Gas and Vacuum Carburizing

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Introduction：

Carburizing media are divided into three kinds: liquid, solid carbonaceous compounds, and atmospheric. In both gas and vacuum carburization processes, the steel part is subjected to an atmosphere with high carbon potential.

The optimization of the industrial carburizing process parameters is typically pursued by a trial and error method. In addition to being time consuming and expensive, this approach yields suboptimal results at best [1]. In this project, effective gas and vacuum carburizing models are developed. The models may also be used to optimize the processes.

A simulation program, CarbTool©, has been developed by CHTE (Center for Heat Treatment Excellence) for the calculation of the carbon concentration profile during the gas and vacuum carburizing processes.

The solution algorithm used in CarbTool© is based on the finite difference method (FDM), and the code is developed using Microsoft Visual C++ in Window OS. The tool has been built on the concept of the carbon flux at the surface between the gas and steel is to be specified by the user. The outputs of CarbTool© are the carbon concentration distribution profile inside the steel part and the surface carbon concentration profile as a function of time.

Users input parameters about the carburization process, such as carburization temperature, carburizing time, and carbon potential or carbon flux. After a quick simulation the carbon profile along the distance below the surface can be plotted with the case depth labeled according to a user defined value.

In a current case, comparable carbon profiles for a series of steels are required for fatigue testing. These profiles need to be achieved by gas carburizing in endothermic gas as well as vacuum carburizing in cyclohexane. The modeling was used to design and revise the process parameters to achieve the same surface carbon concentration and effective case depth.

Methodology

The project focused on three tasks:

Task 1: Develop a fundamental understanding for both atmosphere and vacuum carburizing process.

Task 2: Design the atmosphere and vacuum carburizing processes to meet the same specification by using CarbTool© to determine the process parameters and compare with experimental results

Task 3: Model the residual stresses and distortion for both atmosphere and vacuum carburized samples and compare with experimental results

Salient Results

In this work, the CarbTool© is optimized based on a series of experiments and recipes are obtained to lead the atmosphere and vacuum carburizing processes to meet the same specification.

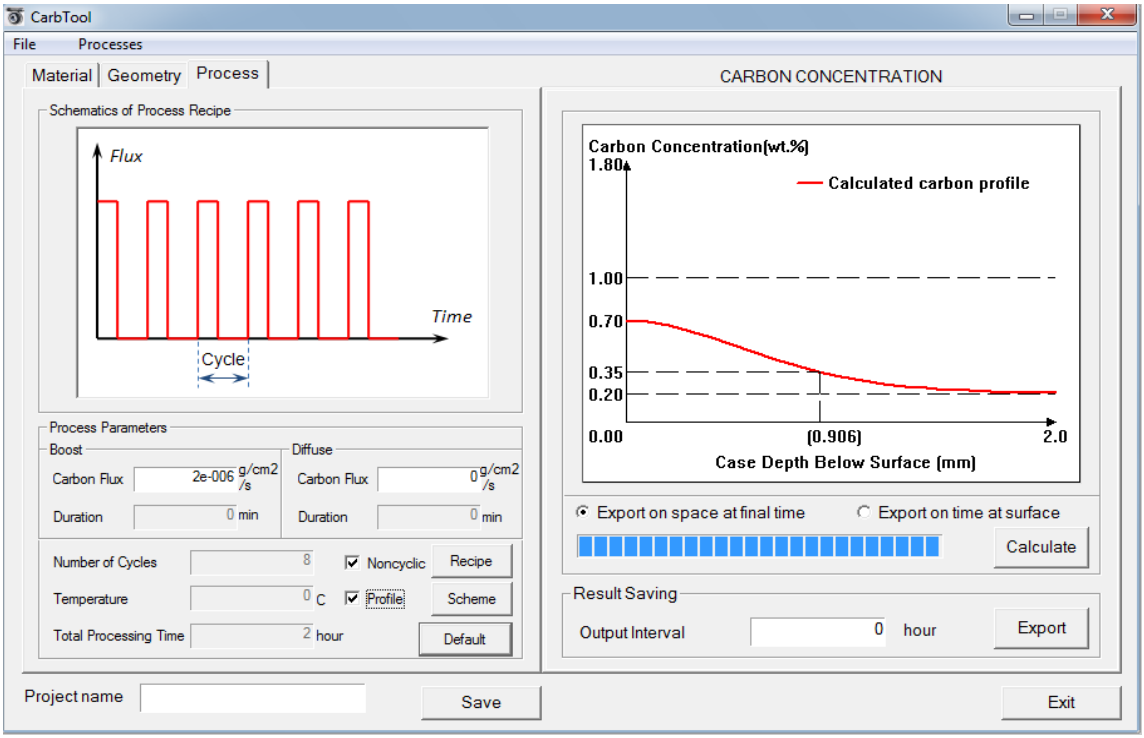

Figure 1 The interface of CarbTool, vacuum carburizing process module

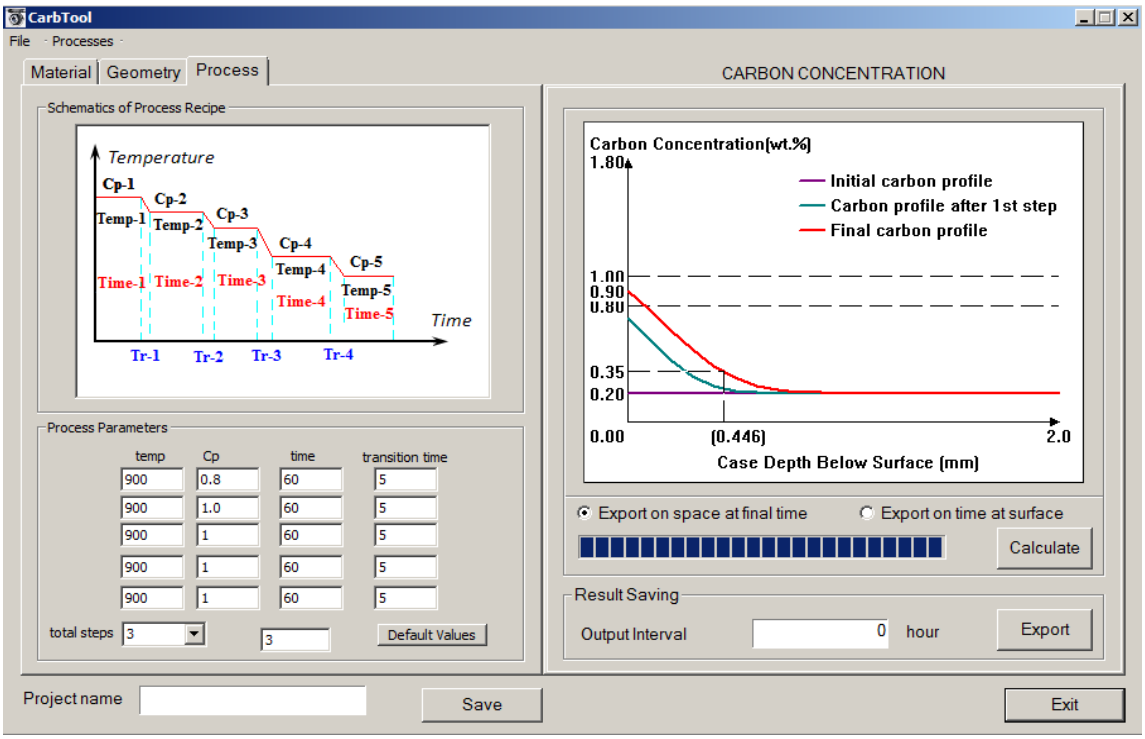

Figure 2 The interface of CarbTool, gas carburizing process module

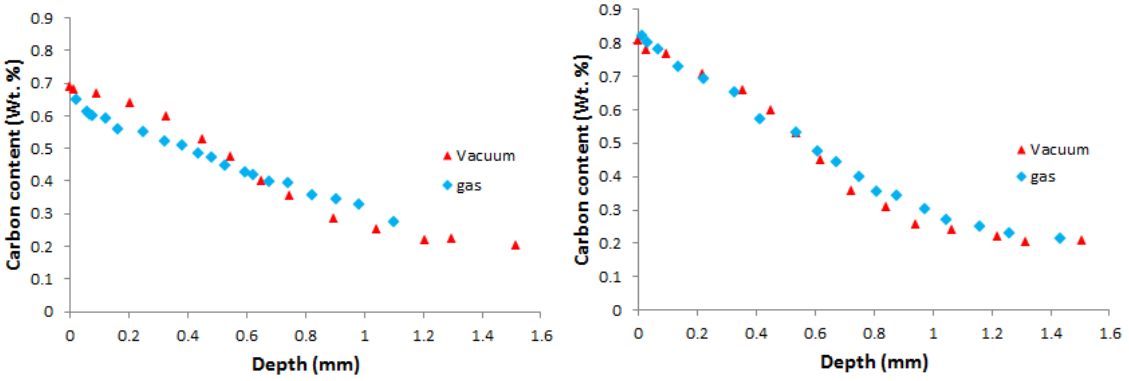

Figure 3 comparison between gas and carburized samples.

[1] Sahay, S.S., "Cost Model Based Optimisation of Carburising Operation", *Surf. Eng.*, 2004, Vol. 20 No. 5, pp. 379.