Automatic billet feeding into heating lines in forges

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Abstracts

Three methods of automatic feeding of billets into the heating line are currently used in forges: vibratory bowl feeder, step feeder or a robotic bin picking. The article describes the basic principles of each method, compares their advantages and disadvantages and discusses the suitability of their use.

1 Introduction

The billets are usually stored loose in transport bins. In order to be processed by an automatic line, they must be loaded into the line in the exact position. This function is fulfilled by vibratory bowl feeders and step feeders, into which the billets are discharged from the transport bin and come out of the feeder in a single row one by one. ROBOTERM has been supplying billet feeding systems to forges since the 1980s. Vibratory and step feeders have undergone many years of development and their applications are proven by practice.

In addition to these conventional feeding systems, robotic feeding directly from the transport bin, called bin picking, is increasingly being used with the development of machine vision. Probably the first Czech application of bin picking in a forge is its integration into a fully robotized forging line delivered in 2022 by the DEL company to a major european forge [1]. The software used for the machine vision is from Photoneo, a originally Slovak and now international company specialising in bin picking. This application proves that bin picking can successfully replace conventional feeding systems in some cases.

Each of the automatic feeding methods has its advantages and disadvantages, so it is important to choose the most suitable one for the individual application.

2 Vibratory Bowl Feeder

2.1 Principle

Into the vibratory bowl feeder (Fig. 1) the billets are discharged from the transport bin. The bowl performs oscillations that move the billets along a spiral path. Misoriented billets are dropped off the track back into the bowl by adjustable guide slats. If the oscillation of the bowl exceeds the gravitational acceleration, the billets jump and the operation of the vibratory feeder becomes noisy. In practice, this limits the feed rate. To prevent this from happening, the speed and mass eccentricity of the vibration motors must be correctly adjusted. If maximum feeding speed and low noise are required, the vibratory feeder can be equipped with an accelerometer and the speed automatically regulated according to the load.

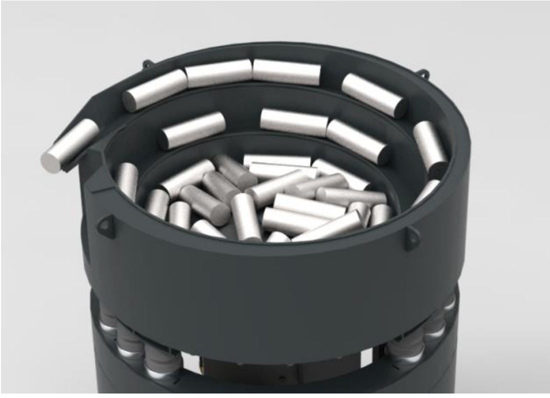

Fig. 1 – Vibratory bowl feeder

2.2 Advantages and disadvantages

Due to its versatility, the vibratory bowl feeder is suitable for most continuous induction heating lines. It is mechanically robust and contains a minimum of mechanisms and moving parts. It can feed a wide range of diameters and lengths of billets and can also feed billets of non-circular cross-sections. To ensure correct orientation of the billet, the length of the billet should be approximately 1,3 times its diameter. This is usually required by other mechanisms after the heater. When changing the size of the material to be fed, it is necessary to adjust the guide slats, which takes several minutes. The noise level of modern vibratory feeders is very low, so they are not audible among the other machines in the forge. This does not apply to transport bin dumping, which is, on the contrary, very noisy. The feeding speed depends a lot on the friction. Grease and moisture on the surface of the billets reduce the speed. The amplitude of the oscillations is only about 1 mm, so the operation of the vibratory feeder is relatively safe and be done without additional safety features such as fencing. The disadvantage is the limited service life of the track, which, although made of abrasion-resistant steel, is subject to wear, especially when feeding billets with sharp edges. A worn track is usually repaired by welding and grinding.

3 Step Feeder

3.1 Principle

A step feeder consists of a hopper and a vertical conveying system consisting of movable and fixed steps. The billets are discharged from the transport bin into the hopper of the step feeder (Fig. 2), from which they are picked up by the movable steps. The steps are driven by a crank mechanism and alternately move up and down. Correctly oriented billets are rolled on the movable step in top dead center to a fixed stage from which they are rolled again in the next stage to next movable step in the bottom dead center. Incorrectly oriented billets are not held on the step and fall back into the hopper, or they can be dropped by an additional dropping mechanism or returned by a dropper located on the conveyor downstream.

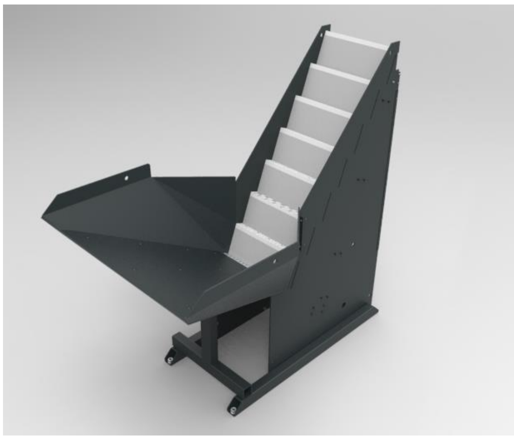

Fig. 2 – Step feeder

3.2 Advantages and disadvantages

The plate stacker offers the highest feeding speed, therefore it is used in cases where the vibratory feedr is not able to provide a short enough cycle time. However, it does not handle as large range of billet diameters and lengths as a vibratory stacker. It does not usually feed square billets but can be designed to do so. As with the vibratory feeder, the length of the billet must be approximately 1,3 times the diameter. The mass of billets rolling in each step is followed by noise. A step feeder is generally noisier than a vibratory feeder. However, the greatest noise occurs when the transport bin is discharged into the hopper. Additional drop mechanisms can extend the range of billet sizes, but will significantly increase the noise because they drop the billets from a great height. Operational adjustments are not required unless additional dropping mechanisms are included. The advantage can be to transport the billets to a high height while keeping the hopper position low. The footprint is small and, thanks to acceptable safety, the device can run without fencing or other protective features.

4 Bin Picking

4.1 Principle

Bin picking is a general term for the robotic removal of loose parts from a transport bin and its subsequent loading using machine vision. A 3D scanner, which is usually placed above the bin or on the robot arm, scans the bin with the billest in a defined cycle. The control software evaluates which sections can be gripped and sends instructions to the robot. The robot usually has a magnetic gripper (Fig. 3) that transfers the billets to the conveyor of the heating line. Although bin picking applications are the same in basic principle, they can vary greatly in capabilities depending on how sophisticated their software and hardware are [2].

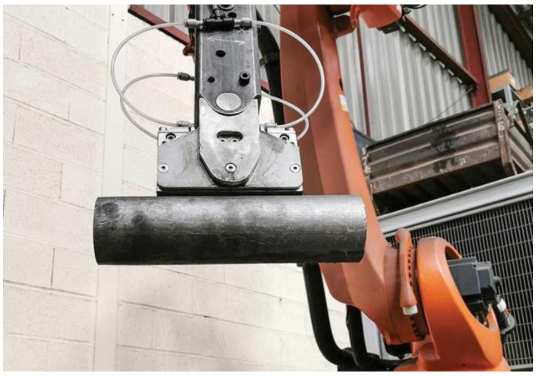

Fig. 3 - Bin picking [2]

4.2 Advantages and disadvantages

Bin picking is more complex and more expensive than conventional feeding systems, but it offers advantages that make it the best choice in some cases. The big advantage of bin picking is the quiet operation, as the noisy emptying of the billets from the transport bin is completely eliminated. Another advantage is the ease of counting billets and distinguishing batches from individual bins. The requirement for batch differentiation is difficult to solve in conventional feeding systems by using a pair of feeders to ensure that individual batches are not mixed. Bin picking allows easy feeding of heaters that heat the billets one at a time. Vibratory feeders and step feeders need a separating device in such cases because the billets come out of them in a row just behind each other. The robot can transport any shape and size of billet as long as the gripper and control software can accommodate them.

The disadvantage can be too long cycle time, which is around 15 s. However, this limitation is not an obstacle if the cycle time is already limited by other equipment in the line, e. g. the process time of the heating or forming process. The scanning itself is challenging due to the variability of the lighting conditions. Direct sunlight coming from a skylight in the hall can cause problems and then the shading of the whole system has to be solved. Scanning glossy billets can also be problematic. If a magnetic gripper is used, non-magnetic materials cannot be gripped. The robot must avoid collisions with the transport bin, which places great demands on the bin shape, accuracy and positioning. Ribs and stiffeners that protrude inside the bin make it difficult to take out the billets. Transport bins in forges are often heavily deformed, which can also cause collisions. Therefore, for bin picking, special bins are sometimes used that have a precise shape and smooth inner walls.

The necessity to avoid collisions and the limited possibilities of the gripper lead to the fact that it is usually not possible to take out all the billets from the bin. The success rate of removal is between 90% and 100%. To improve the success rate, the bin is sometimes tilted or shaken to redistribute the billets inside. The magnetic gripper can grip the billets by the cylindrical surface or the base, but in some cases the robot needs a re-gripping station, which however prolongs the cycle time. To avoid a feeding interruption during bin exchange behind the guard fence, an automatic pallet exchange system or alternating picking from two bins can be used, or the robot takes the billets from a special prepared stock during exchange. Usually one gripper cannot be used for the whole range of billets, so the replacement of the gripper has to be solved. For each combination of billet dimensions, a gripper must be selected in the control software and the gripping points defined [3].

Many bin picking problems are successfully solved by various additional arrangements and auxiliary mechanisms, but these make the overall solution more expensive. Because bin picking is relatively young, its application requires more development and testing than conventional automatic feeding systems. Consequently, its commissioning time is longer. Taking into account the current high demand for bin picking in various industries, the system can be expected to be further improved and its implementation in plants will grow.

5 Conclusion

For most applications of automatic billet feeding in forges, the vibratory bowl feeder is the optimal choice due to its versatility and simplicity. For applications that require very fast feeding, a step feeder is used. Bin picking is a more expensive and more complex alternative of automatic feeding, but brings new advantages. It is mainly used in cases of requirements for minimum noise, feeding billets separately one at a time and for billet counting and batch differentiation.

Literature:

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