## VI. ANALYSIS OF THE TOTAL FEED OF WHEEL

The total feed fa can be found from the formula when spring grinding:

$$f_a = a_p + f_a' \tag{9}$$

Where $a_p$ is grinding feed; $f_a$' is compensated feed which aims at overcome spring elastic potential energy.

Because spring has certain elasticity, wheel must produce enough positive pressure which applied on spring, by this way, abrasive grains with certain linear speed can cut spring metal matrix. Obviously, grinding feed $a_p$ is based on compensated feed $f_a$'. When spring is grinded with critical grinding thickness $a_{min}$ of abrasive grains, the positive pressure between wheel and spring is defined as critical positive pressure. The critical grinding thickness $a_{min}$ of abrasive grains can refer to table 1. [6]

TABLE.1. CRITICAL GRINDING THICKNESS $a_{\min}$

| Material | $r_g$ | $a_{\min}$ | $k_s = a_{\min}/r_g$ |
|---|---|---|---|
| Hardened carbon steel | 6 | 1.5 | 0.25 |
| Cast-iron | 6 | 3 | 0.5 |
| Annealing carbon steel | 6 | 4 | 0.67 |

Where $r_g$ is the radius of micro blade of abrasive grains; $k_s$ is a parameter which can characterize the cutting ability of material.

Grinding demand decides on selection of $r_g$, different granularity can corresponding to different harshness. In general, we use alumina grains for wheel when spring end grinding, and the keenness of alumina grains can be shown by $r_g$ and tip angle of abrasive grains α, as follow in table 2

TABLE.2. THE KEENNESS OF ALUMINA GRAINS

| Granularity | 46# | 60# | 80# | W40 | W28 |
|---|---|---|---|---|---|
| $r_g$/μm | 28 | 18 | 13 | 4 | 2.7 |
| a/(°) | 110 | 108 | 106 | 98 | 90 |

When springs are grinded with critical grinding thickness of abrasive grains, the formula of grinding force:

$$\begin{aligned} F_a' &= 9.81a_{\min}\{C_F\cdot[b(\frac{l}{a}-1)\sqrt{2al-l^2} \\ &+ ab\arcsin\frac{l-a}{a}+\frac{1}{2}\pi ab]\cdot N/v_2\}\tan\beta \\ &= 9.81\mathrm{r_g}\cdot\mathrm{k_s}\{C_F\cdot[b(\frac{l}{a}-1)\sqrt{2al-l^2} \\ &+ ab\arcsin\frac{l-a}{a}+\frac{1}{2}\pi ab]\cdot N/v_2\}\tan\beta \end{aligned} \tag{10}$$

Positive pressure from pressure spring should meet the formula:

$$\begin{aligned} F_N &= K\cdot f_a' = \mathrm{F}_a'/N \\ f_a' &= \mathrm{F}_a'/(\mathrm{K}\cdot\mathrm{N}) \end{aligned} \tag{11}$$

Where FN is elasticity of single spring; K is spring stiffness; N is the number of spring.

The relationship between total feed and grinding can be found from Eqs.(7) 、 Esq.(9) and Eqs.(11), it plays an important guiding significance in spring end grinding and can vastly improve the grinding efficiency and grinding quality.

## VII. CONCLUSIONS

1. The process of spring end grinding is analyzed and the feasibility of controlled-force grinding using for spring end grinding is proved. The grinding force formula by analyzing geometric model of spring grinding is introduced to ensure the power of grinding head motor. These theories are of great help in designing spring grinder and confirming technology.

2. The process of spring grinding must have a constant grinding force. As the grinding depth increase, grinding area will increase and grinding feed will decrease.

3. Spring is considered as an elastomer and the grinding feed can be divided into two parts: one is grinding feed and other is compensated feed. The former is built on the latter, so we must consider both feed in spring end grinding.

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