NOISE CONTROL ON A 340-SOURCE ELASTIC YARN COVERING MACHINE

A R Raymond

PDA Ltd, 212 Manchester Rd, Warrington, Cheshire, UK.

1.0 INTRODUCTION

1.1 Background

Wykes of Leicester make high quality elastic yarn for various textile applications. Their main production areas are extremely noisy and, although the company operates an efficient and conscientious safety policy, noise has remained a problem in some areas.

An occupational noise survey and assessment was conducted in the main production areas and very high measured noise levels were confirmed in some parts. The most severe levels were found in the 'covering section' where 40 machines contributed to measured noise levels of over 100 dB(A) Leq(s)[2].

Operators were fairly static throughout their 8 hour day and, consequently, received personal daily exposures of over 100 dB(A) LEP,d, well in excess of the Noise at Work Regulations Second Action Level[1].

1.2 Covering Machine Description

The OMM-Type covering machines used at Wykes of Leicester Ltd have approximate dimensions of 10m length x 1m width x 2m height.

The machine basically covers elastic yarn with fine thread and winds it onto a total of 160 spindles. The spindles are arranged in two rows on either side of the machine and each row is driven by a motor-driven belt. The belt is tensioned by approximately 160 jockeys.

1.3 Noise Control Philosophy

Clearly the excessive noise levels had to be reduced and 4 techniques were examined. Broadly speaking, these were room acoustic treatments, partitioning, screening/enclosures and noise control at source. For reasons of predicted performance, access, ventilation and cost, noise control at source was the most viable option[2][3].

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Noise Control at Source depends upon detailed identification of the sources and a clear understanding of how the noise is generated and how it leaves the machine and reaches the operators' ears. This usually involves a very detailed and relatively costly analysis project but the solutions are nearly always simple and rarely restrict access or ventilation. Equally important, however, is the fact that Noise Control at Source solutions, once implemented, nearly always cost only a tiny fraction of other more traditional techniques.

2.0 INVESTIGATIVE TECHNIQUES[3]

Noise source identification and analysis was clearly going to be very difficult on a machine surrounded by 39 virtually identical machines. Fortunately, Wykes were happy to install a single machine in a side room so that analysis could continue uninterrupted without having to halt normal production.

Once the room had been 'calibrated' the results could easily be translated to the real shop-floor environment.

2.1 Background Noise

Background noise measurements were made with the machine switched off, at 18 positions around the machine. The single-figure levels ranged from around 68 dB(A) to 73 dB(A), Leq(s). At each position, octave band noise levels were recorded at frequencies from 31 Hz to 16 kHz. The results were used to 'calibrate' the test room and all subsequent noise levels in this paper are corrected for background noise in all octave bands.

2.2 Room Acoustics

The test room gave a dramatically different acoustic environment than that found on the shop-floor. To ensure that we could translate results found in the test room environment back to the normal or typical shop-floor environment with reasonable confidence, we examined the basic acoustic characteristics of both areas.

2.3 Noise Map

Figure 1 shows the noise levels in dB(A) Leq(s) at the 18 key measurement positions. In each case the microphone was positioned about 0.5m from the machine surface or 0.5m from the test room wall, as appropriate. The microphone was orientated towards the machine surface.

It can be seen that, at all positions, the noise levels are all between 104 dB(A) and 107 dB(A), the spatial average being 105.6 dB(A).

In addition, octave band analysis was performed at all these positions. Not only were all single-figure noise levels very similar, but all octave band traces were almost identical, suggesting lots of very similar sources or the entire machine behaving as one big source. It will be seen later that, to a certain extent, both possibilities were found to be true.

2.4 Close-to Analysis

This technique was used to detect hot-spots and localised sources. It was not used to analyse or predict overall machine levels, it simply identifies parts of a machine which behave differently to others.

In this case, however, we performed a large number of measurements, in dB(A) and in octave bands and failed to find any hot-spots. The noise levels were virtually identical on nearly all parts of the machine.

2.5 Narrow Band Analysis

The only variation in the sound field was found using narrow-band analysis.

Firstly, consider the narrow-band spectrum shown in Graph 1. This was measured at 1m from the side of the machine. The spectrum can be broken up into 2 distinct ranges.

a) 0 to 5 kHz is largely broad-band noise

b) 5 kHz to 20 kHz is characterised by a large family of tones, all harmonically related to a fundamental frequency of 290 Hz.

This narrow band analysis was repeated close to the machine. Firstly, Graph 2 shows the analysis just under a horizontal rail, near one of the spindles. Secondly, Graph 3 shows this repeated above the rail, near the same spindle.

Comparison of these analyses is very revealing.

Graph 2, close to a spindle, below the supporting rail. Compared to measurements made at 1m:-

a) 0 to 5 kHz shows an increase in amplitude. This would be expected as measurements are made much closer to the machine.

b) 5 kHz to 20 kHz shows the amplitude of the tones decreasing more and more as frequency increases. It is likely, therefore, that the supporting rail is acting as a screen to sources which are only found above, and close to, the rail.

Graph 3 close to a spindle, above the supporting rail. Compared to measurements made at 1m:-

a) 0 to 5 kHz shows an increase in amplitude (closer to the source(s)).

b) 5 kHz to 20 kHz shows an increase in amplitude (again closer to the sources but, this time no evidence of screening is present).

So, only sources above the support rail contribute to the noise climate above 5 kHz. Sources, which appear to be the same above and below the rail, contribute to the noise climate below 5 kHz.

2.6 Vibration Analysis

Clearly the above analysis suggests that the spindle support rails may be a source of noise. With this in mind, the vibration of a rail was tested in octave bands and compared with the measured, airborne noise levels. The trace shapes were very similar and appeared to confirm this tie-up, backed by aural tests with a stethoscope.

With the machine turned off and the analyser set in averaging mode, the rail was repeatedly tapped with a hammer until the spectrum became steady. The results of this simple test showed strong peaks up to about 5 kHz, all harmonically related to a fundamental natural frequency of 300 Hz.

3.0 SOURCE IDENTIFICATION[3]

3.1 Tones Above 5 kHz

The previous section shows that the sources responsible for these tones are above the spindle support rails. The only possibilities are the spindles themselves and/or the jockeys. The rotational speeds of all rotating parts were measured with an optical tachometer and those for the spindles and jockeys were as follows:-

Spindles	290 Hz
Jockeys	230 Hz

Referring back to the narrow band analysis of Graph 1, the tones are all harmonics of 290 Hz.

We were able to safely conclude that the spindles were the major noise source above 5 kHz.

3.2 Broad-Band Noise Below 5 kHz

Close-to analysis above and below the support rail showed no difference in the noise climate below 5 kHz. The previous section showed that the vibration in the rail was such that the rail itself was the source of noise below 5 kHz. The rail was also found to be susceptible to resonant excitation below 5 kHz, with a fundamental natural frequency of 300 Hz.

The rotational speed of the spindles (290 Hz) is clearly the main mechanism driving these resonances.

3.3 Ranking the Sources

All the above analysis shows that the bulk of the audible sound energy is between approximately 250 Hz and 5 kHz and that the main component between these frequencies was likely to be the vibrating support rail. Our close-to analysis was then used to separate the components of spindle/jockey noise from support rail noise. This is shown, in octave bands, in Graph 4.

Clearly, rail vibration has been confirmed as the main mechanism of noise production with spindle and jockey noise only predominant at very high frequencies.

4.0 NOISE CONTROL SOLUTIONS[3]

4.1 Rail Vibration

The spindles and jockeys provide the ultimate source of vibrational energy to their support rails via rigid fixing. Clearly this vibration path had to be 'broken'. The most practical method was to isolate the spindles and jockeys from the rail with simple and cheap material such as Tico S.

Our analysis also found that a significant amount of vibration was being transmitted into the machine chassis and from rail to rail via rigidly fixed tie bars. The simplest way to 'starve' the entire machine of vibrational energy was obviously to use Tico S, again, to isolate all support rails from the chassis and from each other.

The rails are made from 4mm steel and are not suitable for damping treatments to reduce resonances.

4.2 Spindles

Wykes had discovered a newer make of spindle which required less maintenance and, as a by-product, produced less vibration and less high frequency noise. These new spindles were specified, effectively at cost to the noise control programme as the main reason was better maintenance.

4.3 Jockeys

It was found that spring loaded jockeys had a smoother movement and produced less vibration and less high frequency noise.

4.4 Predicted Noise Reductions

The vibration isolation performance of a pad of Tico S in the set-ups described was tested in octave bands. Fitted as described above, the rail-vibration component of the noise should be reduced by 28.6 dB(A) at most locations around the machine. In terms of overall noise levels we predicted a total reduction of 11.3 dB(A) from vibration isolation alone. This will be mainly effective below 5 kHz.

We were unable to test the performance of the new spindles and jockeys but we conservatively predicted a further improvement of 3 dB(A), mainly at high frequencies.

5.0 COMMISSIONING TEST RESULTS(3)(4)

At the time of the commissioning survey, not all our recommendations had been carried out.

5.1 1st Phase of Implementation

The spindles and jockeys had been isolated from the rails but the rails had not been isolated from the chassis or from each other.

Graph 5 shows the measured results against the initial noise levels and our predictions. The shortfall in low-frequency noise reduction would be further reduced by fully isolating as described.

The overall reduction was 13.8 dB(A).

5.2 Later Phases of Implementation

Since the commissioning survey Wykes have implemented the rail isolation recommendations. Although commissioning has not been carried out by PDA, at the time of writing this paper, Wykes were able to confirm an extra reduction of 2 dB(A) giving a total reduction of 15.8 dB(A) against the predicted 14.3 dB(A).

6.0 CONCLUSIONS

The bulk of the hazardous noise from Wykes of Leicester's covering machines was between 250 Hz and 5 kHz.

Most of this noise was due to support rail vibration which was being excited near its natural frequencies by the spindles and jockeys.

Spindle and jockey noise was only significant above 5 kHz.

Rail vibration was effectively reduced by using simple and cheap vibration isolation pads, namely Tico S. This provided substantial reduction in the noise levels below 5 kHz.

Spindles and jockeys were replaced with inherently quieter versions and effectively reduced high frequency noise.

An overall reduction in excess of 15 dB(A) was achieved which, when translated onto the acoustic environment of the shop-floor, will bring daily, personal exposures down to marginally above the Noise at Work Regulations' First Action Level of 85 dB(A) LEP,d.

7.0 REFERENCES

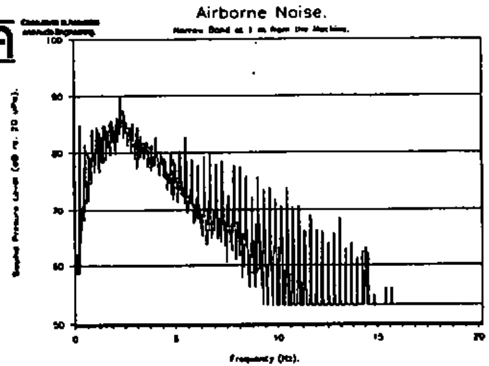
1) HSE. The Noise at Work Regulations 1989.

2) A R Raymond. Wykes of Leicester Ltd - General Occupational Noise Assessment, Feasibility Study and Detailed Specification of Acoustic Segregation, Acoustic Partitioning and Room Acoustic Treatment.

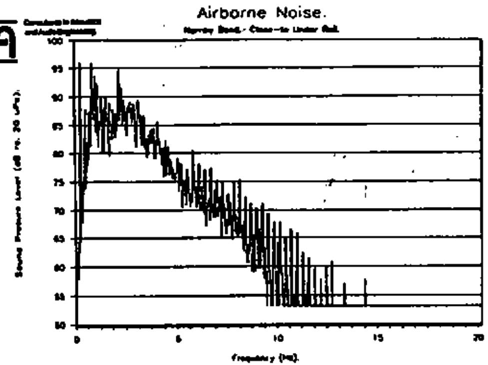
3) P R Dunbavin. Wykes of Leicester Ltd - Noise Control Research and Development Project on an OMM Type 63 Covering Machine.

4) G Morris. Outline Readings of OMM Test Machine Before and After Rail Modification.

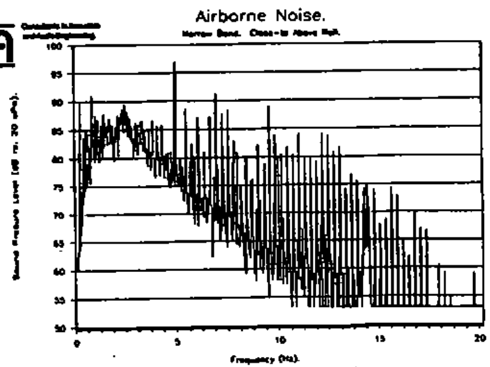
Graph 1.



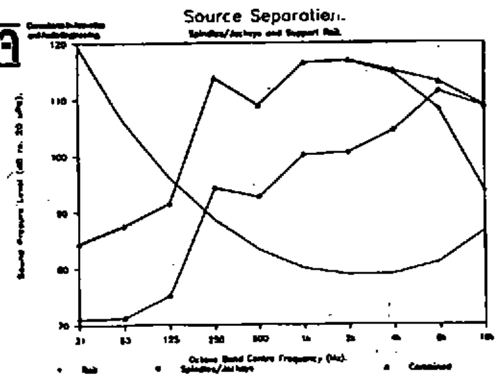
Graph 2.



Graph 3.



Graph 4.



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Graph 5.

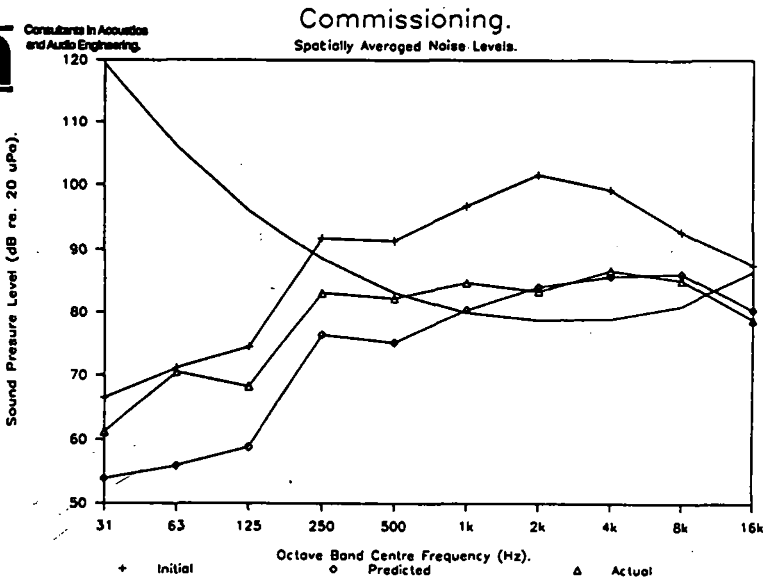

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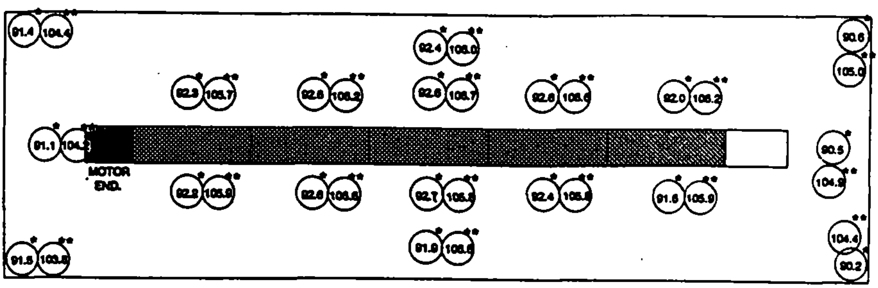
Fig No. 1. Noise Map of Test Room

* = Test-Room Commissioning Levels 22.1.92

** = Original Test-Room Datum Levels 13.11.91



MEASUREMENTS ARE dB(A) Leq (s).