Compact and Multifunction Controller for Parts Feeder

1. Introduction

Vibratory parts feeders are commonly used in production lines of various industrial fields, which include car manufacturing, electric appliance manufacturing, food processing and semiconductor device manufacturing. Controllers that control vibration of these vibratory parts feeders have to be compact and light weight while being capable of supporting ever diversifying applications.

NTN has commercialized a new series of parts feeder controllers aiming at size reduction, lighter weight and multi-function capability. This report provides information about the advantages of these new controller products.

2. Overview of NTN’s new Parts Feeder controllers

In 1996, NTN marketed a digital controller for parts feeders—the first in the bearing manufacturing industry in Japan. Its higher control accuracy and improved operation, not obtained from conventional analog controllers, was highly appreciated. This controller became the standard digital controller for parts feeder in the manufacturing industry in Japan. The controller models described in this document are NTN’s third generation parts feeder controllers, and boast both compact light-weight design and multi-function capability through incorporation of additional user-friendly functions thanks to unique digital control technology.

3. Advantages of the new controllers

(1) Compact size, and light weight

In terms of the physical volume, the size of the new models—K-ECH45/K-ECJ45—are 60% of the size of the old model (see Table 1 and Fig. 3).

The challenge to size reduction of the controller is how to reduce the surface area needed for heat radiation and interfacing arrangement.
Table 1 Comparison table of new and old model

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>New model (low capacity)</th>
<th>New model (high capacity)</th>
<th>Old model</th>
<th>Features of new model</th>
</tr>
</thead>
<tbody>
<tr>
<td>External dimensions W × H × D [mm]</td>
<td>60 × 140 × 142</td>
<td>82 × 140 × 142</td>
<td>80 × 180 × 180</td>
<td>Compact size as small as approx. 60% the old controller of a same control capacity</td>
</tr>
<tr>
<td>Supply voltage</td>
<td>100/200V</td>
<td>100/200V</td>
<td>100V</td>
<td>New model is capable of inputs of both 100 V and 200 V.</td>
</tr>
<tr>
<td>Control capacity</td>
<td>2A</td>
<td>4.5A</td>
<td>4A</td>
<td></td>
</tr>
<tr>
<td>Allowable frequency range</td>
<td>30 ~ 500Hz</td>
<td>30 ~ 500Hz</td>
<td>30 ~ 250Hz</td>
<td>Can drive SMD feeder.</td>
</tr>
<tr>
<td>Multi-speed function</td>
<td>Panel + 3 stages</td>
<td>Panel + 3 stages</td>
<td>No</td>
<td>Internally includes three speed memories.</td>
</tr>
<tr>
<td>Analog voltage command</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Can be connected to three valves.</td>
</tr>
<tr>
<td>Valve control function</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Can be connected to three valves.</td>
</tr>
<tr>
<td>No work-piece warning function</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Can be connected to three valves.</td>
</tr>
<tr>
<td>Fault signal output</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Fault signal is triggered when a fault occurs.</td>
</tr>
<tr>
<td>Alarm signal output</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Alarm signal is triggered when alarm situation occurs.</td>
</tr>
<tr>
<td>Over-load protection function</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Greater selectable range for load protection curves.</td>
</tr>
<tr>
<td>F/V curve</td>
<td>18 sets</td>
<td>18 sets</td>
<td>2 sets</td>
<td></td>
</tr>
<tr>
<td>Constant voltage function</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Constant amplitude function</td>
<td>No</td>
<td>Built-in</td>
<td>No</td>
<td>Optional; externally provided</td>
</tr>
<tr>
<td>Resonance point tracking function</td>
<td>No</td>
<td>Built-in</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 1 Externals view (right side : new model)
Fig. 2 Wiring enclosure (right side : new model)
Fig. 3 New controller outline dimension

New model is capable of inputs of both 100 V and 200 V.
To be able to reduce heat radiation area, it is most important to mitigate heat generation from the built-in parts. The heat generation on the controller has been reduced by adoption of an appropriate FET and improvement in the drive circuit; thereby the surface area needed for heat radiation has been reduced by 20%.

Furthermore, the location for mounting the radiation fins on the new controllers is a side face instead of the rear face on the old controller; thereby a greater radiation area is available and the size of the radiation fins can be reduced by half. Note that the rated current greatly differs between the medium sized general-purpose vibrator and large-sized general-purpose vibrator. Previously, one controller model has been used regardless of necessary control capacity. In contrast, two differently sized controller types are now available—the larger size controller features greater control capacity. The smaller capacity controller (K-ECF25/K-ECG25) that is responsible for control of vibrators up to a medium size, boasts a reduced size—46% of the old model.

On the new controllers, the surface area is large enough for interfacing work, including wiring work is provided since the entire control panel can be fully opened (see Fig. 2). Now, the wiring space is as large as the front face of the controller: at the same time, the signal circuit employs a compact plug-in-type terminal block. Consequently, the new controllers boast an increased number of I/O points despite their smaller space requirement.

Furthermore, adoption of smaller radiation fins has led to a light-weight enclosure design that does not require greater mechanical strength: consequently, thinner wall thickness can be adopted, leading to 30% weight reduction with the entire controller.

(2) Multi-function capability

• Overload protection

The new controllers are capable of setting the rated current of the vibrator so that the vibrator connected to the controller is reliably protected against a possible overload. The level of current flowing to the electro-magnet in the vibrator can greatly vary depending on the dimension of gap between the magnet and the armature. Previously, incorrect setup of the controller could cause overcurrent to flow the electro-magnet. The NTN’s new controllers automatically regulate their output voltage in order to protect the electro-magnet. The new controller models each include a PLC controlling one-chip microcomputer that contains control functions needed for various parts feeder types. What the operator must do on our new parts feeder controller is to select an intended function and then set up timer duration. The user of the parts feeder controller does not need to a programming tool and software specific to an intended parts feeder. NTN’s parts feeder controllers are very easy to use.

• Control for solenoid valve

When the parts feeder is a two-track (two-lane) type as shown in Fig. 4, a conventional parts feeder controller needs to control the solenoid valve for a relevant track (lane) in accordance with the current status detected by a work-piece presence sensor, by using a compact programmable logic controller (hereinafter referred to as “PLC”). This system poses a cost problem since an additional PLC, DC power supply, casing, etc. will be needed in order to control two air-supply solenoid valves. NTN’s new series of parts feeder controllers do not need additional control components in this control scenario because the new controller models each include a PLC controlling one-chip microcomputer that contains control functions needed for various parts feeder types. What the operator must do on our new parts feeder controller is to select an intended function and then set up timer duration. The user of the parts feeder controller does not need to a programming tool and software specific to an intended parts feeder. NTN’s parts feeder controllers are very easy to use.

• Switch-over between carrier frequencies

Our new parts feeder controller models adopt sinusoidal wave PWM* technique to drive parts feeders. To improve control accuracy for this technique, a higher carrier frequency for modulation is preferable: however, higher carrier frequency can trigger higher harmonic noise which can adversely affect measuring instrument involved. The controller models K-ECH45/K-ECJ45 permit the operator to select one of three carrier frequencies. This ability to change over carrier frequencies helps mitigate adverse effect of higher harmonic noise.

* PWM: Acronym for Pulse Width Modulation: one technique to generate AC waveform.
(3) Novel vibration sensor

We have also developed a novel vibration sensor. To detect vibration, piezoelectric elements are often used. In the aspects of electrical characteristics, piezoelectric elements feature much greater output impedance and this fact leads to more demanding requirements from the cables connected to the piezoelectric elements. Our newly developed sensor not only includes a built-in band-path filter that allows only signals of the necessary band to pass but also features lower output impedance to alleviate limitations on the cable to be connected to the vibration sensor. Consequently, when wanting to extend the cable for the vibration sensor, the user of vibration sensor can extend the line by using an ordinary cabtyre cable and terminal block without adopting a shielded cable. Use of a shielded cable was necessary for conventional vibration detection systems with piezoelectric elements. Wiring work is much simplified.

Fig. 5 shows an appearance of our novel vibration sensor. Fig. 6 gives a view of cable extension with a length of ordinary cabtyre cable; this type of connection was difficult with the old controller model.

Fig. 6 Typical arrangement of cable extension for new vibration sensor

(4) Constant amplitude operation mode

On our two new controller models, K-ECG25 and K-ECJ45, the magnitude of amplitude of vibration is adjusted with an amplitude dial to a target value. The controller automatically regulates its output voltage so that the signals from the vibration sensors are kept at constant level. Typical examples of control characteristics of our new controller obtained from this constant amplitude function and resonance point tracking function described below are shown in Fig. 7.

Our new controllers are capable of automatic regulation of their output voltage so that they restore the amplitude on the parts feeder to the original level even when a load on parts feeder has increased (for...
example when the work-pieces have been loaded into the parts feeder). The parts feeder can keep supplying work-pieces at constant vibration frequency. Previously, the constant amplitude function on our old controller model could be enabled only after manual adjustment with GAIN potentiometer. The new controller models are capable of automatic GAIN adjustment. New controller models help the user always select an optimal GAIN without relying on the judgement of an operator of the controller.

(5) Resonance point tracking run mode

The resonance point of a given parts feeder can vary depending on the factors including the quantity of work-pieces in its bowl. Our two new vibratory parts feeder controller models K-ECG25 and K-ECJ45 are capable of automatically tracking the resonance point of the parts feeder being controlled and accordingly control the vibration frequency of the parts feeder. A vibratory parts feeder utilizes resonance phenomenon to amplify vibration on it to line up and feed work-pieces to an assembling machine. For this reason, the parts feeder will operate at optimal efficiency when the vibration frequency matches the resonance point. This arrangement may not be advantageous in that vibration-feed operation at resonance frequency is vulnerable to outside disturbance and as a result stable vibration is not readily achieved. To address this problem, our old controller model was designed to run at a frequency where its vibration is stable, somewhat higher than the resonance point, even though the load current is higher than that in resonance point-matched mode. The new controller models are capable of resonance point tracking run mode where the controller detects occurrence of resonant state based on signals from vibration sensors, thereby the controller automatically regulates the vibration frequency so that the parts feeder is always locked to resonant state. Vibration on the feeder remains stable even when the vibration frequency coincides with the resonance point, thereby load current needed for the test parts feeder controlled by the new controller to generate a given amplitude is approximately 20% lower compared with the old controller, (percentage decrease in necessary current can vary depending on the model, settings and operating conditions, etc. of the vibrator).

To enable resonance point tracking function, a certain adjustment is necessary, however, the new controller models automatically achieve this adjustment thanks to their auto-calibration function. The operator does not need to waste time for this procedure. On the NTN’s new parts feeder controllers, once calibration work is complete, an intended run mode automatically starts and a corresponding mode indicator lamp will light up. The operator of our new controllers can easily execute the necessary setup and checkup procedures.

Since resonance point auto tracking function alone does not provide stable vibration frequency for the vibratory parts feeder, our new controllers in resonance point auto tracking mode unconditionally enable the constant resonance mode.

The resonance point tracking function is useful in particular in realizing high-speed feeding of work-pieces: however, this function may be less effective in terms of inching-speed work-piece feeding performance or reliability of the parts feeder depending on the settings on the vibrator and/or the type of work-pieces handled by the parts feeder.

With the new controllers, the “LIMIT” indicator lamp will light up when the parts feeder is running while being controlled by the constant amplitude function and if the control limit is reached. There may be cases where necessary amplitude is no longer achieved due to reasons including excessive fatigue on the leaf spring in the vibrator. The “LIMIT” indicator lamp will light up so that the user can maintain the parts feeder in question.

(6) Other functions

The new controller models are capable of handing various functions and signals, and examples of which include multi-speed capability, control of setup voltage (amplitude) with analog voltage, control dial lockup (inhibition of manipulation), no work-piece detection alarm, fault signal and alarm signal. A user of parts feeder can achieve a diversity of unique control functions by using one unit of the NTN’s parts feeder controller instead of developing a purpose-specific control circuit. Consequently, the user of our parts feeder controllers will enjoy benefits such as reduction in costs for production equipment and stock of maintenance parts.

(7) Costs

NTN has attempted to minimize cost increase over the old model though introducing more functions; thereby the users of NTN’s new parts feeder controllers can use a wider scope of control function at a price approximately comparable to that of the old model.
4. Conclusion

This paper has provided information about the advantages of NTN’s four multi-function, compact and light-weight controller models for parts feeders. NTN will include as an option to the lineup of parts feeder controllers a special step-up transformer unit that allows a 200 V rated parts feeder to be operated with a 100 V power supply.

Because of a diversity of possible applications, parts feeders need to be capable of handing a wide variety of work-piece types. NTN’s new parts feeder controllers satisfy most of these requirements, and cope with higher levels of users’ needs. NTN will remain committed to development of novel parts feeder controller products that are accepted by more users as they help realize the best combination between characteristics of parts feeder proper, optimal tooling and appropriate control scheme.