Chapter 5

Particulate Emission from Spark-Ignition Engines

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I. INTRODUCTION

During the past fifteen years the gaseous components of automotive exhaust have been widely investigated to evaluate their role in air pollution. Relatively little effort has been devoted to the study of particulates emitted from automotive engines. The reason for the greater interest in gaseous emissions is understandable since gaseous components are emitted in considerably larger amounts than particulates, as illustrated in Fig. 1. Nevertheless, gasoline engines still introduce into the United States' atmosphere about one million tons of particulate matter annually,\(^\text{(1)}\) contributing significantly to air pollution. Most notably, particulates affect (a) solar radiation and climate near the ground, (b) visibility, (c) material damage, (d) vegetation, and (e) health. In this paper, these effects are not examined in detail (interested readers are referred to the comprehensive summaries given in Ref. 2); instead, attention is focused on the emission of particulates from spark-ignition engines.

While there are precise definitions of gaseous emissions, there is no exact definition of what constitutes particulate matter in automotive exhaust. Here “particle” or “particulate” is defined as any dispersed matter, solid or liquid (except uncombined water), in which the individual aggregates are larger than single molecules (\(\sim 0.0002 \mu \text{m in diameter} \)) but smaller than about 500 \(\mu\).\(^\text{(2,3)}\) Spark-ignition engines exhaust many particles in this size range which are composed of various organic and inorganic substances.

In addition to the total amount of particulates emitted, the size and composition are also of significance in air pollution problems. For example, small particles may remain suspended in the atmosphere for several months while larger ones settle in seconds. The chemical composition may influence

\(183\)
photochemical reactions, the mineral content of vegetation, and human health. For these reasons, it is desirable to determine the physical and chemical properties of particulates, with special attention to

1. Physical characteristics
   a. Total amount (number and weight) emitted
   b. Size distribution
   c. Shape

2. Chemical composition
   a. Chemical composition of the total particulate matter emitted
   b. Chemical composition of different size particulates

Emission standards should be concerned with the foregoing properties. However, emission standards being considered by the U.S. Government and the State of California do not distinguish between particles of different sizes or composition but are concerned only with the total emission. For automobiles, the emission standard considered for 1975 is 0.1 gram per mile.

The properties listed above depend on several different parameters related to the fuel and the engine, including:

1. Fuel composition
2. Engine
   a. Make of engine