Chapter 1
Introduction

1.1 Motivation

Reams (1939), in his book *Modern Blast Cleaning and Ventilation*, and Rosenberger (1939), in his book *Impact Cleaning*, probably delivered the first serious state-of-the-art reviews about the industrial fundamentals of blast cleaning. They were followed by Plaster (1972) with his two-volume compendium on '*Blast Cleaning and Allied Processes*'. In Germany, Horowitz' (1982) book about *Oberflächenbehandlung mittles Strahlmitteln* (*Surface Treatment with Blasting Media*) became very popular and is still a widely used reference. Since then, 25 years of intense progress in both industrial applications and scientific research have passed. The aim of this book is to provide an extensive up-to-date engineering-based review about the fundamental principles of blast cleaning.

This book is concerned with the blast cleaning of metallic substrates prior to the application of protective coatings or adhesives.

1.2 Introductory Remarks

From the point of view of the material removal mechanism, blast cleaning can be considered to be an erosion process. "Erosion", as a tribological term, is the removal of materials due to the action of impinging solid particles. Erosion is a natural phenomenon [the correct designation in terms of geology is *corrasion* (Bates and Jackson, 1980)] and there exist a number of impressive examples about the material removal capability of natural erosion. One example, the erosion of rock columns, is illustrated in Fig. 1.1.

Blast cleaning is one of the most frequently utilised treatment methods in modern industry. The starting point of the utilisation of blast cleaning for industrial purposes was Tilghman's patent on "*Improvement in cutting and engraving stone, metal, glass, etc*." (Tilghman, 1870). Benjamin Chew Tilghman (1821–1901), an American scientist, invented the "*cutting, boring, grinding, dressing pulverizing, and engraving stone, metal, glass, wood, and other hard or solid substances, by means of a stream of sand or grains of quartz, or of other suitable materials, artificially driven*

Fig. 1.1 The natural erosion (corrasion) of rock columns in Palmyra (Photograph: University of Tokyo)

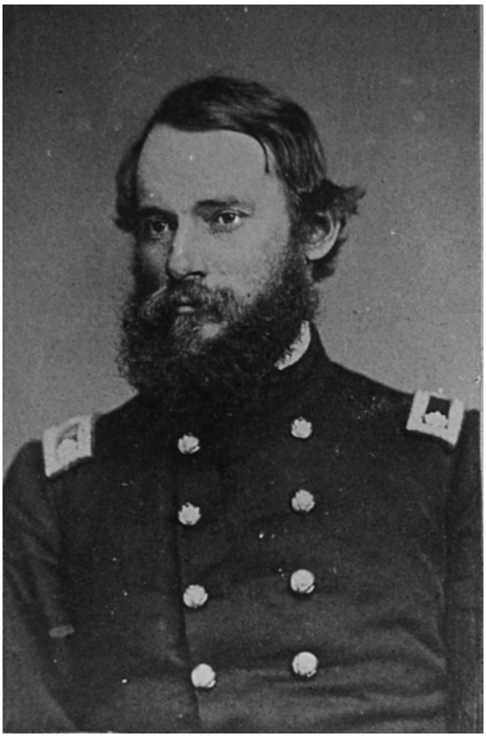

Fig. 1.2 Benjamin C. Tilghman (Copyright: ATT-Net)

as projectiles rapidly against them by any suitable method of propulsion" (Patent No. 108,408, October 18, 1870). It is not only the general idea of what we today call blast cleaning, or grit blasting, covered by this invention, Tilghman also mentioned a number of methods how to propel the solid particles against the material surface. He wrote: "*The means of propelling the sand ... is by a rapid jet or current of steam, air, water, or other suitable gaseous or liquid medium; but any direct propelling force may be used, as, for example, the blows of the blades of a rapidly-revolving fan, or the centrifugal force of a revolving drum or tube, or any other suitable machine*" (Patent No. 108, 408, October 18, 1870). Benjamin Tilghman is portrayed in Fig. 1.2.

The industrial applications mentioned by Tilghman included the following: "*Articles of cast or wrought metal may have their surfaces smoothed and cleaned from slag, scale, or other incrustions*." Reviews about the early developments in industrial blast cleaning were provided by Plaster (1972, 1993). Early applications included applications in the foundry industry, steel industry and corrosion protection industry. Today's applications include the use for micro-machining, polishing, maintenance and surface preparation for coating applications. A recent advanced application in the machining industry is grit blast assisted laser milling (Li et al., 2005).

1.3 Blast Cleaning Methods and Applications

Blast cleaning methods, according to corrosion protection applications, can be subdivided as listed in Table 1.1. Blast cleaning is by definition a method "*where blasting media (as tools) are accelerated in blasting devices of different blasting systems, and where they are forced to impinge the surface of a target (substrate) to be treated*" (ISO 12944-4, 1998). To define a blast cleaning method completely, the following information is required:

Table 1.1 Blast cleaning methods according to ISO 12944-4 (1998)

Blast cleaning methods	Dry abrasive blast cleaning	– Centrifugal abrasive blast cleaning – Compressed-air abrasive blast cleaning – Vacuum or suction-head abrasive blast cleaning
	Moisture-injection abrasive blast cleaning	(No further subdivision)
	Wet abrasive blast cleaning	– Compressed-air wet abrasive blast cleaning – Slurry blast cleaning – Pressurised-liquid blast cleaning
	Particular applications of blast cleaning	– Sweep blast cleaning – Spot blast cleaning

- purpose of blasting;
- blasting system;
- blasting medium type.

A blast cleaning system is designated according to the method, and respectively the medium, that accelerates the abrasive particles up to the required velocity. From that point of view, blast cleaning systems can be subdivided into compressed-air blast cleaning, centrifugal blast cleaning and vacuum or suction-head blast cleaning.

The book deals with the application of compressed-air blast cleaning for the treatment of metallic substrates. This includes the two following applications:

- removal of mill scales, slags and coatings;
- substrate preparation for the subsequent application of coating systems or adhesive systems.

An application example is shown in Fig. 1.3. Coating systems to be applied to blast cleaned substrates include basically corrosion protective coatings and wear resistant coatings. The examples provided in Table 1.2 and in Figs. 1.4 and 1.5 very well illustrate the effects of surface preparation methods on the performance of coating systems.

Figure 1.4 shows the effects of different surface preparation methods on the degree of rusting for a variety of coating materials. It can clearly be seen that blast cleaning to a high surface preparation standard (Sa 2½) could notably improve

Fig. 1.3 Application of blast cleaning for the surface preparation of steel (Photograph: Muehlhan AG, Hamburg)

Table 1.2 Effect of pipe surface cleanliness on cathodic disbonding; conditions: 30 days/38°C (Neal, 1999)

Coating	Cathodic disbonding in mm		
	Surface cleanliness		
	Blast cleaning (white metal)[a]	Blast cleaning (near-white blast)[a]	Power wire brush
Epoxy polymer concrete	–	5.0	17.1
Fusion bonded epoxy (FBE)	6.1	8.9	>40
Heat shrink sleeve	12.7	18.0	27.3
Tape	14.9	31.8	28.5
Coal tar urethane	13.6	16.5	26.9

[a]See Sect. 8.2.3 for surface preparation grades

the resistance of the coatings against rusting compared to the coatings applied over untreated substrate (mill scale) and over power tool cleaned (St 2 and St 3) substrates. The situation in Fig. 1.5 is more complex. It can be seen that a light blast cleaning (sweep blasting) did not succeed for all coating materials. If a PVC-based coating system was applied to the substrate, washing was more effective than blast cleaning. For the alky-based coatings, however, a preparation performed by blast cleaning substantially improved the resistance of the coating material against flaking.

Results of cathodic disbonding tests on coating materials for pipelines are listed in Table 1.2. It can be recognised that a thorough blast cleaning could notably reduce the delamination widths for all applied coating systems.

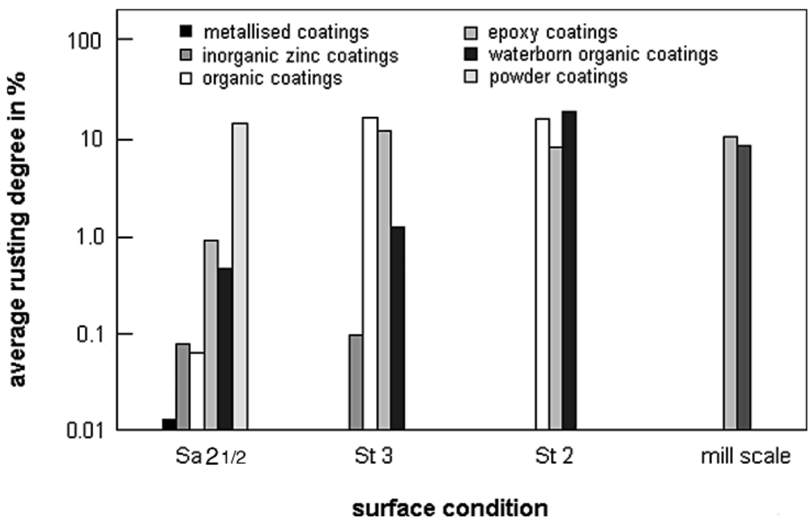

Fig. 1.4 Effects of steel substrate quality on the performance of corrosion protective coatings (Kogler et al., 1995)

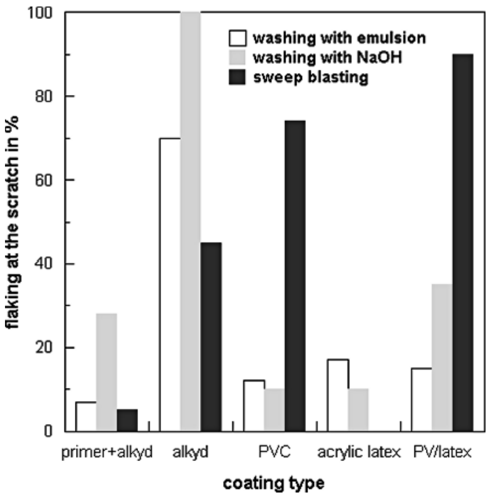

Fig. 1.5 Effects of surface preparation methods on the performance of a duplex coating system (Foghelin, 1990)

Table 1.3 Effects of surface preparation methods on the performance of a zinc-dust-based protective coating system (Brauns et al., 1964)

Surface preparation	Time to complete rusting in months		
	Splash zone	Transition zone	Underwater zone
Mill scale	5	16	10
Acid pickling	8	8	>24
Flame cleaning	8	8	>24
Blast cleaning[a]	24	>24	>24

[a] Abrasive: steel cut wire

Experimental results plotted in Table 1.3 illustrate the effects of different surface preparation methods on the rusting of steel samples coated with a zinc-dust-containing paint. The time of rusting was estimated in three corrosive maritime zones, which are typical for the corrosive loading of offshore constructions. These zones included, in particular, splash zone, water exchange zone and permanent underwater exposure. It can be seen that blast cleaning with steel cut wire notably improved the performance of the corrosion protection system. The time till complete rusting of the paint film occurred could notably be extended if the substrates have been blast cleaned irrespectively of the loading zone.