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DECSIM—A PC-Based Diesel Engine Cycle and Cooling System Simulation Program

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Abstract—This paper describes a PC-based Diesel Engine Cycle and cooling system SIMulation (DECSIM) program that was developed at the Australian Maritime College. DECSIM has been validated against a variety of marine engines and can be used to predict the steady state performance characteristics of two- and four-stroke diesel engines. The program may be used to obtain pressure-crank angle, pressure-volume, and heat release diagrams. Applications of DECSIM are discussed that show how the program can be used to assist marine engineers in fault diagnosis and designers to predict the thermal behaviour of combustion chamber components. The program may also be used to model cooling system behaviour, and so can be used by design engineers to optimize the dimensions of components such as heat exchangers and pumps with acceptable system pressure drop characteristics.

Keywords—Simulation, Diesel engine, Cooling systems, Heat transfer.

1. INTRODUCTION

Diesel engine simulation in use at the Australian Maritime College may be classified into two main areas: real-time simulation and engine cycle simulation. The diesel engine training simulator described by Pal [1] is an example of how a real-time simulator is used at the College to impart operational and diagnostic fault finding skills to aspiring marine engineers. This simulator replicates the main machinery plant of a 120,000 tonne Bulk Carrier including the main propulsion plant, which is a seven cylinder Mitsubishi two-stroke, slow speed engine. It consists of a simulated ship's engine room, control room, separate instructor's room, and minicomputer. Students are trained for normal engine room operations, such as preparing the plant for departure and arrival in port, as well as emergency situations such as a total loss of electrical power and crash astern manoeuvres. An important requirement for such a simulator is that it should faithfully model the machinery's response behaviour in real time. Engine cycle simulation programs, on the other hand, may take several hours of computing time to model an engine's transient response behaviour that may last only several seconds in real time. These programs can be used to predict the performance of a variety of engines, including exhaust emissions, over a wide range of

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operating variables. Engine cycle simulation programs are widely used by engine manufacturers to provide information for the detail design of current and future engines.

The DECSIM (Diesel Engine Cycle and cooling system SIMulation) program described in this paper is a modified version of a program created by Colthorpe [2] to run on a 386 PC computer. The original program was developed for use by students taking the Power Plant Theory elective in the BEng (Maritime) Degree at the College. It was a DOS-based program that permitted students, using a minimum of input data, to investigate the effects on an engine's performance of changing values for engine bore, stroke, injection timing, and valve timing. The value of a simple to use, steady state engine cycle program in the engine thermal analysis work being undertaken at the College was recognized, and the program which became known as DECSIM has been modified and improved over a period of years; see, e.g., [3]. The current program, which runs using either the Windows 95/98 or NT 4 operating systems, has a simplified method of data entry through the use of dialogue boxes; see Figure 1. Some examples are included in this paper to illustrate the cooling system modelling capability of DECSIM and how DECSIM can be used in the thermal analysis of engine components.

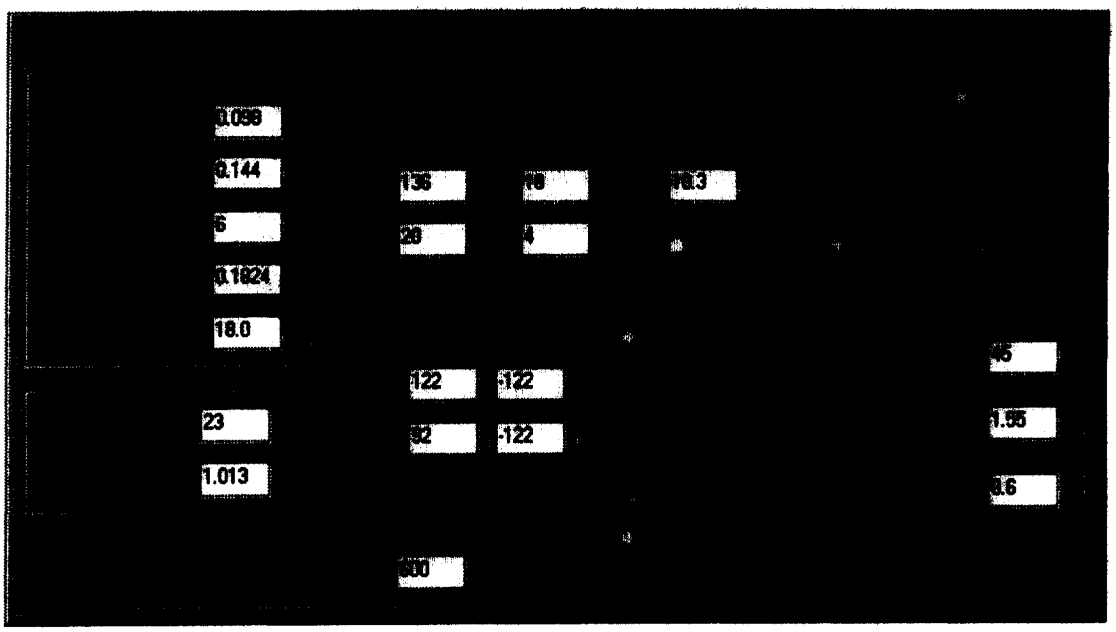

Figure 1. Engine geometry data entry dialogue box.

DECSIM, in common with other engine cycle simulation, uses a number of empirical equations that contain constants which require calibration through information gathered from operational engines. Such information is used to confirm or modify constants used in the heat transfer and combustion equations for particular engine types, and hence, improves the simulation quality. It is also important to note that the program assumes a single cylinder engine with constant pressures in the inlet and exhaust manifolds, and hence, it does not allow for manifold pulse effects of any kind. Performance results are scaled according to the number of cylinders. This is not considered a serious limitation for the prediction of steady state thermal or performance trends. However, when it is important to account for the unsteady flow in the inlet and exhaust manifolds of multicylinder engines, or to model the transient performance of the engine, then it is necessary to use a program which models the inlet gas dynamics. Such programs use either the Method of Characteristics, e.g., [4], or the Lax-Wendroff method, e.g., [5], to solve the unsteady gas flow equations. This refinement will, of course, increase the amount of input data required,