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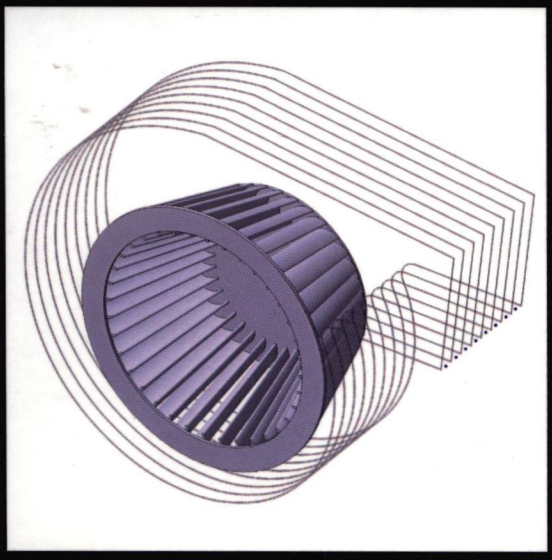
Developments in Turbomachinery Flow

Forward curved centrifugal fans

Nader Montazerin, Ghasem Akbari
and Mostafa Mahmoodi



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To:

Roshanak, Atekeh, and Zeinab

About the authors

Nader Montazerin is professor of mechanical engineering at Amirkabir University of Technology. He received his BS from Sharif University of Technology, Tehran, Iran (1980) and MS and PhD from Cranfield University of Technology, Bedford, England (1982 and 1985). He immediately started lecturing and research at Amirkabir University of Technology, where his interests are centred on experimental fluid mechanics, turbomachines, compressible flow and applied energy. He has published five books and many journal articles. His industrial activities are on gas turbines, national gas networks and energy efficiency.

Ghasem Akbari is assistant professor of mechanical engineering at Islamic Azad University, Qazvin branch, Industrial and Mechanical Engineering Faculty. He has held this position since 2014. He received his PhD from Amirkabir University of Technology, Tehran, in 2014. He has taught several courses at Islamic Azad University including fluid mechanics, heat transfer, thermodynamics and internal combustion engines. He has served on several provincial/academic projects, including the identification of gas consumption bottlenecks as well as its long-term prediction. He is also interested in experimental and theoretical fluid mechanics and turbulence, particularly in turbomachinery applications. He has published several prominent journal articles on the results of research during his PhD period.

Mostafa Mahmoodi is a PhD candidate in mechanical engineering at Amirkabir University of Technology. He received his BS in mechanical engineering – thermo fluids from Yazd University, Yazd, Iran, in 2007. He received his MS in mechanical engineering – energy conversion from University of Kashan in 2011. His PhD thesis is on numerical and experimental study of aeroacoustic behaviour of squirrel cage fans.

Preface

Squirrel-cage fans are strange. Precious electricity produced by gas and steam turbines is lost to the very inefficient forward-curved fans of the heating and ventilating industry. The research studies on gas and steam turbines are expensive and very competitive worldwide. On the contrary, forward-curved squirrel-cage fans are cheap and simple to build which makes any application of research findings very simple.

The study of the complicated flow field requires advanced measuring techniques such as laser Doppler anemometry. The combination of building different fans, doing performance tests and examination of the flow field with laser anemometry was an attractive research field that was carried out for many years by the team that had written the present book.

Early in this research, modifications to the inlet were proved to be productive. The improvements were far more significant than what was already reported in the literature for other modifications. Later, the present team started with the rotor and the idea of a half-cone rotor and a half-cone with a lean angle that proved to have merit in many cases. Tests on the volute geometry indicated that it was not the shape of the volute cross-section that is important, but the spread angle. Larger spread angle could result in larger flow rates and could override all optimizations to the inlet! Still an optimum spread angle could be defined that gives an aerodynamic flow for a limited space.

It was soon known that optimizations without modelling are very expensive and time-consuming. Simulation of the flow in this fan is not an easy task. Three-dimensional flow, separated flow after the inlet, large number of blades and separated three-dimensional boundary layer inside the blades were all the most important complications in any simulations. Although modelling is not accurate, it was proved to be successful in determining the trends. The modellings were managed to direct research for correct experimental setups and minimum costs.

With the gained experience on fans and laser anemometry, it was natural to move into stereoscopic particle image velocimetry. Squirrel-cage fans are ideal instruments for sample flow measurements in centrifugal turbomachines. They give flat sidewalls and easy access to measuring plane. They rotate slowly and have many features like separations and jet/wake flows that have baffled research studies for a long time.

It was a fortunate occasion that Chandos Publishing invited us to write a book on such fans at this stage. This opportunity provided us with the best chance to review what was achieved during the past twenty-four years. The first four chapters of the book contain our studies on fan performance, fluid flow and fan optimization. Chapter 5 deals with aeroacoustic and sound generation behaviour of the forward-curved

centrifugal fans. Chapter 6 investigates the contribution of jet–wake–volute interactions to flow characteristics and turbulence models which are more advanced, and we expect it to find serious application when the computing capacity for simulating centrifugal turbomachines increases.

We are grateful to acknowledge prior publication of a part of our research in the *Journal of Power and Energy, Journal of Turbulence* and *International Journal of Heat and Mass Transfer*. Detailed references are given at the end of each chapter.

I (the first author) have enjoyed the work of two excellent PhD students in the past few years who kindly accepted to be my coauthors in this book. Dr Akbari defended his PhD in 2014 and Mr Mahmoodi shall complete his PhD in a couple of years. There are still many of my old students who contributed to the subject presented in this book and I just name them here with much respect:

Mr Matin Hosseini; Mr Mohammad Reza Shetab Booshehri; Mr Mohammad Reza Najjari; Mr Seyyed Alireza Hosseini; Dr Reza Sepahi Samian; Mr Hossein Akhavan; Mr Soroosh Shahabadi; Mr Masood Nikkhoo; Late Mr Morteza Akbarizadeh; Mr Javad Alinejad; Mr Sina Samarbakhsh; Mr Seyyed Mohammad RezaeiNiya; Mr Arash Heshmat Dehkordi; Mr Saeed Zeinali; Dr Ebrahim Damangir; Mr Mohammad Hassan Hessami Azizi; Mr Mojtaba Gholamian; Mr Mehdi Askari Shahi; Mr Ahmad Kazemi Fard; Mr Ali Toorani; Mr Mohammad Jafar Mahmoodi; Mr Hamid Reza Mirzaei; Dr Seyyed Saeed Mirian; and Dr Ehsan Tooyserkani.

The work is also incomplete if we do not mention other researchers who have done parallel works on squirrel-cage fans round the globe. As far as we know, the only team who has produced continuous research in this field is from Oviedo University in Spain. Their articles have been of much interest and inspiration to us. Other researchers have not been consistent and only produced occasional results. We are indebted to all the inspirations we received from these groups and have tried to cite their works at the end of each relevant chapter.

Nader Montazerin
Tehran
March 2015

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