

Effect of foundry size on the dust concentration of different work phases

by MATTI KOPONEN, M.Sc.,¹ EERO SILTANEN, M.Sc.,² ANTERO KOKKO, M.Sc. (Eng.),³ BERNDT ENGSTRÖM, M.Sc.,³ and JUHANI REPONEN, B.Sc.⁴

KOPONEN, M., SILTANEN, E., KOKKO, A., ENGSTRÖM, B. and REPONEN, J. Effect of foundry size on the dust concentration of different work phases. *Scand. j. work environ. & health* 2 (1976): suppl. 1, 32—36. The dust concentrations of different work phases in iron foundries of different sizes were studied. The results of the total dust measurements made during the Finnish Foundry Project were considered according to the eight main work phases, and the 51 iron foundries were divided into four groups according to the number of foundry workers. The division between the groups at 25, 50, and 100 workers is related to the degree of mechanization in Finnish foundries. The total dust concentration clearly increased in sand making and melting as the size of the foundry increased. The concentration decreased in molding, coremaking, knock-out, and cleaning as the number of workers increased. No significant differences between the foundry groups could be found during casting. The factors affecting the differences in dust concentrations are discussed.

Key words: dust measurements, foundry work, iron foundry.

Transferring and handling dusty materials cause high dust concentrations at many workplaces, and the foundry industry is an industry with many dust problems. In recent years these problems have received more and more attention. New foundries have been provided with modern dust control techniques, but older facilities have used generally the same techniques for the last 20 to 30 years.

The foundry industry in Finland is a typical small industry. Only nine of the almost 130 iron, steel, and nonferrous foundries employ more than 100 workers, and even the largest foundries employ about 450 workers only. Some of the larger foundries form a section of a firm manufacturing machines. The major part of the smaller foundries act as subcontractors producing castings. The production series are generally small. This limited type of production is a restricting factor for the automatization of the foundry processes.

The nature of foundry work has changed as the degree of mechanization and automatization has increased. From work including all foundry phases it has progressed to continuous serial work. Therefore the nature of dust exposure in foundries can have changed too.

For many reasons dust exposure can be different in the small and large foundries. First processing cycles can vary according

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to the type of foundry. Some foundries operate continuously with all work phases going at the same time, whereas others, especially small foundries, have 1- to 3-day process cycles. Second the standard of dust control can vary in the large and small foundries due to the different methods and economical problems.

Dust concentrations in different foundry phases have been discussed in many papers (3, 5, 6, 10, 11). The results presented have been mean or median values of all the foundries in the particular study.

In the present paper we have divided the iron foundries in Finland into four groups according to the number of workers in the foundries and examined dust exposure data to determine if dust concentrations in different work phases are dependent on the size of the foundry.

MATERIAL AND METHODS

Dust measurements

During the Finnish Foundry Project in 1972-1974 (4, 9) dust measurements were made in 60 of the iron and steel foundries and in 8 nonferrous foundries using sand molding. The results of the 51 iron foundries are discussed in the present study.

Gravimetric dust measurements were carried out with stationary and portable samplers during two consecutive work shifts (9). The duration of a sampling period was generally one shift (7-8 h). If different work phases were performed during a shift or if different work methods were used, we tried to collect dust samples from every phase separately, but it was not always possible. We have based our evaluation on the total dust concentrations measured.

Foundry size

The 51 iron foundries were divided, as shown in table 1, into four groups according to the number of foundry workers. The total number of workers exceeded 3,000.

The division of the groups was based on the degree of mechanization and automatization of the foundry work. Generally

Table 1. The number of workers and foundries in the four foundry groups.

Group no.	Number of workers	Number of foundries in group
1	≤ 25	22
2	26- 50	15
3	51-100	9
4	> 100	5

speaking, the limits 25, 50, and 100 workers represented the differences between manually operated, partly mechanized, mechanized, and partly automated foundries in Finland. The production of Finnish foundries has been presented in another report (1).

Work phases

In the comparison between the foundry groups measurements from the following eight work phases were used: sand making, molding, coremaking, melting, casting, knock-out, cleaning, and other works. These main groups include all work methods in the phase. For example, molding includes hand molding, machine molding, and slinger molding; the knock-out phase includes all methods involved in removing the castings from the molding sand.

RESULTS

Differences between the foundry groups

The comparisons between the foundry groups were based on the mean values of the total dust concentrations of the groups. The dust concentration measured during sand making increased as the size of the foundry (i.e., the number of the workers) increased, as shown in fig. 1. The mean values from small foundries, group 1 (less than 25 workers), and large foundries, group 4 (more than 100 workers), were 13 mg/m³ and 33 mg/m³, respectively.

The same trend was also found for melting operations. The highest value, 16 mg/m³, was found in group 3 (50-100 workers) and the lowest value, 7 mg/m³, in group 1. The mean for group 4 was 10 mg/m³.

SAND MAKING

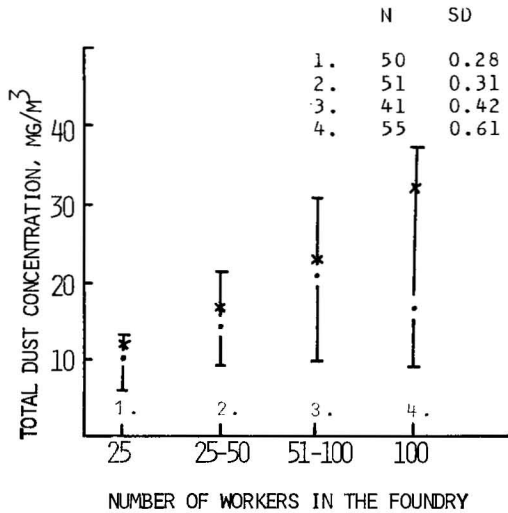


Fig. 1. The total dust concentration during sand making versus the size of the foundry. (x = mean, • = median, upper end of the line = 75 % point of distribution, lower end of the line = 25 % point of distribution, N = number of samples, SD = log. standard deviation)

MOLDING

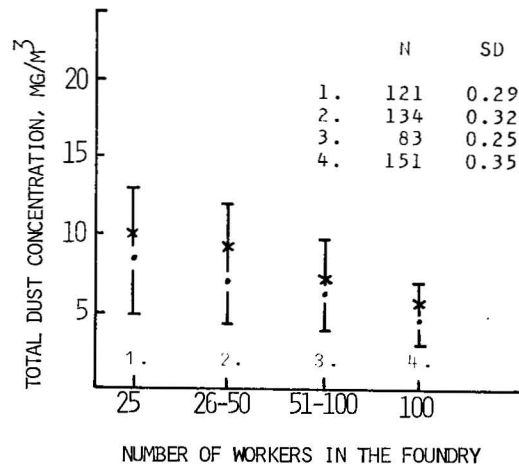


Fig. 2. The total dust concentration during molding versus the size of the foundry. (x = mean, • = median, upper end of the line = 75 % point of distribution, lower end of the line = 25 % point of distribution, N = number of samples, SD = log. standard deviation)

KNOCK-OUT

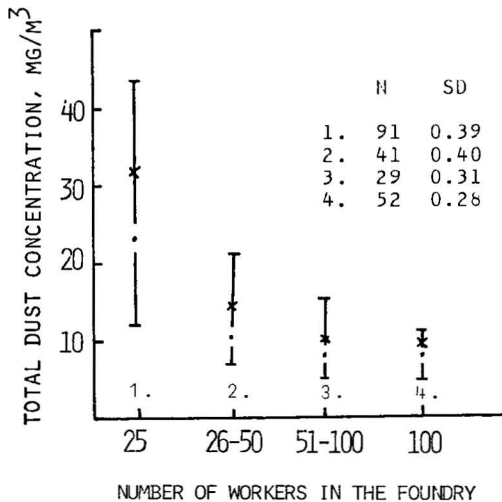


Fig. 3. The total dust concentration during knock-out versus the size of the foundry. (x = mean, • = median, upper end of the line = 75 % point of distribution, lower end of the line = 25 % point of distribution, N = number of samples, SD = log. standard deviation)

CASTING

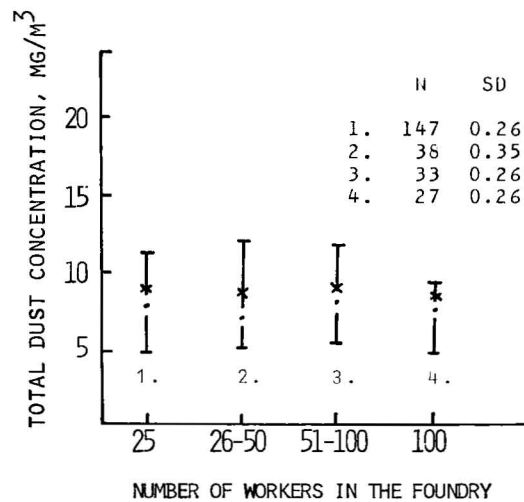


Fig. 4. The total dust concentration during casting versus the size of the foundry. (x = mean, • = median, upper end of the line = 75 % point of distribution, lower end of the line = 25 % point of distribution, N = number of samples, SD = log. standard deviation)

The dust level measured during molding and coremaking operations slightly decreased (from 10 to 7 mg/m³ and from 6 to 4 mg/m³, respectively) as the size of the foundry increased (fig. 2).

Knock-out operations were associated with clearly higher dust concentrations in small foundries (33 mg/m³) than in large foundries (from 10 to 15 mg/m³), as can be seen in fig. 3.

During cleaning the dust level was higher in small foundries (33 mg/m³) than in large foundries (13 mg/m³).

The mean total dust and fume concentrations during casting were similar, about 8 mg/m³, in all foundry groups. The distribution of the measurements within each group was also similar, as can be seen in fig. 4.

When the arithmetic means of groups are compared, a small number of very high concentrations in some groups can affect the mean too much, and the comparison can be misleading. Air pollutant data for workplaces are generally assumed to have a log-normal distribution rather than a normal one (2, 7, 8).

The differences in the dust concentrations of the foundry groups were tested with the t-test. It was supposed that the data is log-normally distributed, and the calculations were therefore made with the logarithms of the concentrations. No remarkable inconsistencies were found between the results, given in figs. 1-4, and the t-test results. The t-test results are shown in table 2. In sand making the dust concentration was lower in group 1 (small foundries) than in all other groups by a significance of $p < 0.05$. Differences between groups 2 and 3 and between 2 and 4 were not statistically significant. During the melting phase group 3 showed the highest concentration: group 3 > group 1 ($p < 0.01$), group 3 > group 2 ($p < 0.001$), group 3 > group 4 ($p < 0.05$), but the small foundries had the highest dust concentrations during the knock-out phase. No statistically significant differences were found between different foundry groups in casting and in the phase "other works."

DISCUSSION

Most of the small foundries were located in very old and cramped facilities. The

Table 2. Significance testing of logarithmic dust concentration differences of the foundry groups in some work phases. Group 1 represents the smallest foundries and group 4 the largest ones. The result of the t-testing is marked by + = $p < 0.05$, ++ = $p < 0.01$, +++ = $p < 0.001$ or — = no statistically significant difference.

Groups tested	Test result
Sand making	
Group 1 < group 2	+
» 1 < » 3	++
» 1 < » 4	+
» 2 < » 3	—
» 2 < » 4	—
Melting	
Group 1 < group 2	—
» 1 < » 3	++
» 1 < » 4	—
» 2 < » 3	+++
» 4 < » 3	+
Molding	
Group 1 > group 2	+
» 1 > » 3	+++
» 1 > » 4	+++
» 2 > » 3	—
» 2 > » 4	+++
» 3 > » 4	+++
Knock-out	
Group 1 > group 2	+++
» 1 > » 3	+++
» 1 > » 4	+++
» 2 > » 4	—
Cleaning	
Group 1 > group 2	—
» 1 > » 3	—
» 1 > » 4	+++
» 2 > » 4	+++

degree of mechanization was low and very little had been done to control dust levels. Local exhaust systems were not used. The sand was generally handled by shoveling. The molding, casting, and knock-out phases were done in the same place and the foundry floor was covered with sand.

In foundry groups 3 and 4 (the larger foundries) the sand making was highly mechanized or automated. The amount of sand handled and transferred was greater than in the small foundries. However, not enough attention had been paid to enclosing the conveyors and sand mixers and installing exhaust systems for them, and some of the larger foundries had very high dust concentrations in their sand plants. Nevertheless there were also some

new sand plants with very low dust levels (1–2 mg/m³).

The increased dustiness in the melting phase of group 3, when compared to all other groups, can be explained by the use of induction furnaces, which were typical for this group. The lack or ineffective use of exhaust hoods on induction furnaces gave rise to high fume and dust concentrations during the melting phase.

The decreased dustiness in molding and coremaking as the size of the foundry increased was caused by the higher degree of mechanization and, especially, the increased use of general ventilation in the larger foundries. The median values of all breathing zone samples taken during hand molding and machine molding were 9.2 mg/m³ and 6.4 mg/m³, respectively. Hand molding is the most used molding method in small foundries.

The removal of castings on vibrating grids under local exhaust ventilation, the use of steel-sand blasting machines, and the effective use of dust controlled grinding cabins have decreased the dust concentrations in the knock-out and cleaning phases in the larger foundries. In contrast the knock-out phase in small foundries is done on the floor with the aid of a sledge and crane. During this process the median of the breathing zone samples was 24 mg/m³. In the mechanized knock-out process it was only 10 mg/m³.

In small foundries everyone makes everything. In larger foundries every worker is continuously confined to the same work phase. The most time-consuming phase in small foundries is molding, in general 1 or 2 days of a 2- or 3-day process cycle. The rest of the cycle includes the short and more dusty phases.

In calculating the long-term dust exposure of workers on the basis of work time and dust concentration in various work phases, we found that in many small foundries the dust exposure of workers did not exceed that of workers in larger foundries.

A comparison of foundry groups based on the number of workers in a foundry includes some factors which affect its validity. The sampling strategy was

planned to be representative of all foundries. Especially in small foundries, however, it was not always possible to measure all work phases separately. The ratio (number of samples/number of workers) became higher in small than in large foundries. In addition the sampling sites could have been selected so that more of the dusty sites or jobs and fewer of the less dusty ones were measured, and the mean values determined for the large foundries could therefore be higher than those determined for small foundries.

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