TEST CASE DOCUMENTATION
AND TESTING RESULTS

TEST CASE ID ICFD-VER-2.1

The Cylindrical Couette flow

Tested with LS-DYNA® v980 Revision Beta

Friday 1st June, 2012

LSTC
Livermore Software
Technology Corp.

Document Information	
Confidentiality	**external use**
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Contents

1 Introduction

1.1 Purpose of this Document

This document specifies the test case ICFD-VER-2.1. It provides general test case information like name and ID as well as information to the confidentiality, status, and classification of the test case.

A detailed description of the test case is given, the purpose of the test case is defined, and the tested features are named. Results and observations are stated and discussed. Testing results are provided in section 4.1 for the therein mentioned LS-DYNA® version and platforms.

2 Test Case Information

Test Case Summary	
Confidentiality	external use
Test Case Name	The Cylindrical Couette flow: 2D flow going through two rotating cylinders
Test Case ID	ICFD-VER-2.1
Test Case Status	Under consideration
Test Case Classification	Verification
Metadata	INTERNAL FLOW

Table 1: Test Case Summary

3 Test Case Specification

3.1 Test Case Purpose

The purpose of this test case is to study the laminar flow of the fluid going through two rotating cylinders of infinite lengths.

3.2 Test Case Description

The Couette flow is one of the few cases where, under some given hypothesis, the Navier Stokes equations admit an analytical solution. It can be shown (see [1]) that for a stationary viscous flow going through two infinite rotating cylinders of radius R_1 and R_2 with $R_2 > R_1$ and of rotating speed w_1 and w_2, the flow's velocity follows the following behavior :

$$V(r) = \frac{(w_2 R_2^2 - w_1 R_1^2)r}{R_2^2 - R_1^2} + \frac{(w_1 - w2)}{r}\frac{R_1^2 R_2^2}{R_2^2 - R_1^2} \tag{1}$$

where w_1 and w_2 are the rotational speeds of the interior and exterior cylinders, R_1 and R_2 their radius and r the distance from the center of the cylinders (see Figure (1)) .

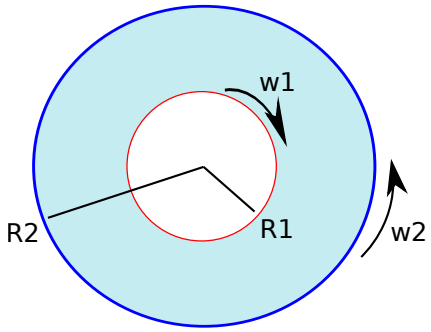

Figure 1: Test case sketch

The test case's main objective therefore is to study the velocity profile as a function of the r-axis for a given θ angle. The results are then compared to the analytical curve.

3.3 Model Description

Figure (2) offers a view of the geometry and mesh. Table (2) describes the mesh and Table (3) gives the physical parameters that will be used.

Model information	
Surface Element size	0.025
Volume Nodes	20540
Volume Elements	40332
Anisotropic Elements added to the Boundary Layer.	2

Table 2: Test Case Mesh Information

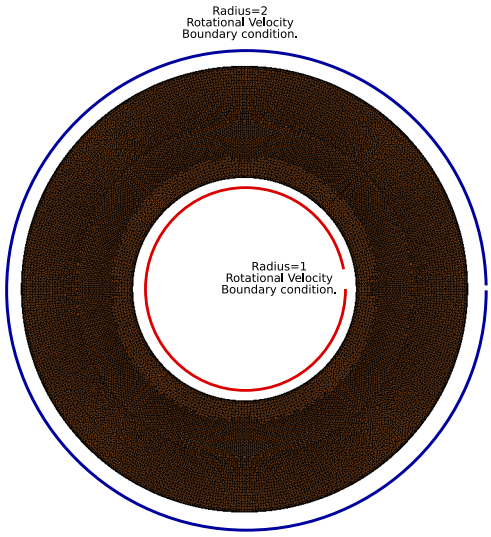

Figure 2: Test Case Geometry and Mesh

Model physical parameters	
Fluid Density	1
Rotational velocity w_1 & w_2	1 & -2
Viscosity	0.02

Table 3: Test Case Parameters

4 Test Case Results

4.1 Test Case observations

The fluid's velocity magnitude can be observed in Figure (3). As expected, the boundary velocity on the exterior cylinder is equal to $R_2 w_2$, and the one on the inner cylinder is equal to $R_1 w_1$. Figure (4) shows the inversion of the velocity vectors zone due to w_1 and w_2 having opposite signs. Figure (5) shows a good accordance between the computed and the analytical solution.

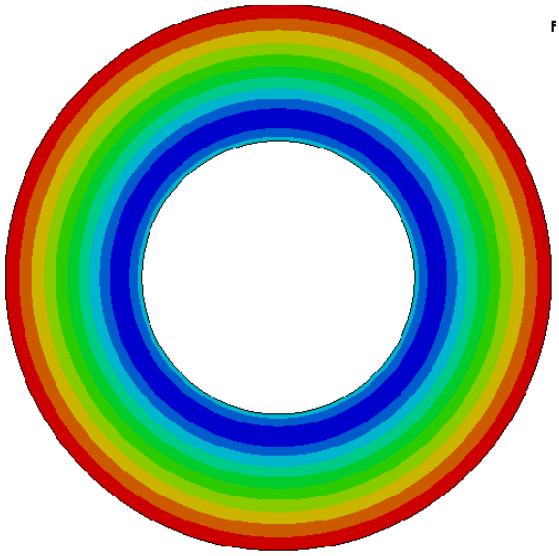

Figure 3: Test Case velocity magnitude

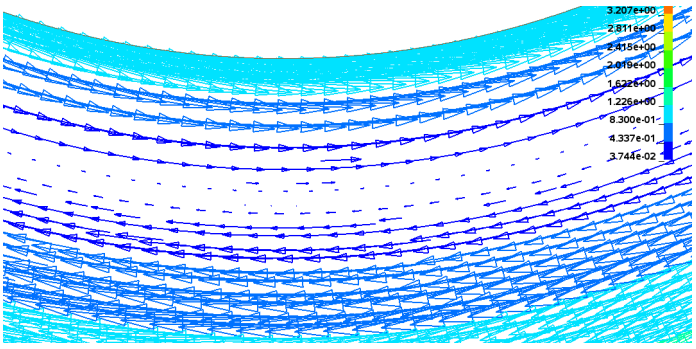

Figure 4: Velocity vectors close to the inner cylinder

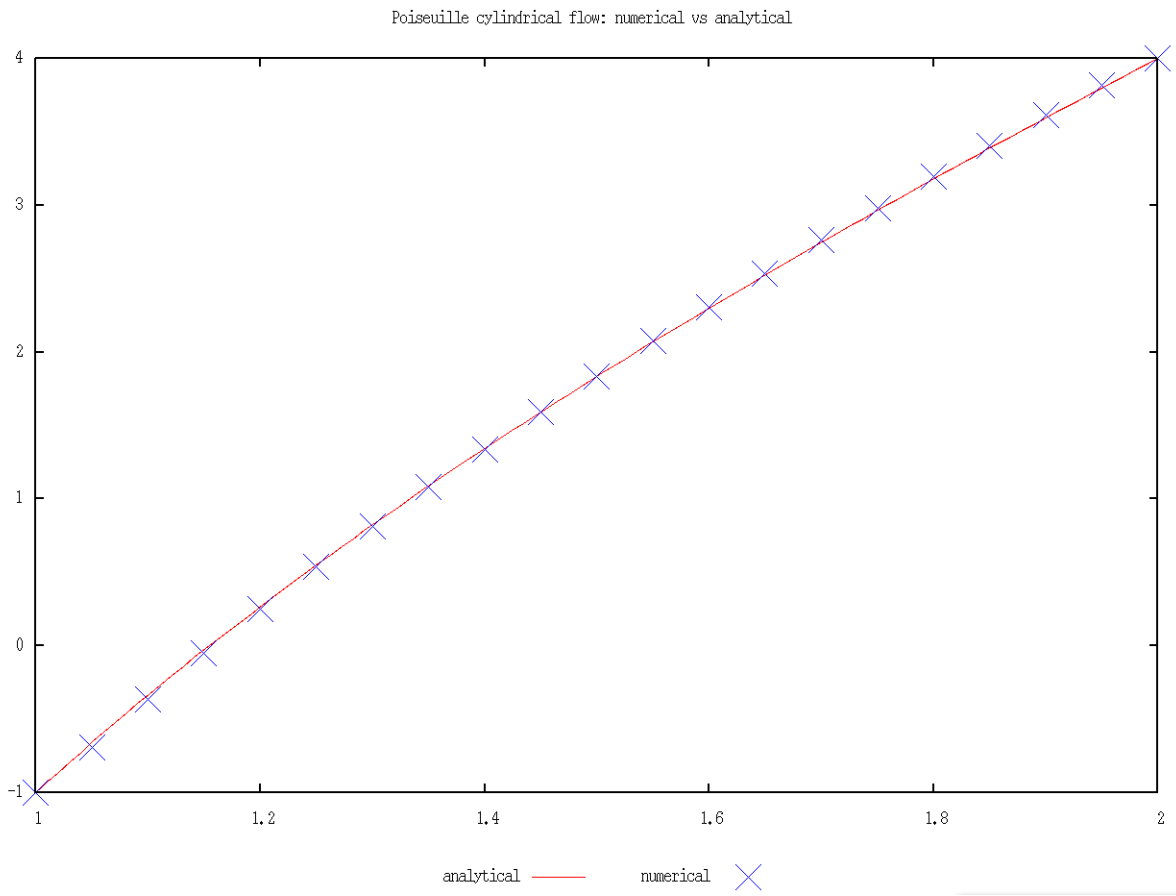

Figure 5: Test Case Velocity profile

References

[1] P. CHASSAING, *Mecanique des fluides. Elements d'un premier parcours*, CEPADUES Editions, 1982.