Detritus processing based on intelligent metal detritus compression system

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Abstract. Based on the automatic metal particles forming machine of treatment is all kinds of machinery manufacturing processing compressible metal shavings a way of processing, based on the actual production needs, intelligent choice of metal debris processing system, the corresponding equipment technical parameters and design to meet the basic mode of production of CNC machine tool chip compression, practice has proved that the sum up the results of the selection and design of metal elastic compression processing system has important significance.

1. Introduction
Along with the rapid development of the mechanical manufacturing industry, the treatment of industrial debris is towards the direction of the intelligent development, people's saving environmental protection consciousness enhancement, so the demand for clastic processing system also will increase, in order to solve this problem will need to have special measures to rework forming of industrial metal debris, easy to transport and recycling. In this paper, the research of the CNC equipment supporting the intelligent metal debris treatment system, for aluminum chips, copper chips, iron chips and other metals for subsequent processing. It can improve the utilization rate of metal materials, improve the working environment of processing plants, save costs and realize the recycling of materials.

2. System selection and design of metal debris compression treatment

2.1. Analysis of metal detritus volume data
According to an aviation enterprise, the material removal data of CNC milling machine equipment is given as shown in Table 1:
Table 1. Statistical table of theoretical debris volume

| Equipment model | In addition to scrap amount MAX Unit: Kg/h | Number of devices | Working time Unit: h/day |
|-----------------|---------------------------------|-----------------|------------------------|
| VMC850E        | 104.2                           | 2               | 16                     |
| VMC850B        | 104.2                           | 2               | 16                     |
| Vmc1050        | 52                              | 2               | 16                     |
| vmc1060        | 52                              | 2               | 16                     |

It can be concluded that the maximum amount of debris produced in a theoretical day is 6000Kg/day, Maximum quantity per unit is 2000Kg/day. There are two ways of rough and finish machining, Formula [1] is obtained from the actual data as follows:

$$Kg = \xi \times kg_{max}$$  \hspace{1cm} (1)

Among: $\xi$ is the parameter coefficient 0.6, $Kg$ is the actual amount of chip removal.

2.2. Modular analysis of metal debris treatment
Currently, there are several modes that can deal with metal debris, as shown in Table 2:

Table 2. Treatment mode of metal debris

| Detrital treatment model | Advantages | Disadvantages |
|--------------------------|------------|---------------|
| Single device independent processing mode | 1. Decentralized maintenance is convenient for management; 2. Simple installation; 3. Widely used, high reliability. | 1. Large floor space; 2. Follow-up processing is complex, without continuity, and the work efficiency is low. |
| Cutting fluid driven several treatment methods | 1. Continuous overall processing 2. Own cooling fluid recovery 3. and reuse system | 1. It covers a large area and is polluted 2. Integrated, not easy to single maintenance; 3. Dry and wet are not separated, and the transportation of debris affects the environment |
| Several mechanical treatments | 1. Continuous, highly adaptable debris 2. Own oil and water recovery system | 1. Large floor space and low efficiency 2. High noise and low stability. 3. Affect the overall automation layout |
| Vacuum treatment of several ways | 1. Fast detritus discharge; 2. Small floor space; 3. Low transportation cost and easy maintenance. | 1. Large one-time investment expense in the initial stage 2. Complex installation 3. Pipeline oil pollution treatment is complicated |
| Intelligent compression processing mode | 1. The detritus is discharged quickly and directly into the compression system; 2. Automatic processing, one-button start, automatic alarm; 3. The transportation process does not affect the environment; 4. Save labor. | 1. Large one-time investment expense in the initial stage; 2. Adaptable to discontinuous detritus, with certain local characteristics. |
According to the overall intelligent layout, production efficiency, maintenance, labor saving, and workshop six Sigma management, intelligent compression processing is more suitable for the future and industry 4.0 and made in China 2025 plan requirements.

2.3. Parameter design of metal debris compression treatment system

Intelligent compression processing system includes compression device, control system and equipment recovery device. The difficulty lies in the selection of pressure parameters, hydraulic pump and the design of motor parameters.

2.3.1. Pressure parameter calculation

(1) Nominal pressure \( P_n \)

Nominal pressure \( P_n \) is also called rated pressure, that is, under normal working conditions, the hydraulic cylinder can work for a long time with the maximum pressure of 25MPa.

(2) Maximum allowable pressure \( P_{\text{max}} \)

The maximum pressure at which the cylinder is allowed to run briefly after exceeding the rated pressure:

\[
P_{\text{max}} \leq 1.5P_n = 37.5 \text{MPa}
\]

(3) Withstand test pressure \( P_t \)

Test pressure to be borne by hydraulic cylinder during quality inspection. Within the specified time, the pressure of the hydraulic cylinder, all parts shall not be damaged or permanently deformed: \( P_n = 25 \text{MPa} > 16 \text{MPa} \),

\[
P_t = 1.25P_n = 1.25 \times 25 = 31.25 \text{MPa}
\]

2.3.2. Selection of hydraulic pump.

(1) Determine the maximum working pressure of hydraulic pump

\[
p_p \geq p_t + \sum \Delta p
\]

\( p_t \)--Maximum working pressure of hydraulic cylinder

\( \sum \Delta p \)--When the pipeline loss occurs between the hydraulic pump outlet and the hydraulic cylinder inlet, the pipeline is relatively simple and the flow rate is small. take \( \sum \Delta p = (0.2 \sim 0.5) \text{MPa} \); When the pipeline is more complex, there is a speed control valve at the entrance, take:

\[
\sum \Delta p = (0.5 \sim 1.5) \text{MPa}.
\]

The device takes \( \sum \Delta p = (0.2 \sim 0.5) \text{MPa} \)

So: \( p_p \geq 25 + 0.3 = 25.3 \text{MPa} \)

Takes: \( p_p = 26 \text{MPa} \)

(2) Determine the flow of the hydraulic pump

\[
Q_p \geq K \left( \sum Q_{\text{max}} \right)
\]

\( K \)--System leakage factor, \( K = 1.1 \sim 1.3 \)

\( \sum Q_{\text{max}} \)--The maximum total flow of a simultaneous operation of a hydraulic cylinder

So:

\[
Q_p \geq 1.2 \times \frac{38526422.3 \times 6 \times 10^{-9}}{60} = 0.000642 \text{ m}^3/\text{s}
\]
Takes: \( Q_p = 0.0007 \text{ m}^3/\text{s} \)

(3) Select the specifications of the hydraulic pump

Hydraulic pump selection according to the actual situation and the maximum working pressure of the hydraulic pump selection, and then according to the maximum flow of the hydraulic pump selection model, hydraulic pump rated pressure should be more than the maximum working pressure 25% ~ 50%, enough to retain the pressure reserve.

(4) Determine the driving power of hydraulic pump

\[
P = \frac{p_p Q_p}{10^3 \eta_p} \tag{4}
\]

\( p_p \) --- Maximum working pressure of hydraulic pump \( \text{Pa} \)

\( Q_p \) --- Hydraulic pump flow \( \text{m}^3/\text{s} \)

\( \eta_p \) --- Total efficiency of hydraulic pump, Plunger pump: 0.80~0.85

So:

\[
P = \frac{26 \times 10^6 \times 0.0007}{10^3 \times 0.83} = 22\text{MPa}
\]

Select axial piston pump, modelMCY14-1B, The parameters for:

Rated speed: 1500r/min \hspace{1cm} \text{Driving power: 24.6kW}

Displacement : 25mL/r \hspace{1cm} \text{Volumetric efficiency:} \geq 92\% 

The rated pressure : 32MPa \hspace{1cm} \text{Maximum theoretical torque} 133 \text{N}\cdot\text{m}

(5) Motor parameters

Motor driving power: 25kW
Jo3-180l type motor and three-phase cage asynchronous motor are selected

Technical data:

Power: 30kW \hspace{1cm} \text{Synchronous speed:} 1480 \text{r/min}
Starting/rated current: 7.0 \hspace{1cm} \text{Starting/rated torque:} 2.0
The power factor: 0.86

3. Design of metal debris compression treatment system

3.1. Mechanical agencies

The equipment is horizontal structure, hydraulic equipment and PLC combined to achieve pressure, stroke, speed and automatic cycle work control. The hopper is connected with the discharge port of the CNC machine tool, and the debris enters the chip pressing space directly from the hopper. The main pressure cylinder is pressed to form once, and the block is pushed automatically and the material is discharged automatically.

![Equipment working process](Fig.1)
3.2. Design of automatic control system
It includes the electrical hardware part and the operation control part, among which, the electrical hardware part includes PLC, touch screen, microcircuit breaker, contactor, proximity switch, etc. The operation control part is composed of touch screen and software control system (STEP7). STEP 7 MicroWIN + WinCC Flexible is adopted in the automation control system.

3.2.1. Control function. Two control modes are designed according to the process requirements:
   - Automatic mode, which is the main operation mode of the device. After the initial parameter setting is locked, the device works according to the operation sequence set by the program.
   - Manual mode. This mode is mainly used for debugging and maintenance of equipment.
   The two control modes can be switched freely, and the emergency stop button is used to stop the machine quickly in case of equipment failure.

3.2.2. Display function. The whole control system consists of login interface, operation interface, alarm interface, debugging interface, manufacturer \ help and so on.

4. Conclusion
The detrital processing based on the intelligent detrital compression system should first consider the feasibility of overall automation, and then consider the design parameters of specific detrital processing methods. Finally, according to the above design parameters, the detrital compression system can meet the design requirements of intelligence, energy conservation and diversification.

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