

**COMPUTATIONAL ANALYSIS OF TWO-DIMENSIONAL INVISCID
FLOW AROUND TURBINE CASCADE USING GAS KINETIC
*BHATNAGAR-GROSS-KROOK (BGK) SCHEME***

By

SALEH NASER ABDUSSLAM

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,
in Fulfilment of the Requirements for the Degree of Master of Science**

June 2004

DEDICATED

TO

*My Parents, Mona, and Abdalmalk
For all their love and understanding*

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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Chairman: Associate Professor Megat Mohamad Hamdan, Ph.D.

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Fluid flows within turbomachinery tend to be extremely complex. Understanding such flows is crucial to improve current turbomachinery designs, and the computational approach can be used to great advantage in this regard. This study presents a gas kinetic Bhatnagar-Gross-Krook (BGK) scheme to calculate the flow within a turbine cascade.

The two dimensional Euler equations with a numerical method based on the gas kinetic Bhatnagar-Gross-Krook (BGK) scheme was developed to simulate the flow around a turbine cascade configuration. The grids around the select model are efficiently generated using a multi-zone structure technique.

Computed results for the even studied cases were compared with experimental data in terms of Mach number distribution. Comparisons of these results with experimental data were made wherever possible and the agreement between the two is found to be good. In addition the gas kinetic Bhatnagar-Gross-Krook (BGK) scheme as the numerical procedure has been tested for its accuracy in solving the two-dimensional compressible inviscid flow fields. Analyzing the results in regular shock reflection revealed that the gas kinetic Bhatnagar-Gross-Krook (BGK) scheme is able to produce numerical results that are comparable, robust, and accurate as Roe's scheme. In addition, the gas kinetic Bhatnagar-Gross-Krook (BGK) scheme converges faster than Roe's scheme. For a given 1000 time iterations, the BGK scheme converges at 887 time iterations while the Roe's scheme converges at 906 time iterations. Therefore, the BGK scheme proved to be more efficient than Roe's scheme.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

**ANALISIS BERKOMPUTER BAGI ALIRAN BOLEH MAMPAT 2-D DI
SEKELILING LATA TURBIN DENGAN MENGGUNAKAN SKIM BGK
(BHATNAGAR-GROSS-KROOK)**

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Aliran bendalir dalam mesin turbo lumrahnya berkecenderungan untuk menjadi terlampau kompleks. Pemahaman tentang aliran sebegini sememangnya adalah suatu perkara yang mustahak bagi meningkatkan usaha reka bentuk mesin turbo pada masa kini. Untuk tujuan ini, kaedah pengiran mampu digunakan sejauh mana yang mungkin. Kajian ini akan membentangkan sejenis skim berangka yang dikenali sebagai skim gas-kinetik BGK untuk menyelakuan aliran dalam “lata turbin”.

Persamaan dua dimensi Euler dengan kaedah berangka yang diasaskan kepada skim BGK gas-kinetik telah dibentuk untuk mengira aliran mengelilingi “lata turbin”. Grid yang digunakan untuk model yang terpilih adalah berdasarkan kepada koedah struktur berbilang-zon.

Keputusan pergiliran untuk kes yang dikaji dibandingkan dengan data-data yang diperolehi daripada eksperimen. Perbandingan ini adalah berdasarkan kepada pengagihan nombor Mach. Hasil perbandingan ini menunjukkan bahawa persetujuan di antara keputusan pergiliran dan eksperimen adalah memuaskan. Selain daripada itu, skim berangka BGK turut diuji

kejituannya dalam menyelesaikan medan aliran tidak likat boleh mampat dua dimensi. Hasil analisis dalam pemantulan kejutan biasa menunjukkan bahawa skim BGK mampu menghasilkan keputusan yang setanding, semantap dan sejitu skim Roe. Disamping itu skim kinetic Bhatnagar-Gross-Krook (BGK) menepah lebih cepat dari skim Roe. Untuk 1000 kali iterasi, skim BGK menepah pada 887 kali iterasi manakala skim Roe menepah pada 906 kali iterasi. Oleh yang demikian skim BGK terbukti lebih efisien dari skim Roe.

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I certify that an Examination Committee met on 4th June 2004 to conduct the final examination of **Saleh Naser Abdusslam** on his **Master of Science** thesis entitled "**Computational Analysis of Two-Dimensional Inviscid Flow Around Turbine Cascade Using Gas Kinetic Bhatnagar-Gross-Krook (BGK) scheme**" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be award the relevant degree. Members of the Examination Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotation and citations which have been duly, acknowledge. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

SALEH NASER ABDUSSLAM

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