NOISE RADIATED BY CORKPAPER CUTTING KNIVES.

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In modern cigarette-making machines corkpaper coming from a bobbin and connecting tobacco rod and filterplug is cut in pieces approx.40 mm long,with a speed of 2000 to 3600 pieces per minute.
Such a making machine is a combination of a rodmachine,where tobacco rods are formed out of cut tobacco and a filterassembler or tipping machine,where tobacco rods and filter plugs form filtercigarettes.
This paper deals with the filterassembler being one of the most serious noise sources in the cigarette industry.
An investigation in co-operation with TNO (Institute of Applied Physics at Delft) and Prof.Richards was carried out with the purpose of showing the machine supplier the need and ways to improve the machine.

A thorough inventory of all noise sources in the filterassembler showed that the cutting device,where cork paper is cut,was the dominating noise source out of a total of about 30.
The cutting process is in fact a squeezing process where cork paper is pressed and cut between rotating tungsten carbide knives with a top angle of 90^{o} mounted on a kniferoller and a tungsten carbide circular cork drum.
In order to ensure that all 8 rotating knives cut the corkpaper completely,the cutting process starts before the line connecting the centre lines of both the kniferoller and corkdrum.
Time records of the near-field airborne signal form a useful means to investigate the system,especially if they are triggered to one of the rotating knives.
Adding the position of the abovementioned connecting line gives a clear insight as to when (time) and where (distance) a phenomenon occurs.
Applying this method during production showed that there was a 3,7 kHz dominating signal beginning at about 4 ms before the connecting line and ending at about 2,5 ms before the connecting line.
Time records,measured with a B & K narrow band frequency analyser 2031,were transformed into a 1/18 octave analysis by means of a HP 9825 desk top computer,showing a dominating narrow peak round 3,7 kHz.
Time records of the other 7 knives showed the same times,although amplitudes were different and even amplitudes of the same knives were different.

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The next step in the investigation was to find a relationship between the measured airborne time records and the possible structure noise.
Cutting corkpaper involves considerable forces,so an important dF/dt could be expected.
Structure noise was measured with an accelerometer and as time records added to the airborne noise time records.
The relationship between structure noise and airborne noise was a confusing one,because the structure noise starts at 2,5 ms before the connecting line where the airborne noise just ends.
This means that the measured structure noise could not be the origin of the airborne noise.
But then,what was the origin of the airborne noise?
To find a way-out it was necessary to stop further acoustical work and to concentrate on the mechanical behaviour of the cutting elements.
Obviously there had to be some part that was excited and was radiating airborne noise.
An analysis of the cutting elements learned that each knife has a central adjusting screw which determines the negative clearance and thus the cutting force during cutting.
If a knife is not in a cutting position it is flown outwards by the centrifugal force calculated as being 4,6 Newton.
The gravity force is 1,5 Newton,so the resulting force in top-position will be 3,1 Newton,which is the minimum force.
This means that if a knife is not cutting it always tends to flow outwards.It is,however,held in position by means of two rings, being part of the kniferoller,that grip the two shoulders of the knife.
In this position the abovementioned adjusting screw is free.
There is in fact during each revolution of a knife an alternating impact,once between knife and rings and once between knife and central adjusting screw.
This could have been the origin of the measured airborne noise.
It was impossible to connect measuring instruments on the revolving system to find out which of the two possible noise sources was dominating.
Therefore an artificial method was chosen.

The knife roller was taken out of the machine and placed with its shaft on wooden blocks on the table in a very quiet room.
One knife was mounted and play between knife and rings and between knife and central adjusting screw was possible.
Near-field airborne noise measurements were carried out while impact noise was carefully caused by hand,assuring that only one of the possible sources gave the signal.

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No significant information was achieved from the impact between knife and central adjusting screw.
But the impact between knife and ring produced a signal with the same dominating peak in a 1/18 octave analysis as the one caused by a running machine.
Although the similarity was striking it could not be called an evidence.
It was,however,enough information to carry out an experiment on a running machine.
To that end the kniferoller was fitted with rubber rings,o-rings, between knife shoulders and rings,so that impact between these parts was totally impossible.
The result was that no further significant time record could be measured and that the noise radiated by the cutting device was lowered by 6 dB(A).
The whole investigation formed,together with their own work in this field, a basis for the machine supplier to improve the machine.
This work has now been completed.

What we learned from this project is that time records give useful information about movements of machine-parts.
Above all it is essential that,besides an acoustical treatment, the operation of a machine is known thoroughly.