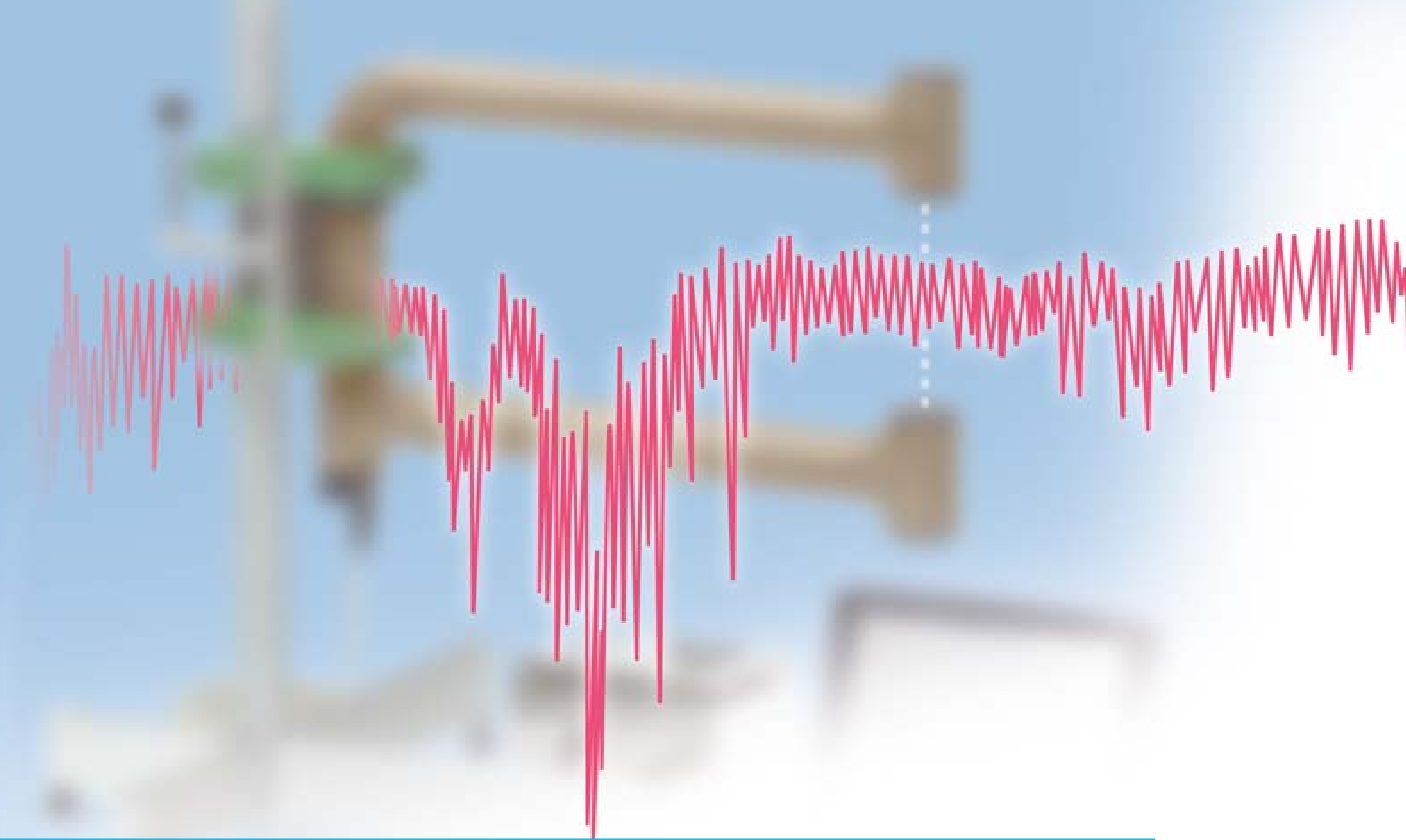

Press Release

Determination of periodic MD mass variations in the paper sheet

Establishment of their causes – ODIN measurement

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Establishment of their Causes – ODIN Measurement

Summary of Contents

Determination of periodic MD mass variations in the paper sheet

Summary

Measurement and control systems relating to mass variations **across** the sheet are installed and operating satisfactorily on most machines. However, these systems recognise only slowly changing dimensions in the sheet and production process.

Faster and more dynamic variations which logically only occur in the machine direction were previously rarely measured. These include periodic variations in mass, moisture or sheet caliper. Systems which involve **MD** measurements on the machine and simultaneously provide the possibility of relating the cause of mass variations in particular areas of the machine, in the approach flow or other parts of the process, are less well known.

A process is introduced here which collects the necessary data for such analyses and evaluates it. With the help of this system, not only are the MD variations obtained and presented visually, but also the exact location of the cause can be established.

Introduction

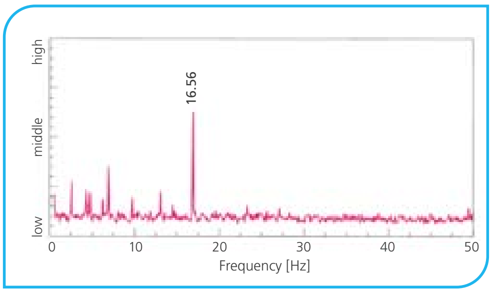
The cause of such MD variations can, for example, be level variations in the previous process. In the forming section disturbances caused by the shake and dewatering elements or even vacuum oscillations are possible causes. The largest group of possible causes can be found in faulty rotating or moving parts – starting with pumps or pressure screens in the approach flow, via rolls, forming fabrics and felts in the forming and press sections, up to the calenders before the reel-up.
The resulting **variations in the sheet** (MD variations) appear in different forms and can be related directly to the condition of these components and their constructional characteristics. Obviously the equipment necessary for Heimbach TASK specialists to carry out measurement and analysis, together with successful location of the causes, must be portable (Ill.1).

Ill.1 Transportable Measuring Equipment

The following case studies document the localisation of some causes at the calender, in the press section, the forming section and in the short circulation system. Papermaking practice determines the sequence of investigation: firstly, the quality **fault in the machine direction** of the sheet should be confirmed by measurement – only then can the source of the problem be sought.

Application of Measurement and Analysis Techniques

MD faults in the sheet are generally seen as **periodic variations** – as **deviations** from the mean of mass, moisture or sheet caliper – and are represented as frequency variations in the machine direction (Ill.2). On the running machine an infra-red beam with a diameter of 0.6 cm is transmitted through the sheet by the lens system of a measuring fork (“ODIN”) (Ill.3).



Ill.2 Variations in the sheet after a calender (35cm from drive side edge)

The signal which is received with the help of an optical sensor is proportionally related to the MD variations occurring in the sheet. (For simplicity only the expression “mass variation” is used in the following text). Mass variations can be recorded in the range of 0.1 –3000 Hz. By observing the time signals lower frequencies can also be recorded. Qualitative evaluations on the deviations themselves and quantitative judgements on their defined height cannot be made.

The space between the two arms of the ODIN measuring fork provides sufficient range of movement for sheet access; even sheet flutter does not cause any inaccuracies in the measurement.

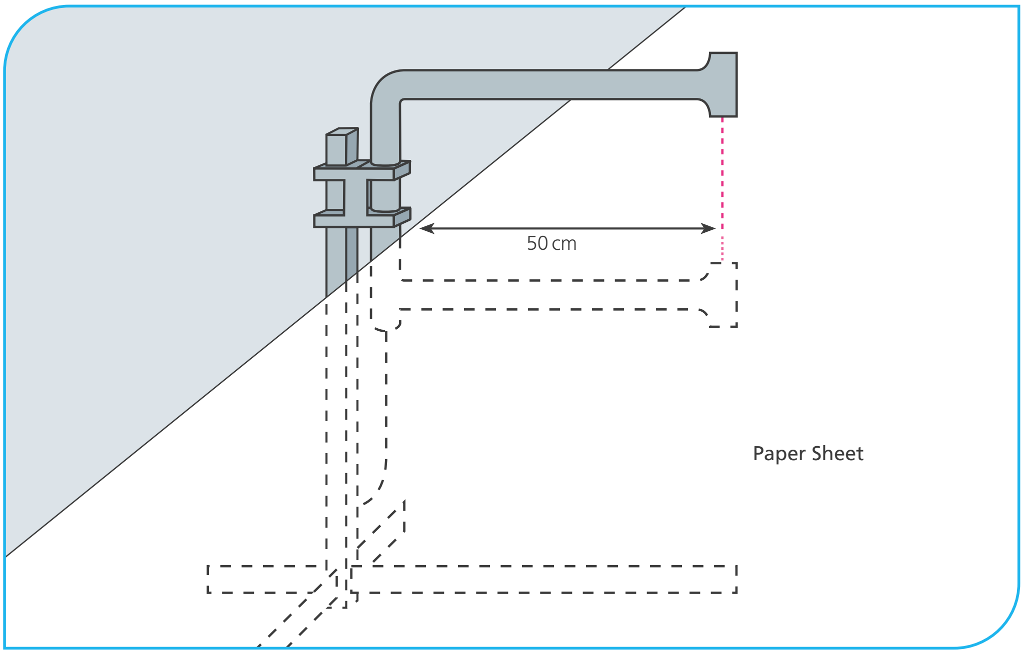
Machine direction faults are generally measured and recorded at the end of the paper machine before the reel-up. At this point all mass variations are visible irrespective of their cause. Logically the search for the cause or causes also starts at the end of the machine. In the course of the investigation measurements are made step by step backwards along the machine with the measuring fork to narrow down the problem source.

If space permits and it is possible to carry out measurements before **and** after a suspected faulty element, the localisation of the cause can be speeded up. Where space does not permit, additional measuring techniques must be brought into play, such as the recording of data on the most frequent problem source: **vibrations** on rotating or otherwise moving elements and/or **differential rotation speeds** of such elements.

These disturbances – as possible causes of the fault in the paper – can only be shown as **periodic oscillations** (frequency diagrams). The data recorded in this way are converted to dimensions, which are analytically comparable to the mass variations in the sheet.

With **data comparisons of one measuring position with another**, the appearance of the mass variation frequencies are highlighted. Only then, when the recorded frequencies (basic frequency – or its multiple = harmonic) agree with the frequencies of mass variation in the sheet, has the cause been found.

Further causes can be eg. variations in consistency, level, pressure or vacuum as well as idle times of control systems. These can be located as causes by time measurements. As already mentioned, the cause can be located at any point along the path



Ill.3 ODIN Measuring Fork

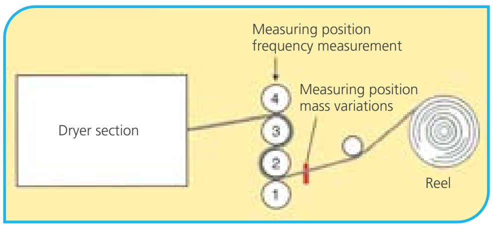
between the reel and the start of the papermaking process. Despite the sophisticated measuring technology, it is the analytical experience of the individual Heimbach TASK specialist, which leads to a rapid and reliable result.

In the following case studies the diagnostic and analytical process in the search for causes is shown. In addition, the examples show the high level of success achieved from the **combined** analysis of the two differing **measurement processes**, namely the determination of the frequency pattern of the mass variations and the establishment of the vibration frequencies of rotating or moving elements and in the short circulation.

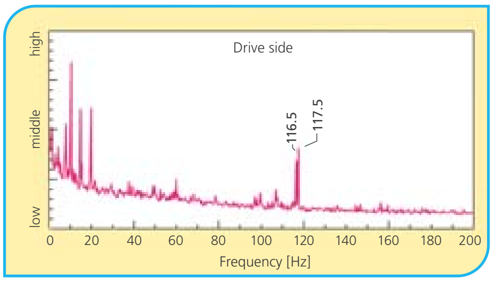
Case Study 1

Production: Newsprint
Problem: Barring in the sheet

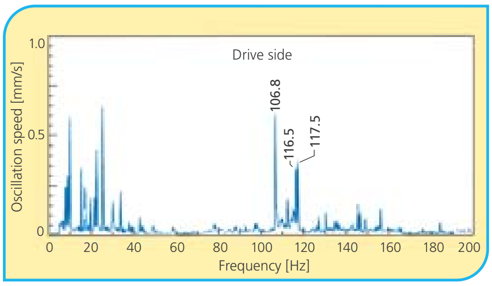
The first measurement on the drive side after the calender (Ill.4) showed mass variations in the sheet with the frequencies very close to each other of 116.5 and 117.5 Hz (Ill.5). As a result the rotation frequencies of the four calender rolls were measured together with a vibration analysis of the whole calender (Ill.6).



Ill.4 Measuring Positions – Case Study 1



Ill.5 Variations in the sheet after the calender



Ill.6 Vibration measurement on the calender

Rotation frequencies of calender rolls:

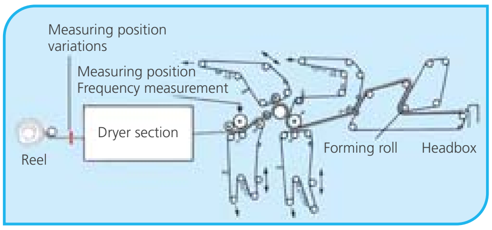
Roll 4	8.4289 Hz
Roll 3	9.7080 Hz
Roll 2	9.7920 Hz
Roll 1	7.5060 Hz

In the vibration diagram (Ill.6) the same two frequencies are clearly seen, which show the mass variations in the sheet (barring) as variations of 116.5 and 117.5 Hz. The comparison of these values with the rotation frequencies of the calender rolls shows the following result: The mass variation of 116.5 Hz is 12 times (the 12. harmonic) of the rotation frequency of calender roll 3, whilst the mass variation of 117.5 Hz is the 12. harmonic of the rotation frequency of calender roll 2. From this it can be shown that both roll 3 and roll 2 have developed 12 flats. From this situation and from the calender roll circumference a barring with a spacing of approx. 18cm was calculated and confirmed in the sheet.
It is worth mentioning a further interesting aspect: In the vibration measurement (Ill.6) a peak at 106.8 Hz with a high oscillation velocity can be seen. This is the 11. harmonic of the rotation frequency of roll 3. Although this frequency dominates in the vibration, it does not show up in the sheet.

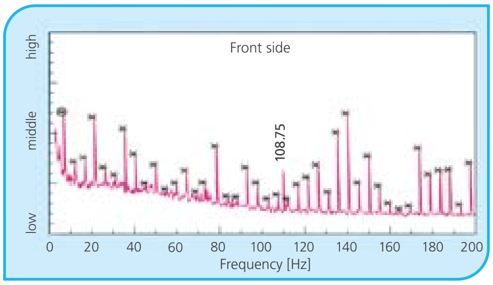
Case Study 2

Production: 54 g/m^2
No quality problem as yet

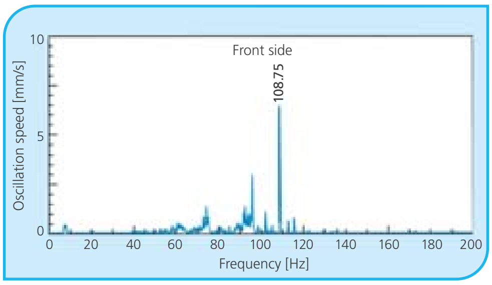
On the occasion of a routine measurement of the sheet immediately after the dryer section on the



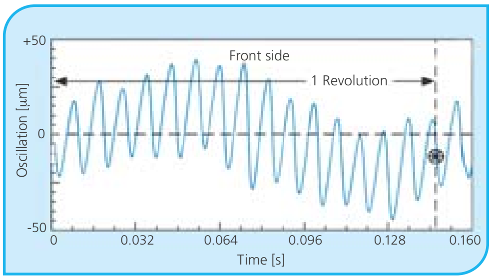
Ill.7 Measuring Positions – Case Study 2



Ill.8 Variations in the sheet after the dryer section



Ill.9 Total 4. Press oscillations, measured on top roll in nip direction



Ill.10 Synchronised time signal of the venta roll, measured on top roll in nip direction

front side (Ill.7), a number of mass variations were recorded (Ill.8). In searching for the cause in the direction of the headbox two disturbance factors crystallised:

Firstly, the total vibration measurement of the 4. Press measured on the top roll in the nip direction (measuring position in Ill.7, Ill.9), at 108.75 Hz showed an oscillation velocity of over 6 mm/s. This frequency was found to be the 16. harmonic of the rotation frequency of the venta roll of 6.7968 Hz, as confirmed by the synchronised time signal of this roll (Ill.10).

The rotation diagram shows 16 peaks being the 16 flats on the surface of the venta roll. However, this disturbance factor is only one of the many peaks in both diagrams (Ill.8 and 9), namely the one at 108.75 Hz. In this case it was only possible to recommend that the venta roll of the 4. Press should be changed.

However, this did not identify the cause of the many other mass variation frequencies. In continuing the search the cause could be found by means of synchronisation of all the rotating parts of the press and the forming sections.

The forming roll of the twin wire former (see Ill.7) provided with its basic frequency (rotation frequency) of 4.82 Hz the starting point for all frequency values which were a multiple (an x. harmonic) of this basic frequency, marked with an asterisk in Ill.8.

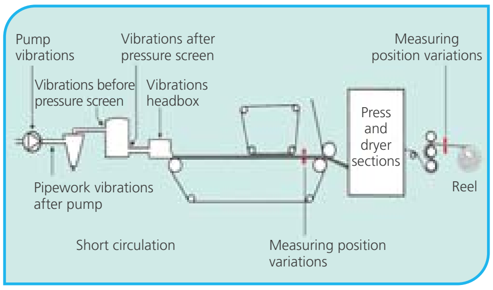
In the event of future deterioration of this roll during production causing severe mass variations in the sheet, the cause has now been identified.

Case Study 3

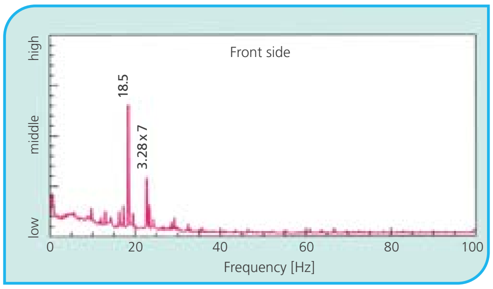
Production 70 g/m^2
Problem: Barring in the sheet

The first measurement after the calender (Ill.11) produced various mass variations in the range of 10-37 Hz including, however, a significant deviation at 18.5 Hz (Ill.12).

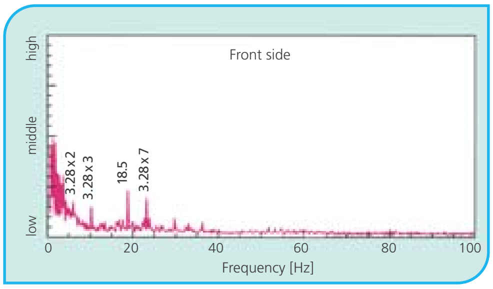
During spot checks on the sheet in the direction of the headbox the same values kept reappearing. This applied also to the frequency pattern recorded on the bottom wire after the top wire former (measuring position in Ill.11, Ill.13).



Ill.11 Measuring Positions – Case Study 3



Ill.12 Variations in the sheet after the calender Forming wire shake frequency 3.28Hz, Stroke 7

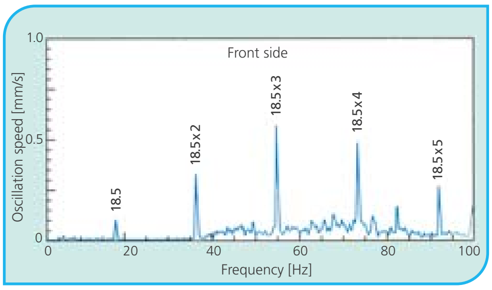


Ill.13 Variations in the sheet after the twin wire former Shake frequency 3.28Hz, Stroke 7

A test carried out by increasing the shake frequency and stroke of the bottom wire and also by disconnecting the shake resulted in the measurements after the twin wire former showed increased deviations from the mean basis weight. Only the peaks at 18.5 Hz remained unchanged.

This proved that the shake – irrespective of its frequency – was **not** the cause of the mass variation. Further investigation in the short circulation system all measurements showed up the 18.5 Hz oscillation.

Finally, a total vibration analysis in the axial direction on the stock mixing pump, which showed several harmonics of 18.5 Hz (measuring position in Ill.11,



Ill.14 Total oscillations of stock mixing pump in axial direction

Ill.14) led to success – in combination with the rotation frequency of this stock pump which was found to be exactly 18.5 Hz.

These findings explain the presence and the constancy of the of the mass variations throughout the whole paper machine. The stock pump created a disturbing impulse in the stock flow once per revolution, which then showed up in the formation as a mass variation in the machine direction.

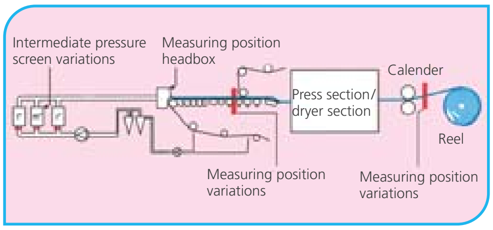
When the stock pump was opened up, it was found to be heavily contaminated particularly on one blade. After the whole pump was thoroughly cleaned the barring at 18.5 Hz was immediately eliminated.

Case Study 4

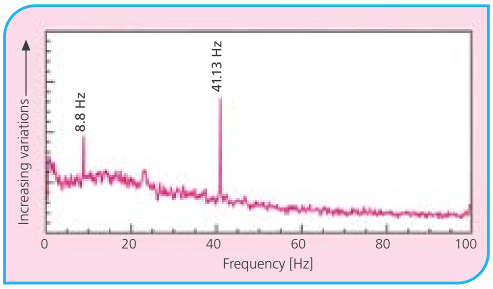
Production: 80 g/m^2
Problem: Barring in the sheet

The first measurement before the reel (Ill.15) was taken at a fabric speed of 855.7 m/min and showed a dominant peak of mass variations at 41.13 Hz (Ill.16). All further measurements in the direction of the headbox including the measurement between Vacufoils 1 and 2 showed this mass variation at the same frequency 41.13 Hz (Ill.17).

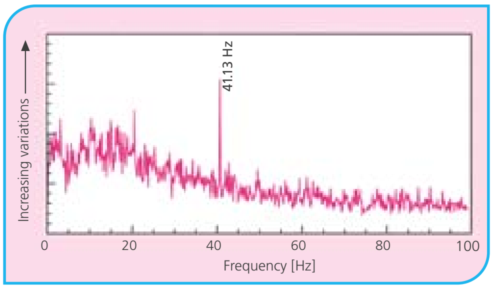
Even a trial increase in the fabric speed to 868 m/min resulted in no change. This confirmed that the machine speed had no influence on the sheet barring.



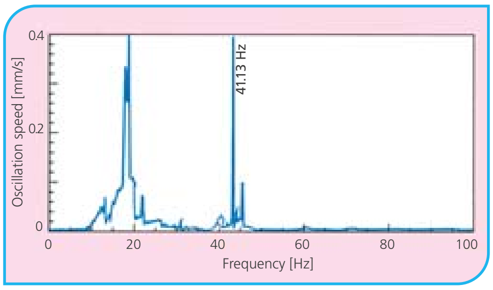
Ill.15 Measuring Positions – Case Study 4



Ill.16 Variations measured before reel 855.7 m/min



Ill.17 Variations measured in the forming section at 855.7 m/min wire speed



Ill.18 Oscillations of intermediate pressure screen in radial direction top; wire speed 855.7 m/min

Vibration measurements at the headbox, at the valves of the centrifugal screens and at the screens themselves repeatedly showed a frequency of 41.13 Hz. At the middle pressure screen, however, the highest amplitude in this critical frequency range was measured (Ill.18).

With a special computer program it is possible to relate disturbing frequencies to a bearing, when the type of bearing and the number of revolutions are known. With this technique it was possible to establish that the rotor bearing of the middle pressure screen was the cause of vibrations in the critical frequency range. Despite the fact that no damage to the rotor bearing was visible, a change was made. After installing the new rotor bearing in the pressure screen the disturbing frequency was no longer present as vibration and as mass variation.

Case Study 5

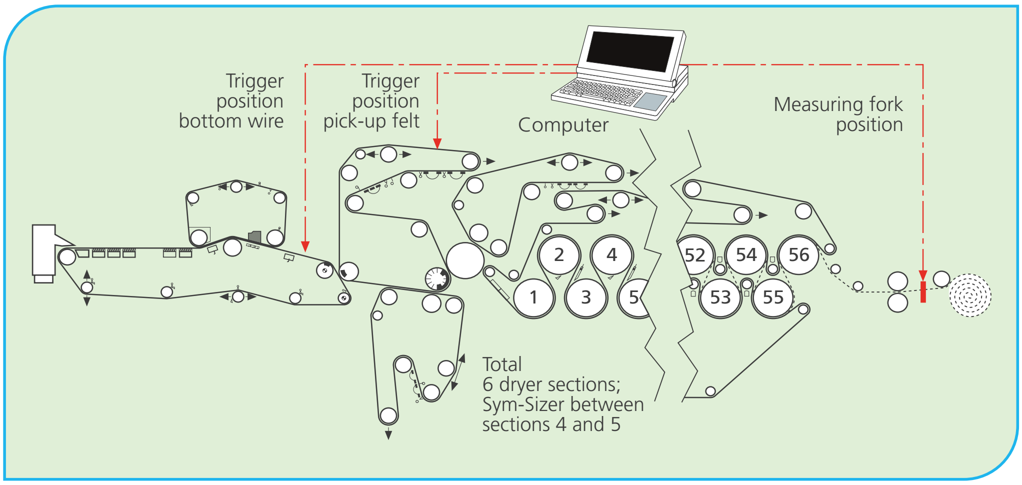
Production: Writings and printings 80 g/m^2
Problem: Sheet marking

Following the installation of a new bottom fabric in the forming section marking across the sheet was visible in the finished paper. The spacing of this marking was approx. 32 m; its width was only a few cm. Initially there seemed to be no connection to the installation of the new fabric.

Measures taken: Firstly, the papermaker decided that the central roll in the press section was in bad condition (vibration). The central roll could have affected the pick-up felt which had a length of approx. 32 m. It was assumed that the pick-up felt had transmitted the mark to the sheet. As a result both the roll and felt were changed, but the sheet marking remained.

Procedure and outcome of Heimbach measurements:

The ODIN measuring fork was installed on the drive side of the machine before the reel (Ill.19). As the disturbance was at a frequency well below 1 Hz and in addition, regularly, but only very briefly peaked, a frequency analysis would have provided no information. Therefore time signals were examined.



Ill.19 Measuring Positions in the Paper Machine – Case Study 5

In order to localise the cause, the revolution or rotation signal of a "suspicious" forming fabric, press felt or dryer fabric was established and the measurement from the sheet synchronised with it.

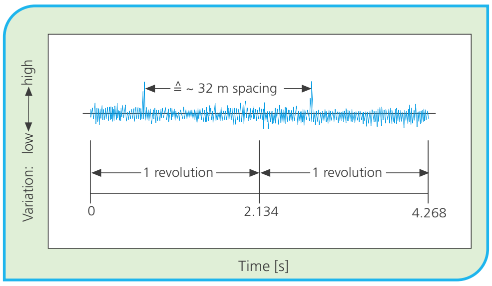
Measurements were then made step by step moving from the reel towards the headbox in order to find the position where the frequency pattern **no longer** tied in with the disturbance (mass variation).

The cause must be found between this point and the last point where the frequency pattern showed the disturbance.

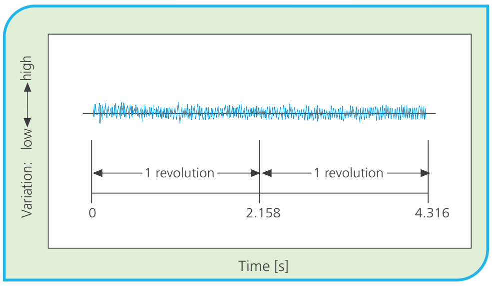
Finally, the recently changed bottom forming fabric, which incidentally was also about 32 m long, was identified as the cause of the disturbance (see trigger position bottom fabric (Ill.19).

Ill.20 shows the high peaks causing the disturbance in the sheet from the bottom fabric. For confirmation two revolutions of the fabric were checked (see Ill.20). The peaks occur clearly at a spacing of 32 m (one per revolution).

In comparison, Ill.21 shows the synchronised measurement on the pick-up felt. There was no noticeable influence of the pick-up felt on the sheet, although at 32 m long it had originally been thought to be the cause.



Ill.20 Trigger Signal Bottom Wire (Forming Section)



Ill.21 Trigger Signal Pick-up Felt

This example shows that occasionally the cause of a problem can be localised and identified even without repeated installation of the sometimes difficult to position ODIN – and that over a distance of about 100 m between recognising the disturbance (measuring fork position) and the cause.

In this case a faulty bottom fabric was the cause of the marking in the sheet. This demonstrates that the "textile components" on the paper machine – that is both the fabrics and the press felts – can also create periodic mass variations.

Determination of periodic MD mass variations in the paper sheet

In order to avoid this type of cause it is strongly recommended that only high value clothing is installed. This applies equally to positions, which are sometimes seen to be making a "secondary contribution to the production process".
Based on their long practical experience Heimbach places great emphasis on manufacturing precision. For example all the forming fabrics of the PRIMOBOND range, a world wide success, are equipped with seams which have precisely the same caliper as the remainder of the fabric.

The permeability of the seam area is also virtually identical to the rest of the fabric. Optimum caliper fabric structure regularity is a major feature of this SSB fabric range.

Similar characteristics also apply to endless press felts and the CONNECT range of seamed felts to ensure efficient, trouble-free installation.
Typical for Heimbach press felts are their compression resistant structures and their outstanding resilience.

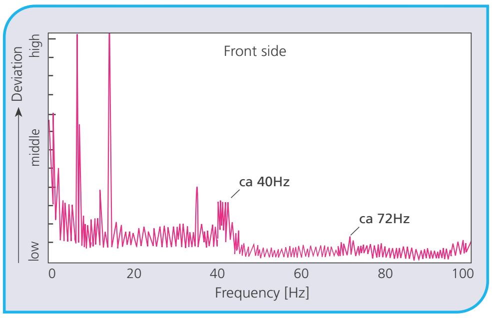
In this respect the ATROMAXX multi-axial felts and the layered substrate non-woven felts have proved themselves in a wide range of positions around the world.

The total of these characteristics, which combine in a felt or a fabric, contribute to smooth runnability and outstanding dewatering, with the result they apply a regular application of pressure to the sheet and contribute to the prevention of mass variations.

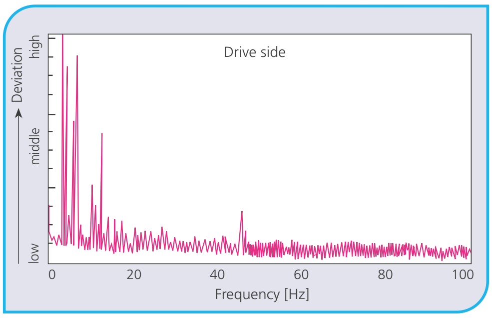
Case Study 6

Production: LWC, online coated, 48 g/m^2
Problem: Mass variations in the sheet

On this LWC machine relatively high MD mass variations were observed before the calender, particularly on the front side. The diagram in Ill.22 shows a measurement with the ODIN measuring



Ill.22 Mass Variations before the Reel – Case Study 6



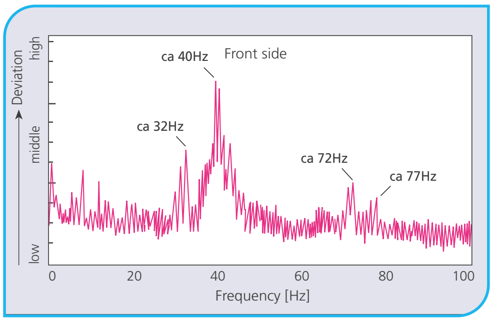
Ill.23 Mass Variations before the Reel

fork on the sheet before the reel-up. The peaks around 20 Hz are not relevant, as was later established; they have other causes, eg. from the calender rolls (thickness variations). How-ever, the peaks around 40 Hz and 72 Hz, as shown in Ill.22, are of importance for the mass variations. A relevant measurement on the drive side (Ill.23) hardly shows any comparable peaks.

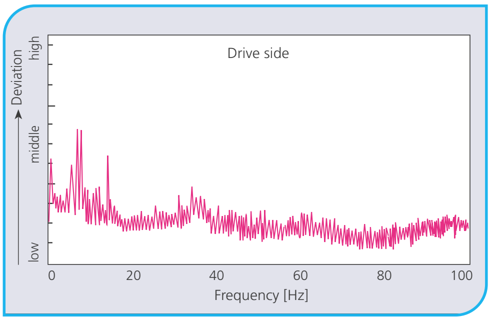
Procedure and outcome of Heimbach measurements:

Further measurements were taken in steps from the reel towards the headbox, initially on front and drive side before the calender (Ill.24 and 25).

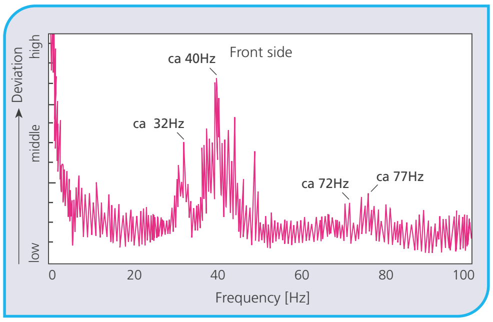
Particularly on the front side measurement the peaks at 40 and 72 Hz are more defined than at the reel – and here also the tendency was clear:
the variations were significantly greater at the front side than at the drive side. The last measurement was on the front side of the forming fabric before the top former and immediately after the 2. Vacufoil section (Ill.26).



Ill.24 Mass Variations before the Calender



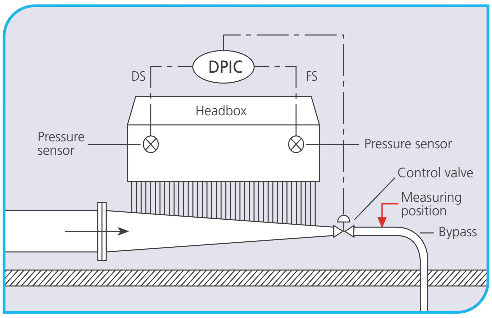
Ill.25 Mass Variations before the Calender



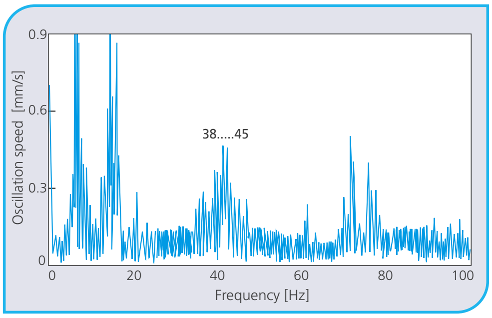
Ill.26 Mass Variations after the 2. Vacufoil section before top wire

Despite the high level of water removal at this point the curve shows a close comparison with the signals from the finished sheet (see Ill.22 and 24).
As a result the suspicion hardened that the cause of the disturbance was not to be found here in the forming section but rather in the approach flow system.

The subsequent measurements on pumps, screens etc. provided no clues; the pattern of the disturbance would also not have been typical for such a source. Also vibration measurements on the bypass pipework to the headbox just after the control valve (Ill.27 and 28) produced no clear agreement.

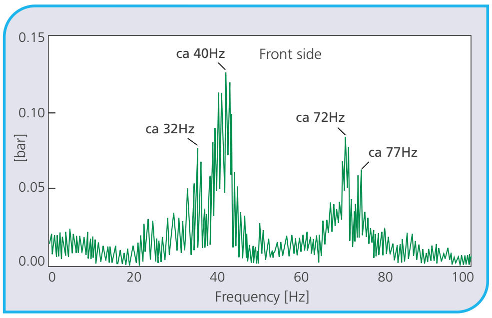


Ill.27 Schematic Layout of Pressure Sensors and Headbox Bypass



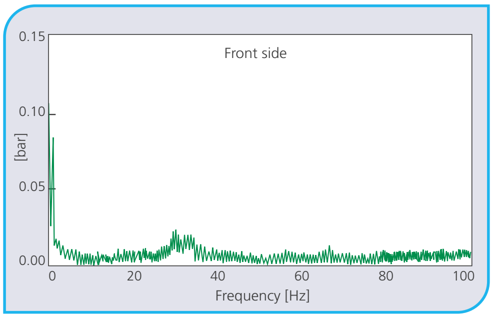
Ill.28 Vibration at Headbox Bypass

The machine measured in this example has pressure sensors installed at front side and drive side of the headbox – and here the breakthrough was made: a frequency analysis (FFT) of the signal of the front side pressure sensor supplied the unambiguous agreement (Ill.29) with the measurement signals on the finished sheet (see Ill.24). The stock entry was on the drive side and the stock exit on the front side – where the control valve was positioned.

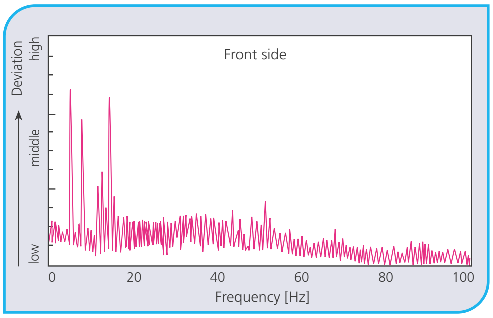


Ill.29 FFT pressure signal at headbox before change of control valve

As a result of this diagnosis Heimbach recommended the replacement of this valve with an improved version. Proof of the validity of this advice is seen in the diagrams in Ill.30: frequency analysis of the front side pressure sensor, and Ill.31: measurement of the sheet with the ODIN measuring fork on the front side before the calender – both after changing the valve. Also the peaks in the sensor pressure signal and also in the MD mass profile have been eliminated. The measuring and diagnostic effort involved in this case study was very comprehensive, but the efforts were more than rewarded by the discovery of a "confusing" cause.



Ill.30 FFT pressure signal at headbox after change of control valve



Ill.31 Mass Variations before the Calender after change of control valve

Conclusion

These practical examples show clearly that with the help of this sophisticated measuring equipment, combined with the relevant analytical experience, hidden and sometimes "insidious" causes of mass variation can be tracked down.

A prerequisite for the continued avoidance of these problems is the competence of the "diagnostic team", who are able to draw from the series of measurements valuable technical data and to deduce from these practical recommendations for the elimination of problems.

The permanent installation of an ODIN measuring fork before the reel to record MD mass variations, would only appear to be a sensible step for those machines which are already equipped with vibration measuring instrumentation.

It should be mentioned that the installation of the portable equipment is sometimes extremely difficult. Cooperation between paper machine builders, paper mills and Heimbach should however make it possible for easy and risk free installation of such equipment at low cost.

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