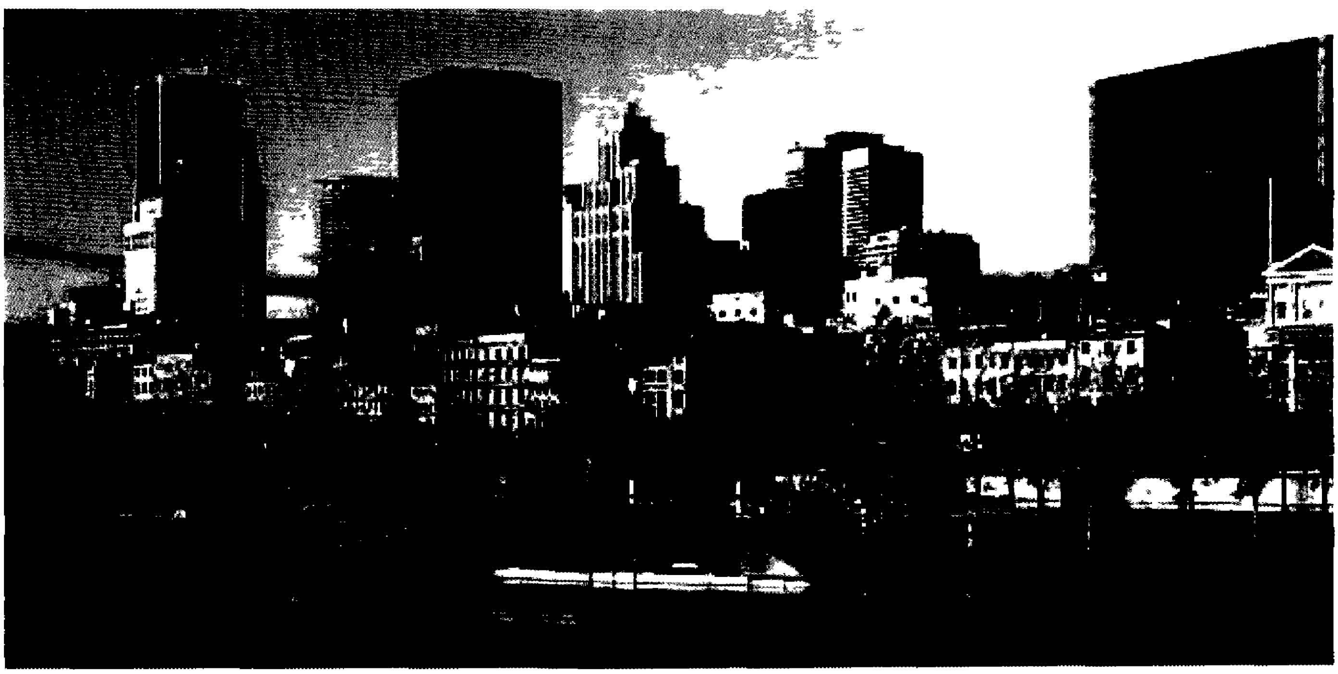
6th International Conference
On

Boundary Element Techniques

27-29th July 2005

La Plaza, Montreal, Canada



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Programme Overview

Wednesday 27th July 2005

8 30	**Registration**	
9 45	**Opening address**	
10 00	**Coffee Break**	
10 30	**Session 1**	
12 10	**Buffet Lunch**	
14 00	**Session 2A**	**Session 2B**
15 0	Coffee Break	
15 30 -16 30	**Session 3A**	**Session 3B**
18 30 – 20 30	**Conference Reception**	

Thursday 28th July 2005

8 30	**Keynote Lecture**	
9 00	**Session 4A**	**Session 4B**
10 00 Coffee Break		
10 30	**Sessions 5A**	**Session 5B**
12 10	**Buffet Lunch**	
14 00	**Session 6A**	**Session 6B**
15 00	**Coffee Break**	
15 30-16 30	**Session 7A**	**Session 7B**
19 00	**Boarding the Bus for the Conference Dinner**	

Friday 29th July 2005

8 30	**Keynote Lecture**
9 00	**Session 8**
10 00	**Coffee Break**
10 30	**Session 9**
12 10 14 00	**Buffet Lunch & End of the Conference**

Session 1: Solids and Structures
Chair: *W Mansur*

10 30 Viscoelastic analysis of functionally graded materials by meshless local Petrov-Galerkin method
Sladek,J , Sladek,V , Zhang,Ch

10 50 Fast 3D contact mechanics BEM algorithm
Abascal,R , Luis Rodriguez-Tembleque

11 10 3D BEM for general anisotropic elasticity
Wang,C -Y, Denda,M

11 30 A numerical Green's function and a local boundary integral equation approach
L S Miers, J C F Telles

11 50 Domain boundary element formulation for poro-elastic solids
Botta,A S , Venturini,W S , Benallal,A

Session 2A: Fracture Mechanics
Chair: *A Cisilino*

14 00 Fracture mechanics analysis of plane anisotropic bodies with concentrated heat sources using BEM
Shiah,Y C , Tan,C L

14 20 An axisymmetric boundary element analysis of interface cracks in fiber reinforced composites
Mantic,V , Graciani,E , Paris,F , Varna,J

14 40 Boundary-domain integro-differential equation of elastic damage mechanics model of stationary drilling
Mikhailov,S E

Session 2B: New Formulations & Computational Aspects
Chair: *R Abascal*

14 00 Boundary element simulation for transient measurements in SECM
Traeuble,M , Sklyar,O , Wittstock,G

14 20 Numerics of the convolution quadrature based poroelastodynamic BEM
Schanz,M , Kielhorn,L

14 40 Green's function for viscoelastic dynamic in a 3D single-layer domain
Martinez-Castro, A E , Gallego,R

Session 3A: Computational & Mathematical Aspects
Chair: *M Schanz*

15 30 3D numerical integration of Galerkin type integrals
Perez Gavilan,J J , Carrera,J

15 50 Determination of the slow gravity-driven migration of arbitrary clusters of solid particles and pherical bubbles in the vicinity of a plane solid wall by a boundary-integral formulation
Sellier,A

16 10 Analytic properties underlying boundary integral techniques
Baker,G

Session 2B: Advanced Material Modelling
Chair: *J Sladek*

15 30 Some applications of FMBEM on 3D composite materials
Zhenhan Yao, Haitao Wang, Ting Lei

15 50 Boundary element modelling and optimisation of structures made of functionally graded materials
Minutolo,V , Ruocco,E

16 10 Modelling thin walled 3D composite structures using the boundary element method
Hoefel,S S , Sollero,P , Albuquerque,E L , Portilho,W

8.30 Keynote Paper Simulation of acoustic-fluid-structure interaction with advanced boundary element method *Gaul,L., Fischer,M*
Chair: A P Selvadurai

Session 4A: Fracture Mechanics II
Chair: *P H Wen*

9 00 A 2-D hypersingular time-domain BEM for dynamic crack analysis in anisotropic solids
Beyer,S, Zhang,Ch, Hirose,S, Sladek,J, Sladek,V

9 20 Bond-line defects in SPF/DB structures with BEM
Di Pisa,C, Aliabadi,M H

9 40 Energy domain integral applied to solve three-dimensional thermoelastic crack problems using boundary elements
Balderrama,R, Martinez,M, Cisilino,A P

Session 4B: Heat and Fluid Flow
Chair: *A Sellier*

9 00 A BEM for the propagation of non-linear free-surface waves
Kinnas,S.A, Vinayan,V

9 20 Dual reciprocity BEM for the transient nonlinear heat conduction problem via time-stepping scheme
Tanaka,M, Matsumoto,T, Takakuwa,S

9 40 Application of boundary element method to modeling of hydrodynamic forces and experimental validation
Gardano,P, Dabnichki,P, Aliabadi,M H

Session 5A: Acoustics and Fluid Flow
Chair: *B Gatmiri*

10 30 Sound pressure reduction provided by an infinite elastic layer containing heterogeneities via BEM
Pereira,A, Tadeu,A

10 50 Boundary element acoustic analysis of perforated absorptive silencers
Zhenlin Ji, Tianyuan Zhang

11 10 Parameter optimisation in Ewald's method applied to shallow water acoustic wave propagation
Santiago,J A F, Wrobel,L C

11 30 The Trefftz method for solving Laplace eigenvalue problems
Zi-Cai Li, Tzon-Tzer Lu, Heng-Shuing Tsai

11 50The flux-correct Green element method for linear and nonlinear potential flows
Taigbenu,A E

Session 5B Computational Aspects
Chair: *N.A Dumont*

10 30 Large plastic deformation analysis without use of internal cells by triple-reciprocity BEM
Ochiai,Y

10 50 Taguchi and BEM analyses on the productivity performance of an oil reservoir
Mohamad Ibrahim,M N, Shuib,S

11 10 Topology optimization of 2D potential problems using boundary elements and generic algorithms
Anflor,C, Santanna,H, Marczak,R, Cisilino,A

11 30 How to avoid computing the nearfield in the fast multipole method
Tausch,J

11 50 Object-oriented modelling of field boundary element method in nonlinear solid mechanics with applications
Sharafi,H, Gakwaya,A

Session 6A: Fracture and Damage Mechanics
Chair: *J C F Telles*

14 00 Bending of elastic plates containing internal geometric defects by the indirect boundary element method
Ventsel,E S, Gwang Jin James Oh

14 20 A B E M damage analysis of historical masonry walls
Mallardo,V, Alessandri,C

14 40 A fundamental-solution-less boundary element method in fracture mechanics
Chongmin-Song

Session 6B New Formulations
Chair: *A J Davies*

14 00 Rapid elliptical functions based 3D mesh generation for complex surfaces
Dabnichki,P, Zhivkov,A

14 20 High superconvergence of combinations of Trefftz method and FEMs for Poisson's equation with singularities
Hung-Tsai Huang, Zi-Cai Li

14 40 Coupling techniques for Trefftz methods
Zi-Cai Li, Hung-Tsai Huang

Session 7A: Nonlinear and Dynamic Problems
Chair *L Gaul*

15 30 Large deflection analysis of shear deformable shallow shells by the field boundary element method
Baiz,P M, Aliabadi,M H

15 50 Boundary elements applied to anisotropic elastoplastic media analysis
Coda,H B, Vanalli,L, Paccola,R R

16 10 Dynamic analysis of Mindlin plates
Wen,P H, Aliabadi,M H

Session 7B: Computational Aspects
Chair: *OChiai,Y*

15 30 The Laplace transform dual reciprocity boundary element method for electromagnetic heating problems
Crann,D, Davies,A J, Christianson,B

15 50 Estimating the condition number of the matrices appearing in the boundary element method
Dijkstra,W, Mattheij,R M M

16 10 A boundary element model for drop deformation in slow viscous flows through a constriction
Das Bhaumik,C, Wrobel,L C

8.30 Keynote Paper
An advanced mode superposition technique for the general analysis of time-dependent problems
Dumont,N.A

Session 8: Transient Problems
Chair: *W Venturini*
9 00 Two time-domain approaches for the computation of stress and velocity at internal points for 2-D elastodynamics
Soares,Jr , D , Mansur,W J , Carrer,J A M , Telles,J C F

9 20 Three-dimensional time-dependent Green's function for unsaturated soils
Gatmiri,B , Jabbari,E

9 40 On the evaluation of damping forces in MEMS
Frangi,A , Spinola,G

Session 9: Solids and Structures
Chair: *C L Tan*
10 30 Boundary element analysis of tunnel construction, the challenges and proposed solutions
Beer,G , Duenser,C , Riberio,S.A

10 50 Stress-strain state provoked by displacement of rigid inclusions in thin plates
Melnikov,M Y , Melnikov,Y A

11 10 Comparison of finite and boundary element results for the stress intensity factors with analytical formulations in LEFM
Leme,S P L , Lima,R F , Bezerra,L M , Partridge,P W

11 30 Crack bridging in uni-directionally reinforced composites
Selvadurai,A P S

11 50 The boundary element method in wear simulation
Sfantos,G K , Aliabadi,M H

Taguchi and BEM Analyses on the Productivity Performance of an Oil Reservoir

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Keywords: Taguchi method, Boundary Element Method, reservoir rock properties, reservoir fluid property oil reservoir

Abstract. The application of Taguchi Robust Design Technique (TRDT) coupled with the Boundary Element Method (BEM) in analyzing the productivity performance of an oil reservoir is presented in this paper Several reservoir rock and reservoir fluid properties, i e permeability, thickness, porosity and viscosity, were chosen in this study The BEM allows the overall simulation of reservoir performance to be made, whereas the used of TRDT allows us to rank the most influencing factor (property) that affects the productivity performance of the reservoir Numerical values obtained from the BEM analysis will be used as input data for the TRDT statistical analysis Results indicated that oil viscosity is the most important factor that affects the productivity performance of the oil reservoir followed by the thickness of the pay zone, the rock permeability and the rock porosity Results of this study can be used by reservoir engineer in making the right choice of Enhance Oil Recovery techniques that is the most suitable for the reservoir

Taguchi Method

In this study, Taguchi Robust Design Technique (TRDT) was used to rank factors that may effect the productivity of oil reservoir. The use of Taguchi orthogonal array helps to determine the minimum number of simulation runs needed to produce the most favourable output for a given set of factors. These factors are rock permeability, reservoir oil viscosity, thickness of net pay and reservoir rock porosity The comparison between full factorial design and Taguchi design is shown in Table 1 The orthogonal array L_9 was used to study the influence of these four factors Each factor was considered at three levels The factors involved and their levels are shown in Table 2 If full factorial experimental design were used, it would require 81 (3^4) trials runs for all possible combinations of these factors to get the optimum result [1] By using the Taguchi orthogonal array L_9 for experimental design, the number of trials runs was reduced to 9 simple and effective experiments

Factors	Level	Total number of experiments	
		Factorial design	Taguchi design
2	2	4 (2^2)	4
3	2	8 (2^3)	4
4	2	16 (2^4)	8
7	2	128 (2^7)	8
15	2	32,768 (2^{15})	16
4	3	81 (3^4)	9

Table 1 : Comparisons of factorial design and Taguchi design

Column	Factors	Level Number		
		1	2	3
1	Permeability (md)	50	100	150
2	Viscosity (cp)	0 5	1	1.5
3	Thickness (feet)	10	20	30
4	Porosity (fraction)	0 15	0 30	0.45

Table 2 : Design factors and their levels for orthogonal experiment

Table 3 illustrates the orthogonal array L_9 [1] Since there were four of three levels factors, these factors were assigned to all four columns in the L_9 array For example in trial number 1, the value for rock permeability, oil viscosity, net pay thickness and rock porosity is 50 md, 0 5 cp, 10 feet and 0 15 (15%) respectively For trial number 2, the value for permeability, viscosity, thickness and porosity is 50 md, 1.0 cp, 20 feet and 0 3 (30%) respectively Nine trials simulation runs using the Boundary Element Oil Reservoir Simulation software with particular combination of factors levels in the array were carried out [2, 3, 4]

Trial Number	Column Number			
	1	2	3	4
1	1	1	1	1
2	1	2	2	2
3	1	3	3	3
4	2	1	2	3
5	2	2	3	1
6	2	3	1	2
7	3	1	3	2
8	3	2	1	3
9	3	3	2	1

Table 3 : L_9 (3^4) Orthogonal Array [1]

Results and Discussion

The results of the nine trial conditions are shown in Table 4 These simulation results is for the case of the following circular oil reservoir with single production well having the following properties

Area = 314 2 x 10^6 feet^2 = 7,212 acre (reservoir area),
r_w = 0.25 feet (well-bore radius),
ρ = 62 4 lb/ft^3 (reservoir fluid density),
p_w = 100 psi (well-bore pressure),
p_e = 2,000 psi (external reservoir pressure) and
Scale = 1 5,000

In the Taguchi analysis, there are three of quality characteristics with respect to the target design, namely "smaller is better" and "bigger is better" [1] In this study, the high value of oil production is desirable, therefore the "bigger is better" quality characteristic was chosen

Trial Number	Total Oil Production in barrel per day (bbl/d)
1	1270 2
2	1270 2
3	1270 2
4	5080.9
5	3810 7
6	846 8
7	11432 0
8	1905 3
9	2450 4
Grand Average	3259 633

Table 4 : Simulation results

Different factors affect the wells productivities to different degrees. The relative effect of the different factors can be obtained by the decomposition of total variation into its appropriate components, which is commonly called analysis of variance (ANOVA) ANOVA is also needed for estimating the error variance The results of ANOVA are shown in Table 5 Data generated in Table 5 especially the Sum of Squares, Variance and Percent were obtained from TRDT educational software, Qualitek-4 [5]

Column	Factors	DOF	Sum of Squares	Variance	F	Percent
1	Permeability (md)	2	23909295 85	11954647 925	-	26 392
2	Viscosity (cp)	2	33008700 598	16504350 299	-	36 436
3	Thickness (feet)	2	26480181 115	13240090 557	-	29 229
4	Porosity (fraction)	2	7194457 734	3597228 867	-	7 941
All others/error		0	0			0
Total		**8**	**90592640.958**			**100.00 %**

Table 5 : ANOVA table

The review of the 'Percent' column in Table 5 showed that the oil viscosity factor contributed the highest percentage (36 4%) to the factor effects, followed by the net pay thickness (29 2%), rock permeability (26 4%) and rock porosity (7 9%) Since the contribution of rock porosity was the smallest and less than 10% therefore it was considered insignificant Thus, this factor was pooled (combined) with the error term This process of disregarding the contribution of a selected factor and subsequently adjusting the contribution of the other factor is known as pooling The new ANOVA after pooling is shown in Table 6. It was observed that as the smallest factor effect (porosity) was pooled, the percentage contributions of the remaining factors decreased slightly, but the ranking of factor effects still remained the same In estimating the performance at optimum condition, only the significant factors were used An examination of the average effects as shown in Table 7 indicates that level 1 of viscosity and level 3 of both permeability and thickness factors will be included in the optimum condition (after excluding the porosity factor) This is due to the highest value of average effects for each factor With this levels combination, one should get the total oil production as 11,432 bbl/d

Column	**Factors**	**DOF**	**Sum of Squares**	**Variance**	**F**	**Percent**
1	Permeability (md)	2	23909205 85	11954647 925	3 323	18 45
2	Viscosity (cp)	2	33008700 598	16504350 299	4 588	28 494
3	Thickness (feet)	2	26480181 115	13240090 557	3 68	21 288
4	Porosity (fraction)	(2)	(7194457 734)		POOLED	
All others/Error		2	7194463 392	3597231 696		31 768
Total		**8**	**31.19**			**100.00 %**

Table 6 : Pooled ANOVA table

Column	**Factors**	**Level Number**		
		1	**2**	**3**
1	Permeability (md)	1270 199	3246 133	5262 566
2	Viscosity (cp)	5927 699	2328.733	1522.466
3	Thickness (feet)	1340 766	2933 833	5504 3
4	Porosity (fraction)	2510 433	4516 333	2752 133

Table 7 : The Average Effects of Factor for Each Level

Most data generated in Table 6 and Table 7 especially were obtained from TRDT educational software, Qualitek-4 [5]

Conclusions

Among four factors considered in this study, reservoir oil viscosity found to be the most influenced factor in producing oil from the reservoir It's followed by the net pay thickness, rock permeability and rock porosity Designing an Enhance Oil Recovery technique that can improve the oil viscosity such as steam flooding would be a good idea in order to improve the productivity of the reservoir

Further analysis shows that (by keeping the viscosity, thickness and permeability at their optimum levels), regardless of any rock porosity value use in the simulation runs, the oil productivity values are still the same This proves that porosity has very small contribution towards the productivity of the reservoir

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References

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