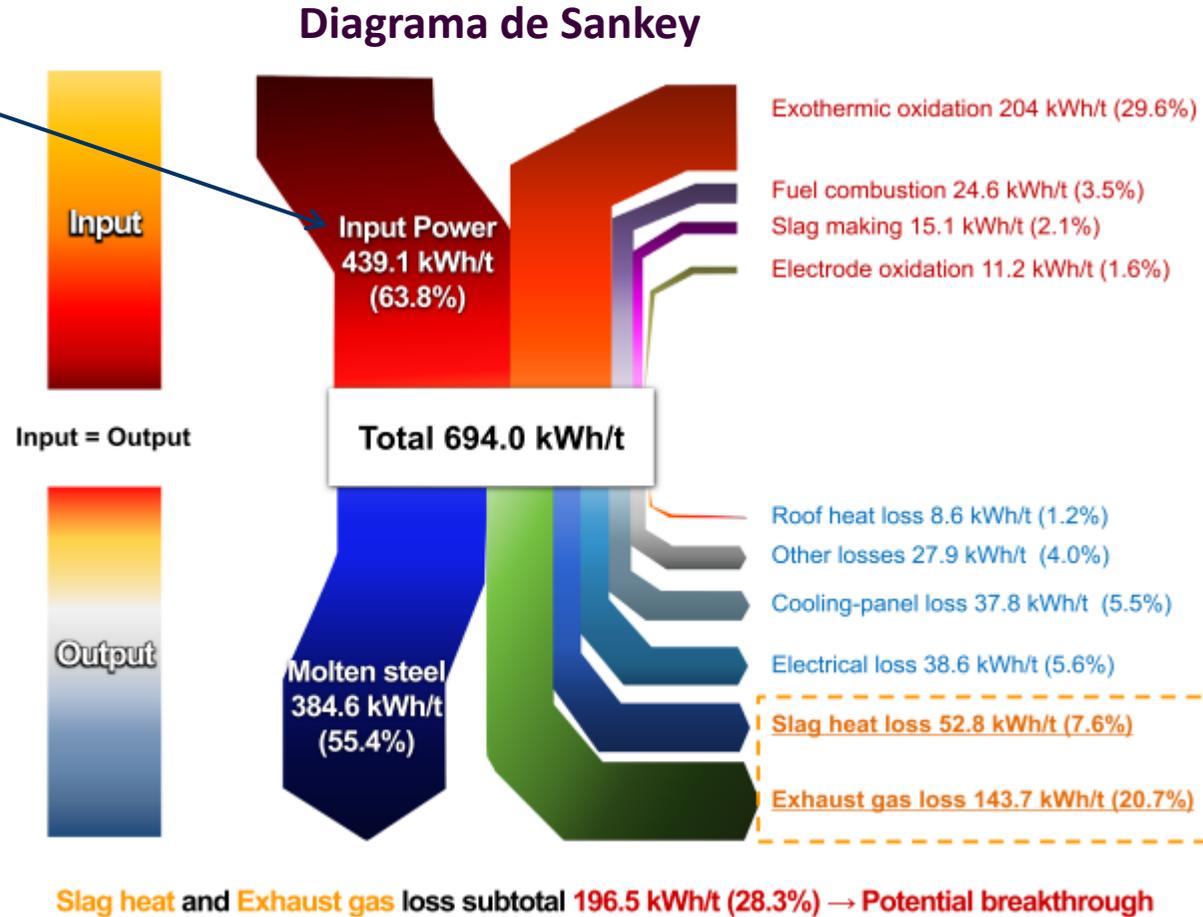


Fig. 4. Energy input and output stream balance for a typical EAF process. Adapted from Atkinson and Kolarik.¹⁰

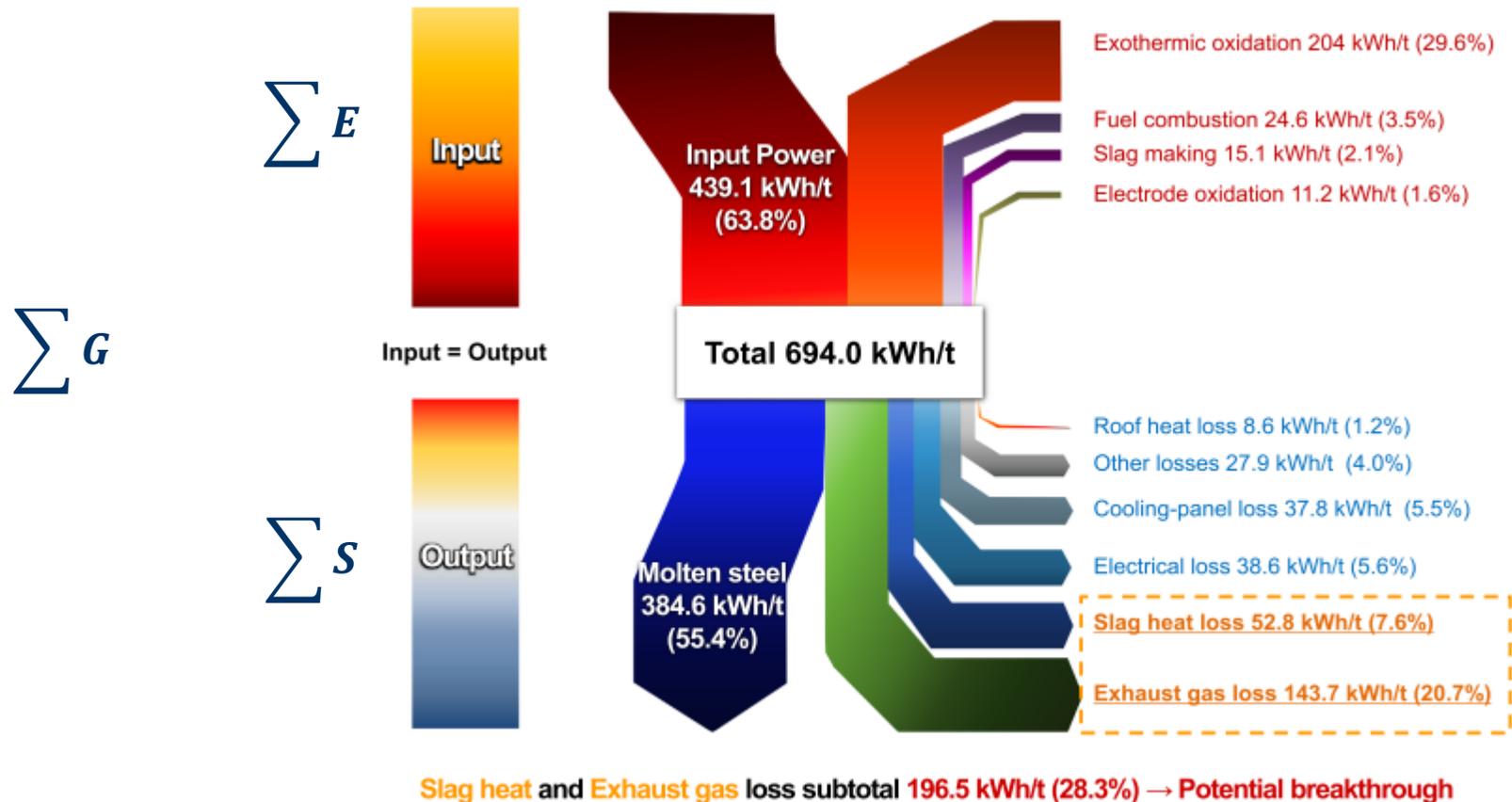


Fig. 4. Energy input and output stream balance for a typical EAF process. Adapted from Atkinson and Kolarik.¹⁰

En edo. estacionario: $A = 0$

Review of Innovative Energy Savings Technology for the Electric Arc Furnace

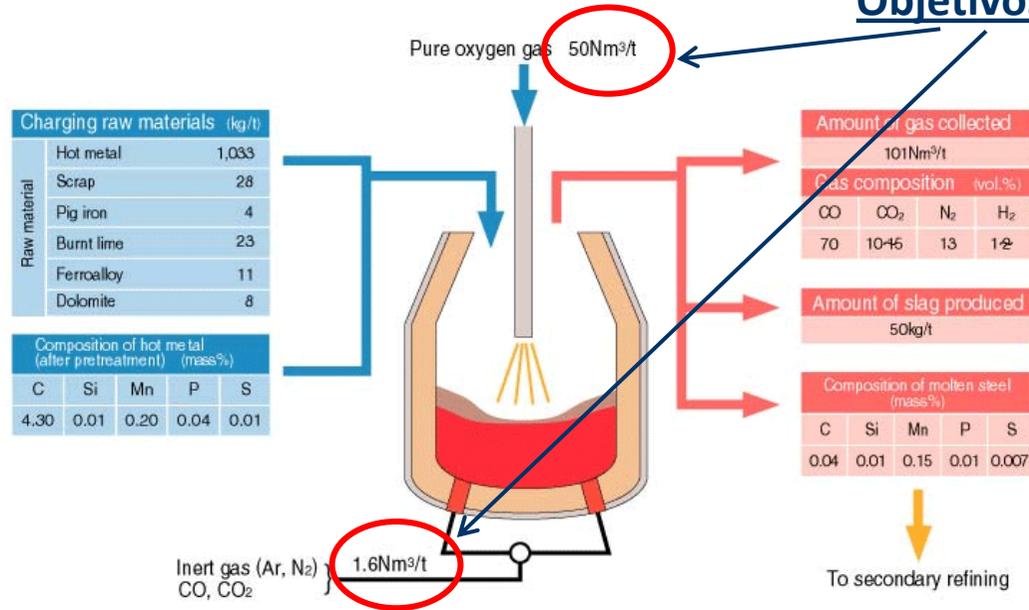


Cálculo de requerimientos de bombeo (Balances macroscópicos de energía mecánica)

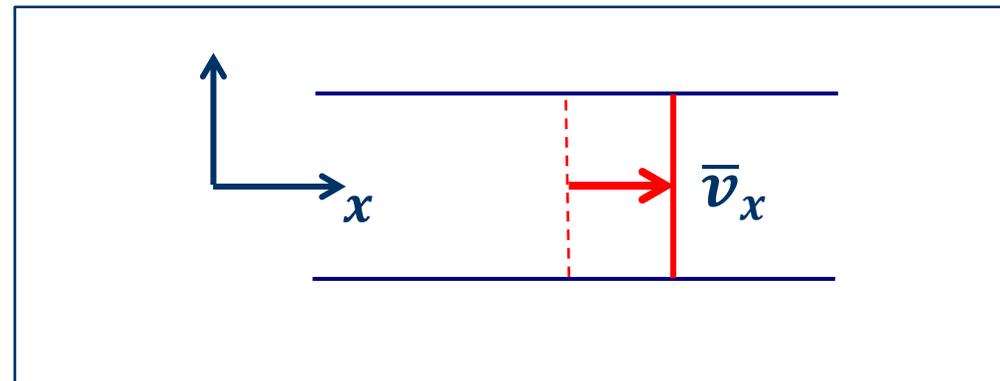
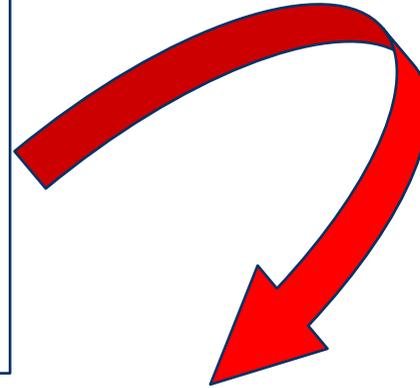
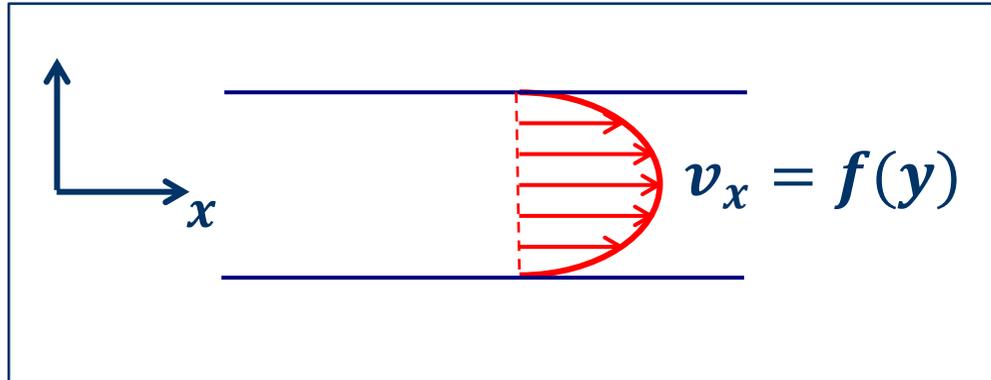
Requerimientos de bombeo para cumplir con BMM

Bottom Stirred BOF Operation Example

Objetivos de cálculo

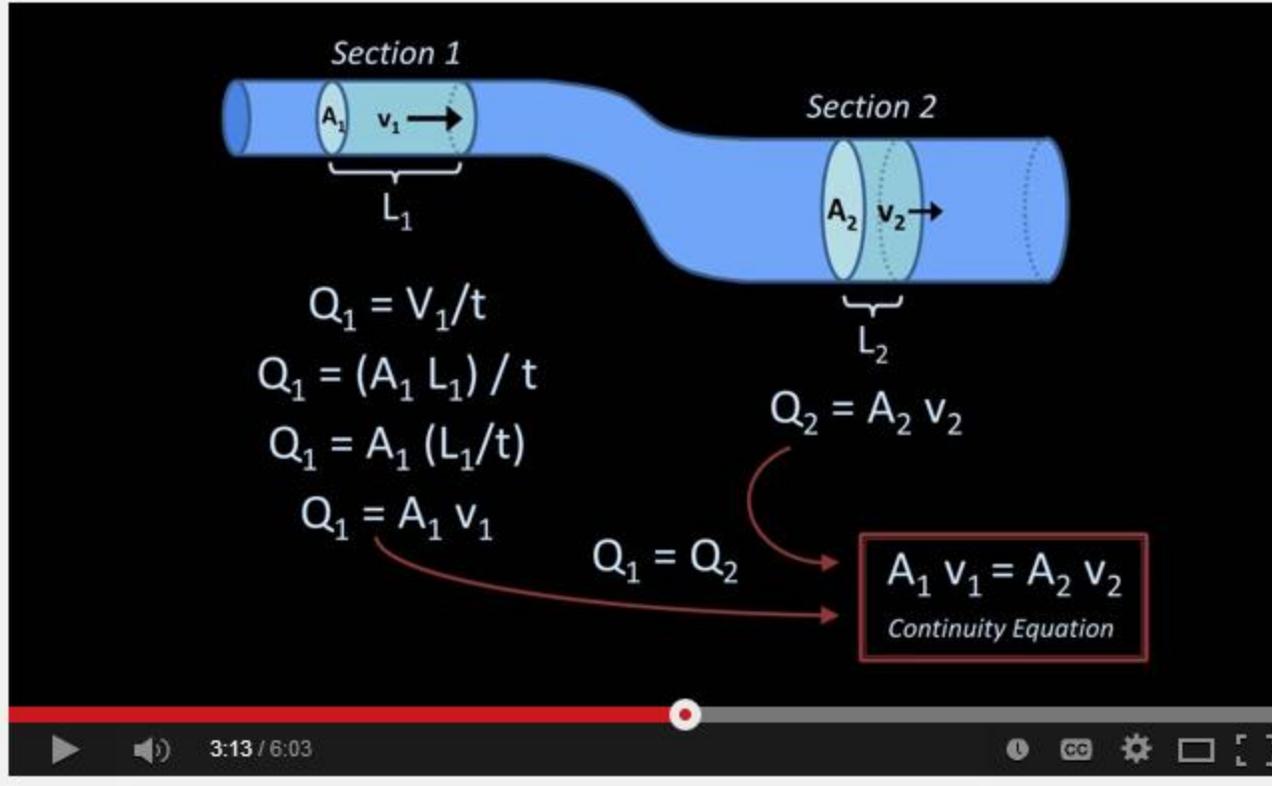


Campo de velocidad y velocidad promedio



Nota: En esta sección del curso trabajaron con velocidad promedio

Ecuación de continuidad (macro)



Section 1

A_1 v_1 →

L_1

Section 2

A_2 v_2 →

L_2

$Q_1 = V_1/t$
 $Q_1 = (A_1 L_1) / t$
 $Q_1 = A_1 (L_1/t)$
 $Q_1 = A_1 v_1$

$Q_2 = A_2 v_2$

$Q_1 = Q_2$

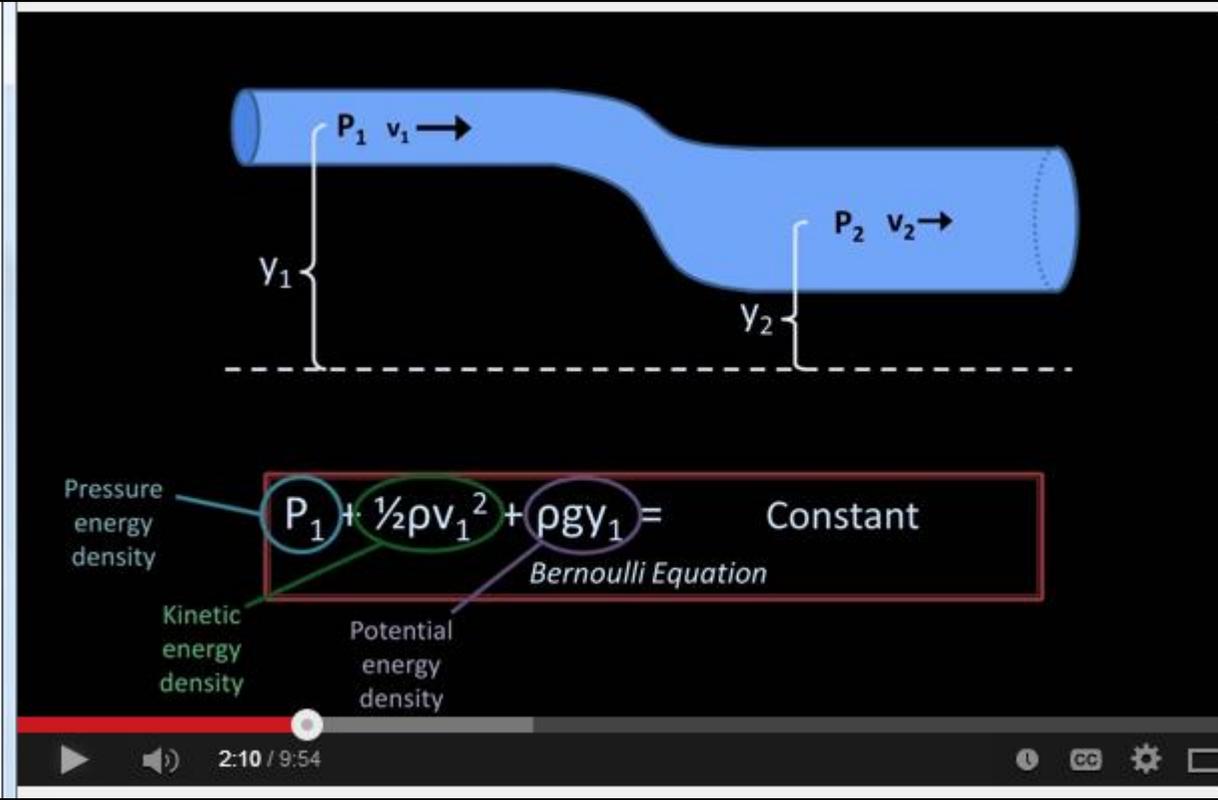
$A_1 v_1 = A_2 v_2$
Continuity Equation

3:13 / 6:03

V es volumen
 v es velocidad

<http://www.youtube.com/watch?v=wykn-JTnacE>

Ecuación de Bernoulli



The diagram shows a blue pipe with a constriction. On the left, the pipe is wider and labeled with pressure P_1 , velocity v_1 , and height y_1 . On the right, the pipe is narrower and labeled with pressure P_2 , velocity v_2 , and height y_2 . A dashed horizontal line indicates the reference level for the potential energy term in the equation below.

The Bernoulli Equation is shown as:

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = \text{Constant}$$

Labels for the equation terms:

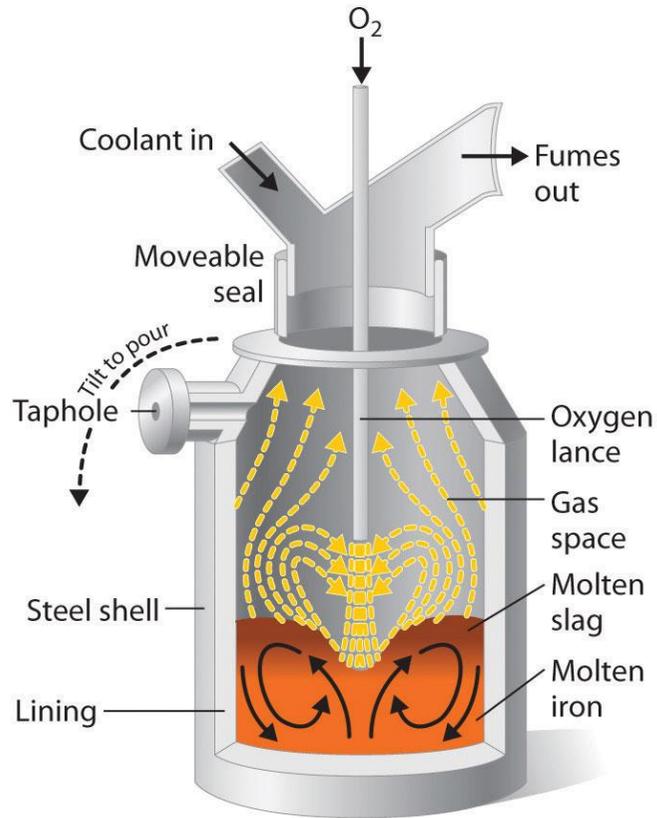
- Pressure energy density: P_1
- Kinetic energy density: $\frac{1}{2}\rho v_1^2$
- Potential energy density: $\rho g y_1$

The equation is labeled "Bernoulli Equation". A video player interface at the bottom shows a progress bar at 2:10 / 9:54.

<http://www.youtube.com/watch?v=IneyT4kRDAU>



Cálculo del campo de velocidad (Balances microscópicos de momentum)



Las reacciones químicas dependen del grado de mezcla que, a su vez, depende del campo de velocidad; éste es función del flujo de gas, entre otras variables.

¿ Cómo calcular el flujo de gas requerido ?

- Método empírico
- IIPMyMat (parte de IPOMyMCI)

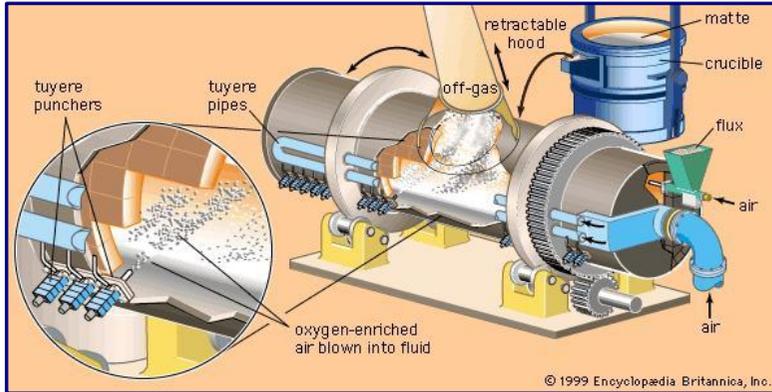
<http://2012books.lardbucket.org/books/principles-of-general-chemistry-v1.0m/s27-03-metallurgy.html>

Concepto de campo



Grado de cocción = $f(r, z, \theta, t)$

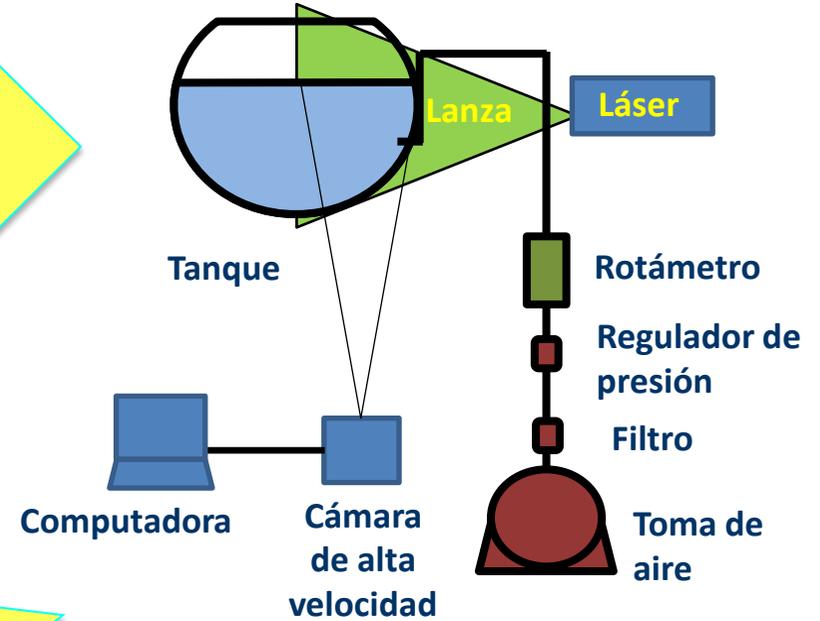
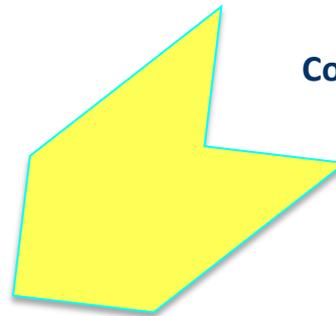
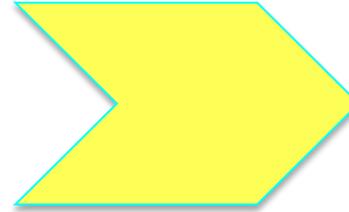
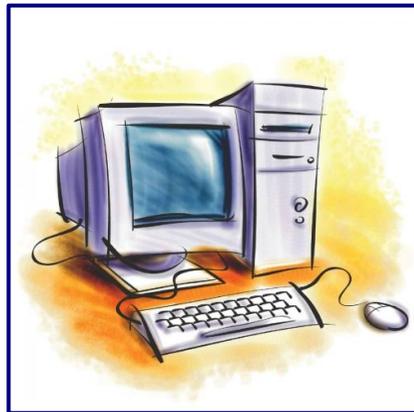
Medición: Campo de velocidad



Convertidor Peirce-Smith

<http://global.britannica.com/EBchecked/topic/136794/copper-processing/81933/Roasting-smelting-and-converting>

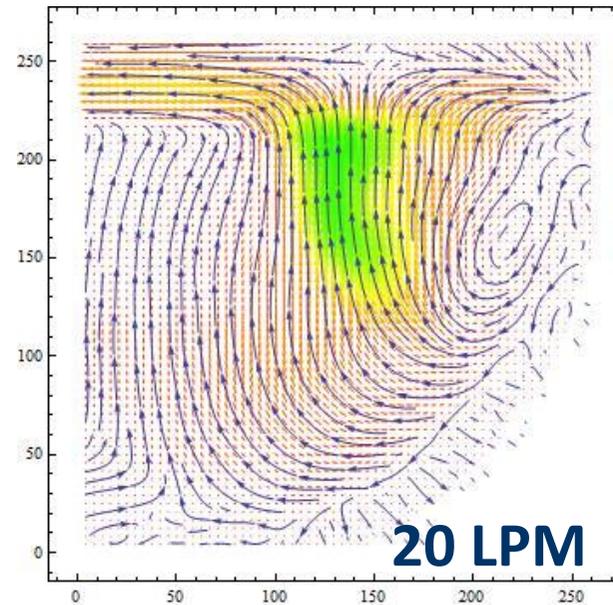
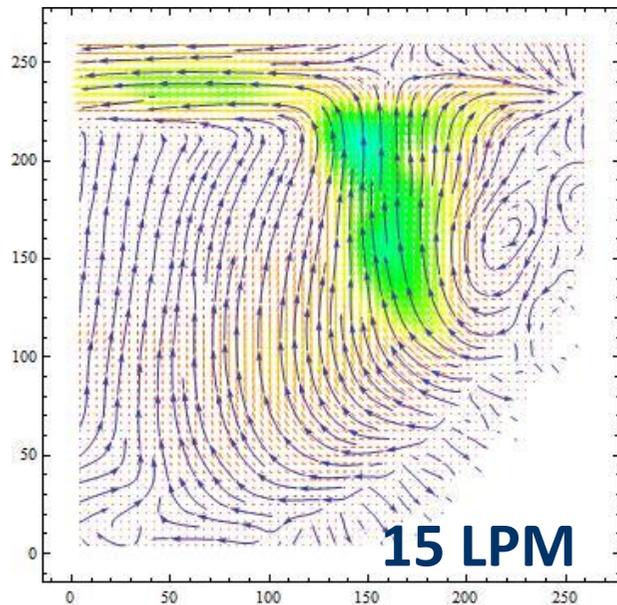
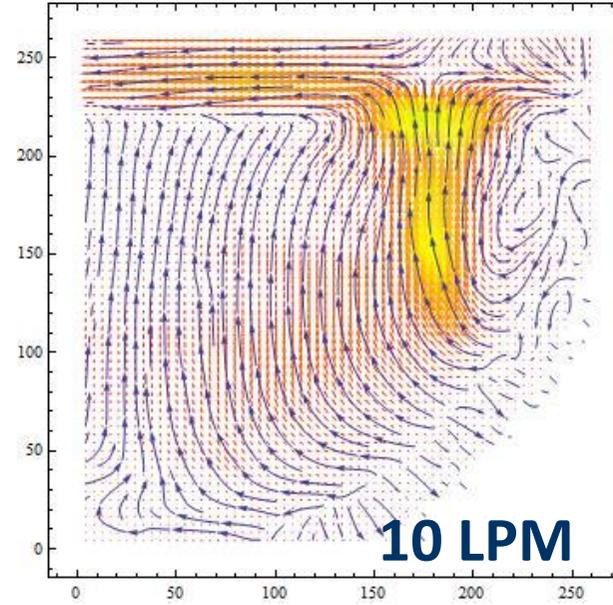
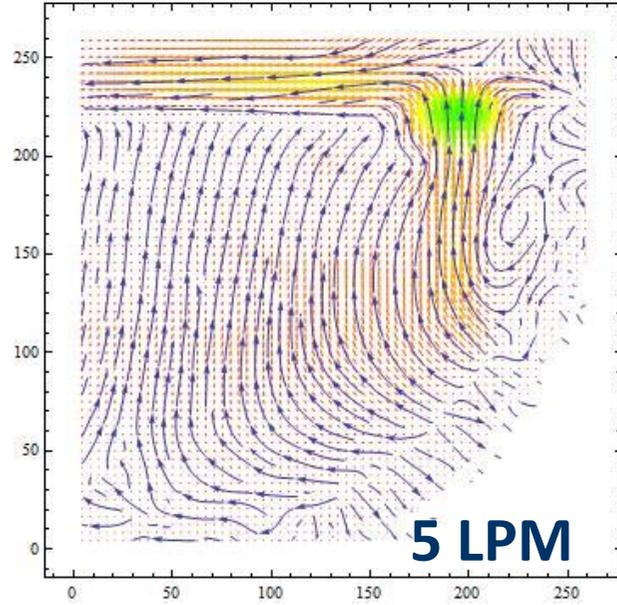
Algoritmo computacional para análisis de datos



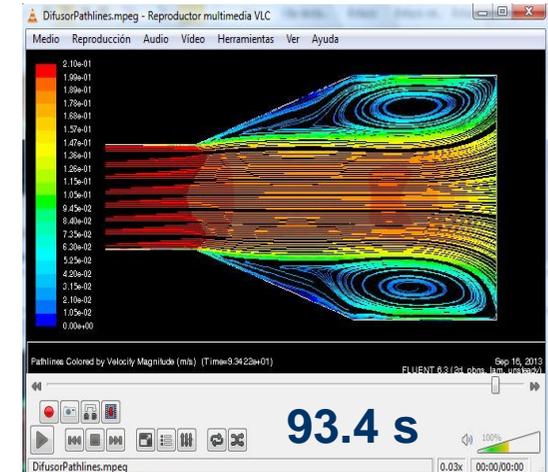
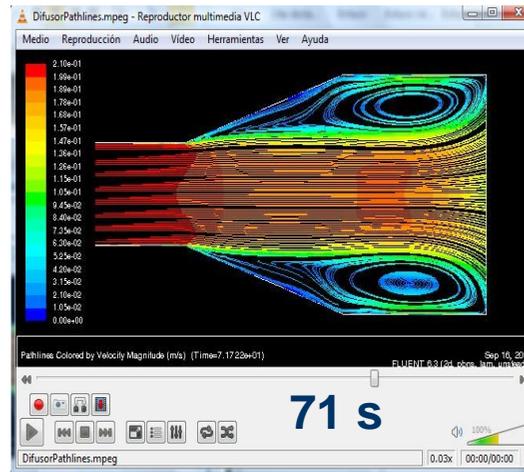
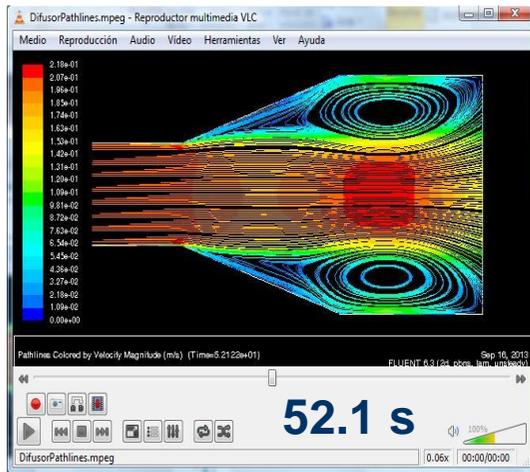
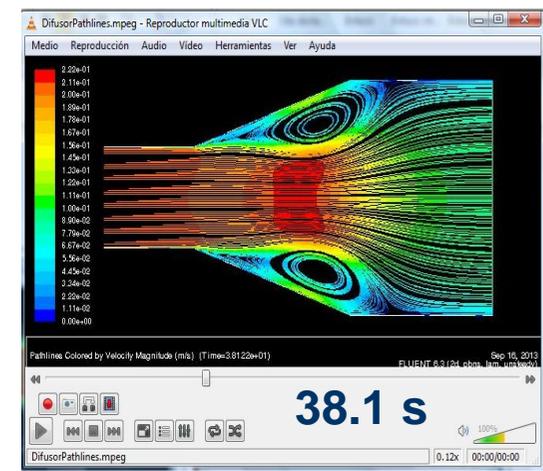
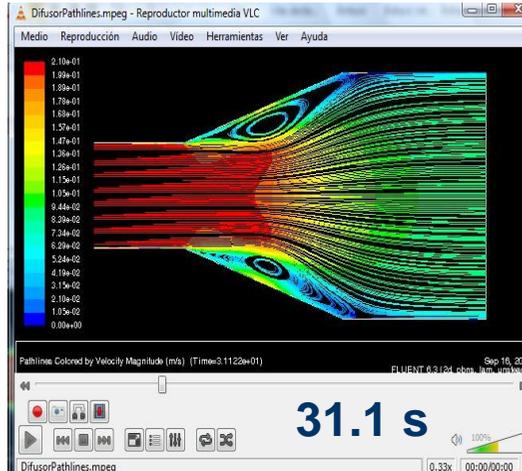
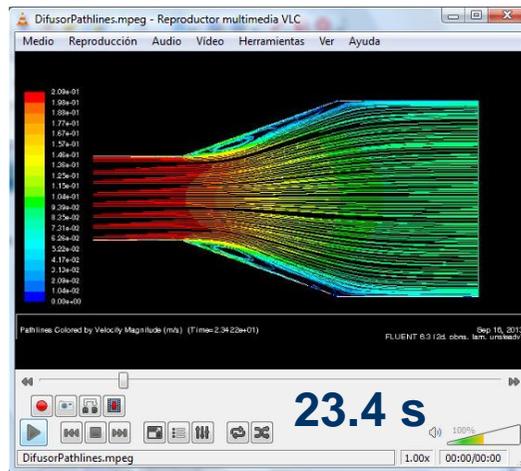
Esquema del modelo físico y el acomodo del laser y la cámara para la técnica de *PIV (Particle Image Velocimetry)*

Juan Carlos Contreras Guzmán
Tesis de Maestría, PCeIM

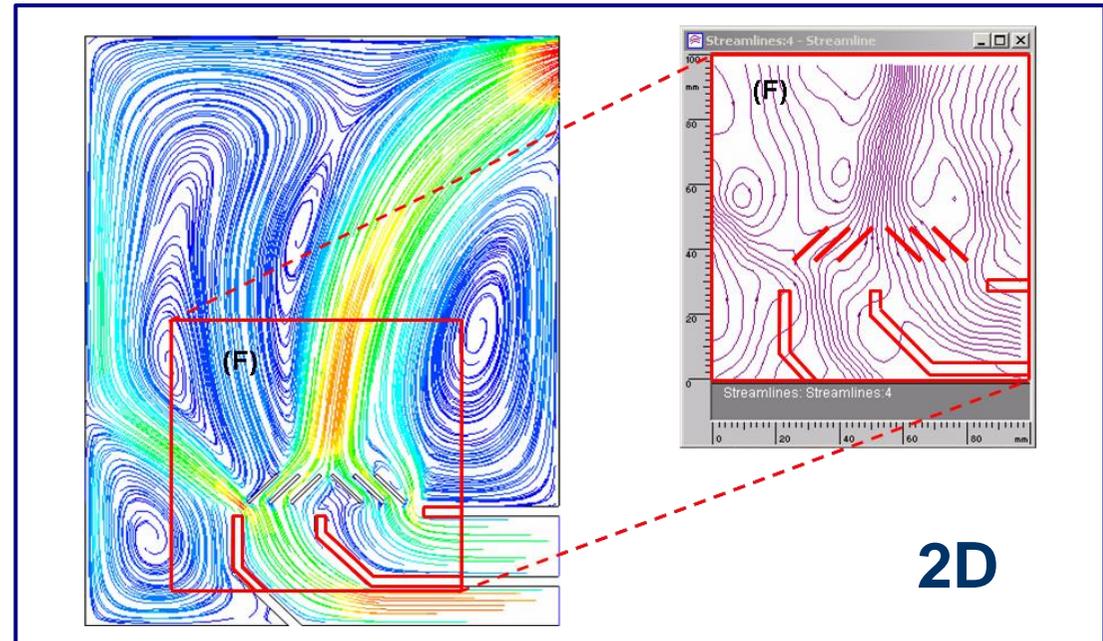
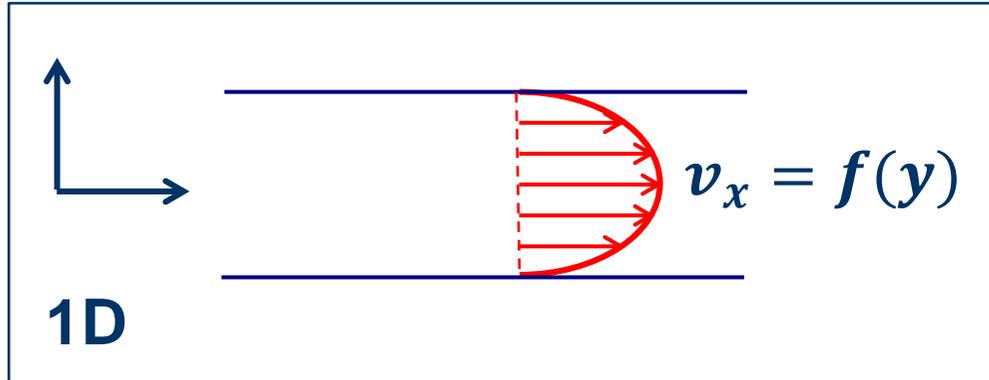
Campo de velocidad medido



Análisis: Edo. estac. vs. no estac.



R. Fernández Flores, B. Hernández Morales and H.J. Vergara Hernández
“Using computational fluid dynamics (cfd) to enhance the student
experience in undergraduate courses on fluid flow”
ICERI 2014



Análisis: Flujo laminar vs. flujo turbulento

Flujo laminar



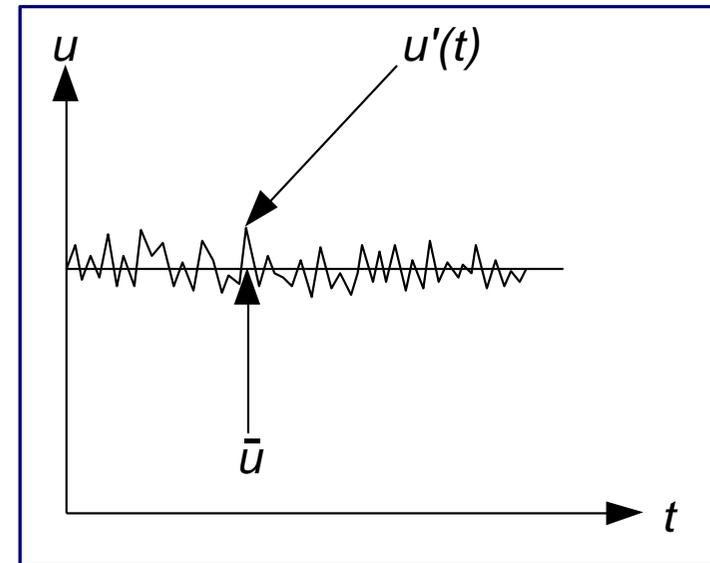
<http://www.pbase.com>

Flujo turbulento

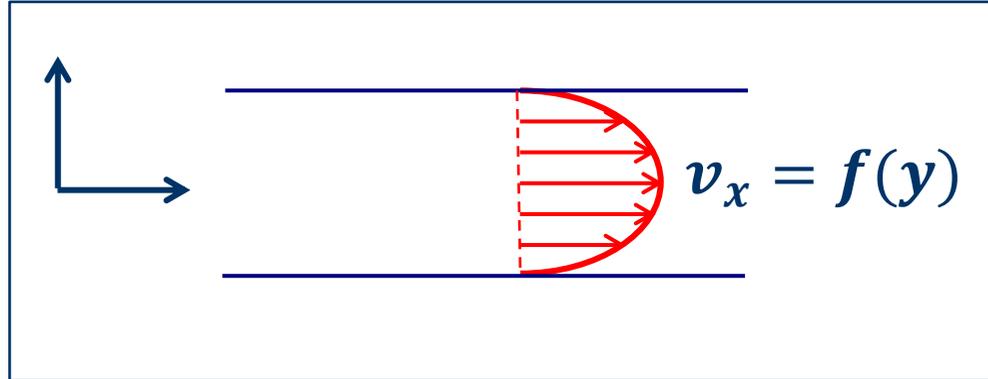


<http://www.britannica.com/EBchecked/topic/609625/turbulent-flow>

Velocidad en una posición fija (flujo turbulento)



Casos estudiados en IIPMyMat: Flujo 1D, laminar, edo. estacionario



- Ecuación de continuidad (bal. microscópico de materia)
- Ecuación de Navier-Stokes (caso especial de bal. microscópico de momentum)
- Condiciones a la frontera
 - Velocidad especificada
 - Simetría
 - *Flux* de momentum especificado