2013_Vol. 2

SCHENCK
Balancing and Diagnostic Systems

# balancing news

Information on the quality and performance of rotating equipment - From the Schenck Balancing & Diagnostic Systems Group

## Schenck Mentors High School Students to a win in a Regional Robotics Competition

### Congratulations Hauppauge - Robotics Eagles


Schenck Trebel Corporation provided mentorship and support to local Hauppauge High school students and the regional FIRST® (For Inspiration and Recognition of Science and Technology) Robotics Competition (FRC) held at Hofstra University in Long Island, NY, April 5-6, 2013.

The Hauppauge Team #358 – The Robotic Eagles contacted Schenck for guidance and mentorship to improve the maneuverability and performance of their competition robot.

The FRC (FIRST® Robotics Competition) of 2013 entailed building a robot (in 6 weeks) that is able to throw Frisbees accurately into netted, boxed goals and climb pyramid shaped obstacles.

Over 10,000 spectators gathered at Hofstra University to watch over 50 teams of high school students compete at this Long Island Regional robotics competition in hopes of earning a spot at the FIRST USA Championship held in St. Louis, Missouri.


After over 80 matches, Team Robotic Eagles placed 1st in the competition, allowing them the opportunity to participate in the national championship in St. Louis, Missouri. The team also received the coveted Chairman's Award. Schenck Trebel Corporation was proud to be a part of this event by supporting the future of LI students and aiding in the advancement of youth engineering and technological education.

Working shoulder-to-shoulder with the Hauppauge students in the development of their technological literacy was a rewarding opportunity for Schenck, to engage in the shaping of our future engineers.

Schenck is a proud sponsor of the SBPLI (School-Business Partnership of LI) - a nonprofit organization establishing programs that link high schools and businesses throughout Long Island. Schenck Corporation's President and CEO, Bertram Dittmar is also a board member of SBPLI.

IN THIS ISSUE:

# Driveline Balancing Trends

Rob Zielkowski: Product Manager – Driveline, Schenck Rotec Corporation

## Critics proven wrong!

About twenty years ago, and again during the recession of 2009, there were two truisms generally accepted:

- Rear wheel drive vehicles and their associated drive shafts would soon be virtually extinct
- With the existence of over 100 driveshaft balancing machines in North America, few new machines would be required.

Move on to 2012, and what has happened?

- With the advent of SUV's, combined with the survival of the truck market, vehicles with rear wheel drive not only survived but their numbers have steadily increased.
- The demand for vibration-free vehicles is gradually rendering obsolete the majority of existing driveshaft machines.
- Now, not only is there a large market for driveshaft balancing machines, but complete axle assemblies are routinely balanced, creating a demand for a new type of machine.

Figure 1: Typical Driveshafts

## The Vanishing Vibration and Tolerances

Full size American cars, along with medium size trucks were typically built with a large separate frame, combined with soft suspension, effectively isolating cabin occupants from noises and vibrations going on beneath them. Both design features have been phased out and vibrations from the driveline now pass easily through the cabin. Even with the advent of the luxury SUV and its expected level of ride refinement, the fact that it basically has a medium truck chasis design makes the challenge of reducing vibrations due to unbalance more difficult. As a result balance/ vibration requirements are tighter and balance tolerances reduced. This variation of tolerance over time is illustrated clearly in the graph below:

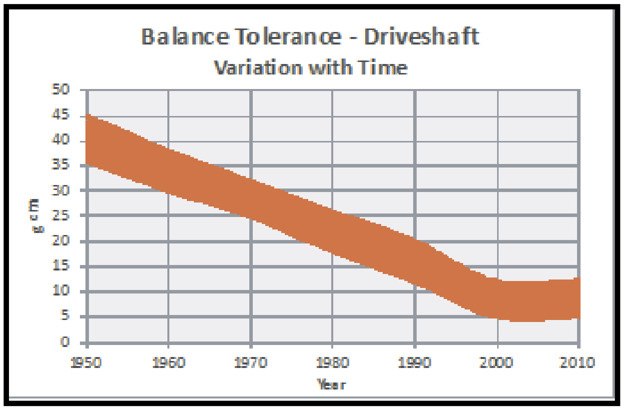


Figure 2: The vanishing driveshaft tolerances

The leveling off of tolerances in the 21st century is perhaps not because of the lack or need for reduced vibration, but rather because the practical limits of manufacturing, both of part and machine are being reached. The achieved balance repeatability of modern Schenck propshaft machines, less than 3 gmm, is the equivalent to a spindle accuracy of below 0.1 µm, or 4 µin. So it is not surprising that 25 year-old machines are inherently incapable of these modern tolerances, and so are being replaced. For some parts, requested tolerances have approached 5 gcm, which is only achievable by close collaboration between the driveshaft manufacturer and drive shaft machine builder.

Figure 3: Schenck 200X Driveline Balancer

## The Advent of Axle Balancing

Up until 30 years ago, the only balancing of a rear axle was with what is known as the “third member.” Only the front portion of the axle housing with the drive pinion was balanced. Over time tests however, revealed that the balance of a complete axle assembly varied with speed. Therefore, a requirement was established to balance the complete assembly at its most critical operating speed of 3200 rpm. This corresponds to a vehicle speed of approximately 110 km/hour. The method of balancing complete axle assemblies in now common practice in North America, and has generated the need to balance parts that typically weigh over 100 kg in volume production.

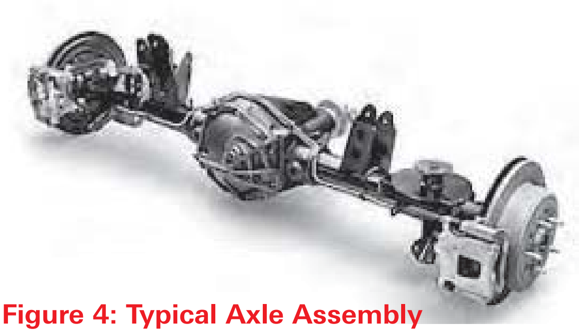

Figure 4: Typical Axle Assembly

Again, over the last few decades these tolerances, as with driveshafts, have fallen dramatically.

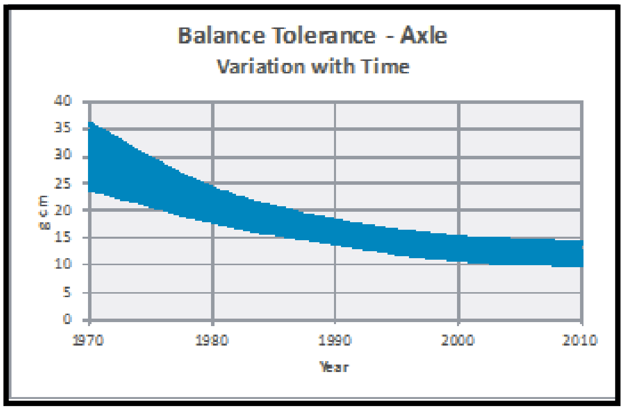


Figure 5: The Vanishing Axle Tolerances

The trend is remarkably similar to the driveshaft trend. The only significant difference is that the lower limit of tolerances is around 10 gcm, not the 5 gcm sometimes specified for drive shafts. This is not because of lack of demand for such low tolerances, but rather that the current design of typical North American rear axles renders this tolerance impossible to reach.

## Rear Axles Manufactured Overseas

Rear axle vehicles in Europe (and Japan) are almost exclusively manufactured for low volume, luxury vehicles. Since the individual critical components of the axles are manufactured to very tight tolerances, usually balancing of the rear axle is not performed.

Whether this is more cost effective than a simple final axle balancing operation - remains to be seen.

## Modern Simple Axle Balancer

In the past, Schenck produced a number of different machines for balancing axle assemblies based on customer requests. Today we have developed a standard design with minor variations that is readily available. Shown in the picture below, the axle is balanced in a horizontal (in-vehicle) orientation, which is the new normal customer requirement.


Figure 6 Standard Horizontal Axle Balancer (Without Guards)

This is a semi-automatic machine: once the axle is loaded by a robot or operator, it measures, corrects by drilling, and performs an audit balance run. It can also automatically perform a 180° index if required. This machine has received wide acceptance by the major North American axle manufacturers.

****Continue on to the next article to find out more on these and other balancing machines/ equipment.**

## Driveshaft Balancing - Low speed, high speed, flexible rotor balancing and analysis

Joseph Palazzolo: Senior Applications Engineer, Supervisor Balancing Services - Schenck Trebel Corporation

Driveshaft balancing requires the utilization of several techniques and a keen eye for successful results. The behavior of a driveshaft must be carefully observed and analyzed with the proper vibration analyzing tools.

These rotor types are typically long slender tubes with operating speeds reaching above their first critical speed. An object is said to reach critical speed when the speed of its rotation corresponds to one of its natural frequencies. This means the shaft will pass through a resonance on its way up to operating speed, as well as during deceleration of the shaft. The shaft will flex as it approaches its critical speed creating high vibration in the system. The definition according to ISO 1925 of a rotor in a flexible state is where it deflects due to modal unbalances during rotation.

Several special balancing procedures can be used to reduce the modal unbalances. These include low speed, high speed and multiple speed balancing procedures, depending on the characteristics of the rotor.

**Figure 1: Fixed Spindle Pedestals and Safety Pedestals with Tooling and Driveshaft**

Schenck's HK40 balancing machine is a special machine designed specifically for balancing driveshafts, both rigid and flexible. When used in conjunction with our portable vibration analysis equipment, flexible shafts can be low speed balanced and the flexible characteristics are measured, analyzed; and a correction technique is then developed.

The Schenck Model HK40 with CAB 920HS balancing machine employs a fixed spindle mounted onto the supports which incorporates a flange to mount the drive shaft. High speeds and dynamic loads are made possible by using high performance, permanently-lubricated bearings in the spindle assembly, and a high speed belt drive system. The rigid structure of the supports can accept the large initial unbalance forces associated with flexible drive shaft balancing. The design of the supports makes it possible to safely balance flexible drive shafts and free of system resonances.

The CAB 920HS utilizes our high speed functions for measuring run-up and vibration velocity monitoring of Bode and Nyquist plots used for additional analysis of the rotor(s). The Schenck HM40 can be utilized similarly for certain shafts without a flange mount provided they have journals that can be run on open rollers.

**The CAB 920HS Instrumentation includes the following High Speed Functions:**

- Measurement During Run Up Software - allowing the operator to observe and monitor rotor behavior and plot the unbalance readings. The dynamic behavior of the flexible drive shafts can be plotted and monitored during acceleration and deceleration.
- Vibration Velocity Measurement - used to analyze resonance peaks after passing a critical speed of the system. At over-critical speeds, the bearing forces are steady, which allows the use of the vibration velocity mode. In this mode of operation, the increased forces are proportional to the increase in speed and can be monitored.
- Double Frequency Mode – The effects of a critical speed can be seen by running at half the critical speed. This can also be used to predict when the rotor will reach its first critical by running at a safe operating speed (50% of the actual critical speed). This increases the safety to both the operator and balancing machine.

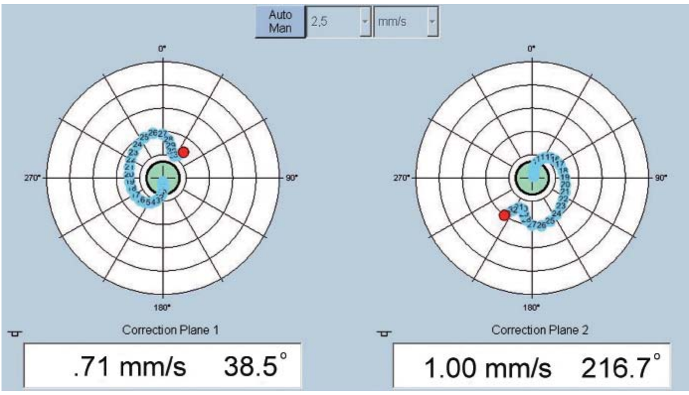


**Figure 2: CAB 920HS Nyquist Output Plot**

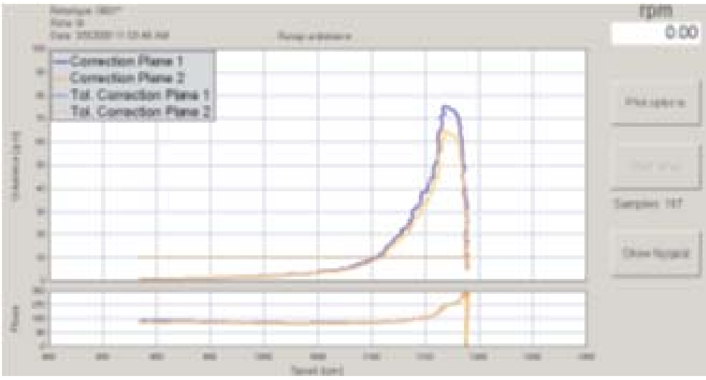


**Figure 3: CAB 920HS Bode Output Plot**

As an added safety measure, the machine uses two top loading safety pedestals. These safety pedestals are designed to contain the drive shaft assembly in the event of component failure that results in the drive shaft becoming liberated from the spindle-based retention system.

**Figure 4. HK40 balancing machine support and safety pedestal.**

The HK40 support is quite rugged and durable for balancing flexible rotors at high speeds.

Note the rugged construction of the spindle housing and dynamometer. The Safety Pedestal features a removable bar to ensure convenient rotor loading and unloading.

The Bearing Force Measuring and Monitoring System is a safety device incorporated with the HK40 balancing machine supports. The system measures the effective centrifugal force on the balancing supports (rotor bearings) and has adjustable limits for machine shutdown and alarm functions.

**Figure 5. Our Force Monitoring System is designed to shut down the HK40 balancing machine should excessive vibration resulting from a resonance condition be sensed.**

Figure 5 shows the vibration monitor mounted to the pedestal-mounted spindle. The spindle features permanently-lubricated ceramic bearings. Note the rugged design of the spindle assembly.

In the event that the drive shaft is approaching a critical resonance, the Force Monitoring System will automatically shut the drive down protecting the operator from injury, as well as preventing damage to the drive shaft and the balancing machine. The unit is constructed from components of our standard VC4000 series of monitoring instrumentation. It will monitor and display the percent of the maximum allowable force for each support. There are two set limits available with this system. The first limit can be connected to an alarm or bell to alert the operator that the pre-set limit has been reached. The second limit is used to shut down the machine's drive system when this limit has been reached.

**Mid-Shaft Displacement Measurement:**

With use of our portable balancing and vibration analysis equipment, we can take mid-shaft deflection measurements as well as measurements at multiple locations along the length of the shaft. This allows us to measure the low-speed, or slow-roll, run-out of the shaft as well as track the deflection response from low to high speed.

Additionally, using two sensors, set at a 90 degree angle from each other, the orbit of the shaft can be measured and displayed. **(continued....)**

**The VIBROTEST 60 and VIBROPORT 80 are both suitable for this type of work.** These modular devices allow individual combinations of measurement functions for data collecting, field balancing, tracking, overalls, machine diagnosis, spectrum analysis, and more. Speed measurement, bearing vibrations, shaft deflection and vibrations are reported into a PC card for memory and can be stored, viewed and manipulated in our PC-reporting software.


**The VIBROTEST 60 Portable Analyzer**

The mid-shaft deflection measurement of the "as-is" shaft can be recorded. A temporary 3-weight set (a weight at the center and a weight at each end of the shaft, 180 degrees opposite the weight in the center) is added to the shaft to impose an influence onto the shaft and the amount and orientation of the weight set location is determined so that the weight set will reduce the amount of deflection in the shaft as it approaches and passes through the shaft's critical speed. The amount and angle of the weight set is adjusted to optimize the response of the shaft. Once the shaft's tracking response is within an acceptable range, one additional 3-weight set is added to the shaft. This set of weights is used to produce an influence coefficient when the shaft tracking response is compared with the response from the previous run. This influence coefficient is used to show the difference between the two different shaft conditions and a deflection change is calculated. This deflection change, accounting for run-out compensation, can then be converted into an unbalance amount. The temporary weight set correction can then be made permanent by either permanently adding or removing material to duplicate the added temporary weight set. Based on the deflection response, a tracking analysis plot can be made which shows the deflection magnitude and phase angle at the mid-shaft deflection sensor.

It must be noted that when attempting to calculate the unbalance based on the deflection, using influence coefficients, at or near the shaft's peak resonance response can produce erratic results in the tracking response, which can have an effect on the calculated results. These results should be reviewed carefully.


**Figure 7: The VIBROPORT 80 Analyzer**

The VP-80 is the newest product in portable instrumentation to be offered by Schenck.

With the use of additional equipment, we may be able to predict the first and possibly the second critical speeds for the driveshaft without rotating the shaft, at all. The calibrated hammer test (or bump test) can be used to predict the critical speed prior to running the shaft up to speed.

The calibrated hammer test is performed to find the natural frequencies in a structure as it is related to the resonance of the structure. A calibrated hammer test uses a hammer with a force sensor mounted on it to strike the shaft being tested. This provides information on how much energy is going into the shaft via the hammer strike and at what frequencies. This provides phase information which is used to confirm that certain frequencies are natural frequencies. This type of analysis provides a great deal of useful information about the shaft prior to ever spinning the shaft to high speeds.

**Schenck Trebel has employed similar techniques of balancing high speed flexible rotors for industrial, automotive and aerospace applications. This equipment and these techniques are utilized by the US Navy, Jet and Helicopter Engine programs for large and small aircrafts, Machine Tool manufacturers and NASCAR.**

**To find out more about the VIBROPORT 80, continue on to the next article....**

# The VIBROPORT 80 (VP-80)

Yulian Filler - Applications Engineer, Schenck Trebel Corp.

Its capabilities range from a portable balancer to a 4 channel machine analyzer, allowing the user to maintain critical assets effectively by helping them decide what kind of maintenance procedure is required. The VP-80 gives a true picture of the machine's condition and allows the user the flexibility of choosing and adding application modules such as Transfer Function, Acceptance Testing, and Tracking.

The VP-80 can be used with the Report and Examiner (ReX) software that is compatible with all current versions of windows software and gives the user the ability to generate reports from the measurements stored on the instrument. The premium version of the software allows the user to analyze the stored time signal data sets and post process them, calculating the FFT and display them in a waterfall spectra plot. It also allows the analysis of rolling element bearings (REB's) for defects and can match the common REB's to their characteristic fault frequencies using an OEM database.

**Features:**

- **Explosion Protection (Hazardous Area)**
  - VP-80 E: ATEX / IECEx
  (II 3G Ex ic IIC T4 Gc; Ta=-10°C bis +50°C)
  - VP-80 : CSA
  (Class 1; Div 2 Groups A, B, C&D; T4A@Ta=50°C)
- **Overalls**
  - Overall, Bearing Value, Crest Factor
  - Simultaneous Visualization Of up to three vibration units (a,v,s)
- **FFT Analyzer**
  - Simultaneous display of Spectrum and Time signal
  - Cross channel phase (difference) without reference
  - Harmonic and Peak cursor
  - FFT: Window overlap, resolution up to 25,600 lines
- **Balancer**
  - Views: 2-plane Polar graphic / Table / Bargraph
  - Threshold monitoring (vibration value)
  - 2-plane balancing with one sensor
  - Manual entry
- **Tracking**
  - Data aquisition of up to 3 vibration chls. + Reference with arbitrary repeatable post-processing!!
  - Bode Diagram, Nyquist, Waterfall, Spectogram
  - Up to 4 orders
- **VIBROPORT 80 Firmware – Highlights**
  - Up to 4 vibr. channels plus speed/reference
  - Frequency range: (DC) 0.18 Hz to 80 kHz
  - Cross-channel functions (dual channel)
  - (Orbit, Max X/Y, Cross-channel phase)
  - Pre-defined measurement setups
  - Time signal support
  - Manual input range options (for vibration and reference/trigger)

Possessing a wide screen for easy data display, a more powerful processor and a long battery life, the VP-80 is what you need to diagnose and maintain a successful preventative maintenance program.

# Trade Shows 2013

**Visit us at our upcoming trade shows to explore new Schenck products and service offerings.**

**Stop by our booth (209-211) at the ADS show and view the demonstrations of our New TB Series - the TBcomfort and TBsonio - Schenck's two machines created for balancing during turbocharger overhaul**

| | | |
|---|---|---|
| **ADS**<br>Manchester Grand Hyatt<br>San Diego, CA | July 30-Aug. 2 | Booth 209-211 |
| **Pump/Turbo Symposium**<br>George R Brown Con. Ctr.<br>Houston TX | Oct. 1-3 | Booth 1131-1133 |
| **PowerGen**<br>Orange Cty Conv. Ctr.<br>Orlando, FL | November 12-14 | Booth 3259 |

# Schenck Academy

**Designed for the balancing professional by the balancing experts.**

Our balancing seminar program is designed to give both maintenance and manufacturing personnel the opportunity to learn new concepts, and improve skills. "Universal theories," applicable to all balancing machines are presented in an interactive environment where students can discuss particular problems and experiences. Hands-on sessions are used frequently to reinforce theory and practice the skills that have been learned.

## Seminar and Workshop Schedule

### July

| | | |
|---|---|---|
| Balancing Workshop IV | July 26 | Santa Ana, CA |

### August

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|---|---|---|
| Balancing Workshop III | Aug. 16 | Chicago, IL |
| Fundamentals of Balancing | Aug. 20-22 | Deer Park, NY |
| Certification Level 1 Exam | Aug. 22 | Deer Park, NY |

### September

| | | |
|---|---|---|
| Balancing Workshop I | Sept. 6 | Houston, TX |
| Balancing Workshop VI | Sept. 13 | Santa Ana, CA |
| Fundamentals of Balancing | Sept.17-19 | Miami, FL |
| Balancing Workshop IV | Sept. 20 | Chicago, IL |

### October

| | | |
|---|---|---|
| Fund. of Jet Engine Balancing | Oct. 8-10 | Deer Park, NY |
| Balancing Workshop I | Oct. 11 | Santa Ana, CA |
| Balancing Workshop VI | Oct. 18 | Chicago, IL |
| Balancing Workshop II | Oct. 25 | Houston, TX |

### November

***NO SEMINARS/WORKSHOPS***

### December

| | | |
|---|---|---|
| Fundamentals of Balancing | Dec. 3-5 | Santa Ana, CA |
| Certification Level 1 Exam | Dec. 5 | Santa Ana, CA |