

## Research Article

### Loading Decrease in Metallurgical Machines

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**Abstract:** The study shows that it is necessary to know running quality (that is load-deflection curve) in order to estimate load degree on machines power lines. Running qualities are limited on the maximal loads (durability). It should be also known the impact parameter points (energy or deformation). Their superposition on the running quality allows determining generated loads degree in machine power line. It is possible to decrease the generated loads to the safest level by changing power line running quality with the help of dynamic spare parts. The type of machine security system depends on drive line data quality K: using shock-absorber preventer, arresting device preventer or a combination of the both.

**Keywords:** Deformation, line force, loading, metallurgical machines

#### INTRODUCTION

The durability of machines is dependent on the load acting on its parts. In order to develop efficient protection against its breaking, it is very important to investigate reasons of loads nature and transformation of working machines including metallurgical ones.

Taking into account a dire state of machines resulting from crippling wear factor and shortage of funds for machine renewal, the question of reliable crash protection system developing is of prime importance in machine service life extension (Artyukh, 2008). Moreover, machine service life can be improved by fortification of its spare parts but on the other hand this way becomes not so effective because it leads to upsizing which results in increases in hardness and weight parts and therefore non-technologic load process.

Metallurgical machine load has been observed in various works including fundamental ones. Herein most commonly was to analyze technological process duty load (particularly in rolling-mill), its stability and destabilization. A variety of works refer to specific kinds of loads such as rolling-mill. All it is theoretical works on oscillating processes investigation in rolling-mills, analysis of oscillation frequency and vibration amplitude in elastic (spring) force moment in different sections of rolling-mills' main lines and the study the split influence in joined parts on the nature of load types. There are also some works on dynamic load force decrease with the help of its amortization (Mazur *et al.*, 2012; Al-Quran *et al.*, 2012).



(a)

(b)

Fig. 1: Destroyed parts of sheet mill mechanical equipment

Destroyed universal shaft and socket of plate mill 3000 is shown in Fig. 1. Such crashes appear annually and more than 50 working roll bearing part breakages take place monthly in finishing train of continuous wide-strip mill 1700 (Arcelor Mittal). The same situation is observed in many others metallurgical complexes. The question arises where it possible to explain such a numerous breakages by maintenance staff incompetence or system errors during engineering and exploitation of mechanical equipment.

Recently published works specify the process of load appearance and point out some ways of its management primarily the type of load decreasing according to the normal strength condition (Artyukh, 2005).

#### THEORY AND PRACTICE

There are two kinds of machine loads according to the crash protection system: service (work) load and parasitic load. The first one is out of mechanics' line of responsibility and the second one is to be the major aspect of investigation. It is of high importance to be

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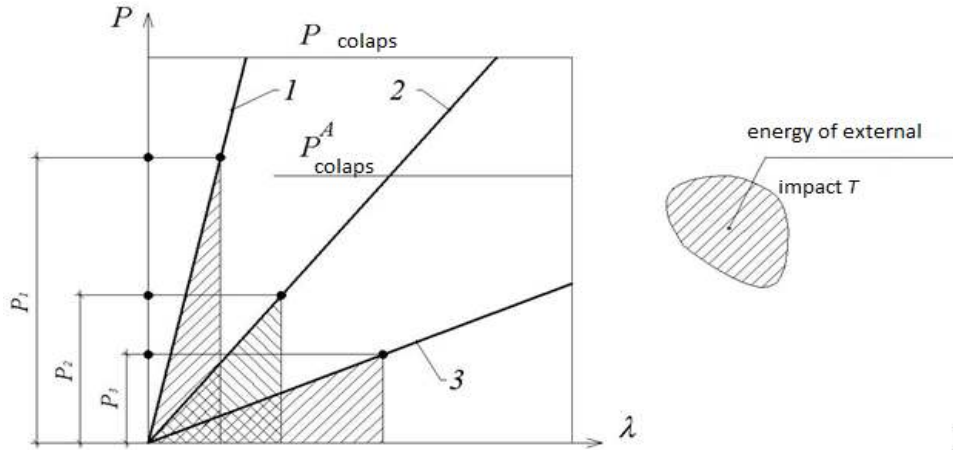


Fig. 2: Drive line operating characteristics

able to manage and decrease them up to set them at naught (Artyukh, 2010). In contrast to the conservative workloads; parasitic ones (typical nearly of all machines) are rather changeable and depend on different aspects. Because of machine exploitation period and run out; these loads are constantly increasing and lead to various breakages. Owing to this or to external action; each of these load kinds are generated in machine drive lines. The main reasons that cause such loads are: the energy and deformation influence (elastic system) upon machine drive lines. Thus the loads, which depend not only on influence rate but also on drive line spring rate and power capacity, generate in observed elastic system, characterized by running quality (load-deflection diagram).

### MATERIALS AND METHODS

The three (1, 2, 3) running qualities for one and the same drive line are shown in Fig. 2. The hardest is the first one, which refers to the drive line without a special certain spare part-shock absorber. The drive line loading under the external T-energy influence is shown in Fig. 2 (unrestricted lined surface). This energy is to obtain the same surface content T (hatched triangle with P1 y-coordinate) on the line marked 1. Here P1-is a generated energy under the observed type of loading. Under a certain T degree P1 force reaches Pcolaps indicator which means destruction.

### RESULTS AND DISCUSSION

Loading decrease (P1) may occur under the permanent external influence. Thus it is necessary to change operating characteristics. Setting energy-consuming part (shock-absorber module) in drive line we changed operating characteristic. Such a change is shown by power indicators 2 and 3 on Fig. 2. The hatched triangles on these indicators are equal in area to T-energy but the generated loads are different, where  $P_3 < P_2 < P_1$ . Thus that's the basic principle of shock-absorption-the change of options of elastic system

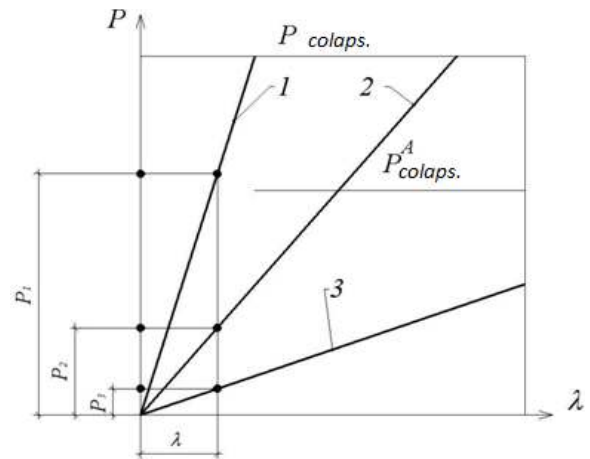


Fig. 3: Operating characteristics of machine drive line. Deformation influence  $\lambda$

under the permanent external influence in such a way, so it can generate the safest (lowest) loads.

Figure 2 show that because of installed shock-absorbers in drive line Pcolaps degree is going down up to P colaps degree. But despite P colaps decreasing the generated powers P2 and P3 are rather lower than P<sup>A</sup> colaps indicator. So it can be concluded that shock-absorber system is working in a proper way. Another effect is observed on indicator 3, which doesn't permit to reach full power capacity because of deformation restriction  $\lambda$ . This restriction can be related to shock-absorbers main dimensions and should be taken into consideration in its engineering process.

Figure 3 shows the elastic system influenced by deformation. All these 3 indicators, which are the same as were shown on Fig. 1, have a certain degree of external influence deformation  $\lambda$  that, in its turn, reveal the generated loads data  $P_3 < P_2 < P_1$ .

All these examples confirm the importance of having knowledge in the sphere of drive line operating characteristics that under the particular impact permit to find out all force options reflecting machine drive line

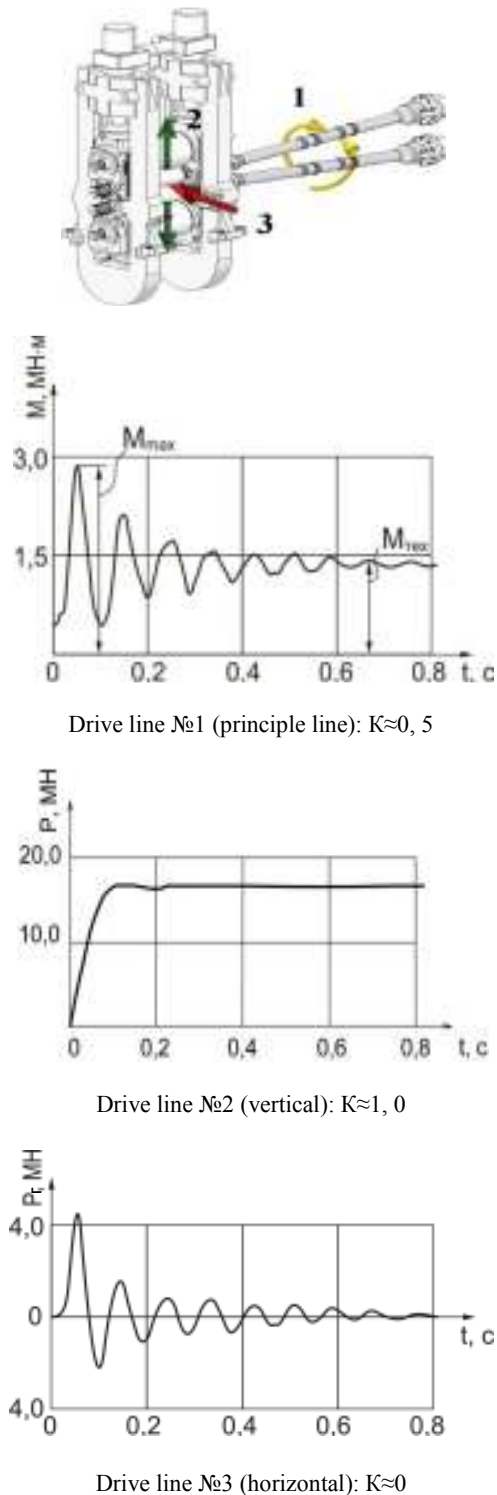


Fig. 4: The quality of different drive lines in preliminary roll mill stand №3

endurance. Energy-consuming spare parts, which have an impact upon operating characteristics, increase power capacity of the whole drive line and decrease generated there loads are called dynamic component. It is highly important that dynamic component installation

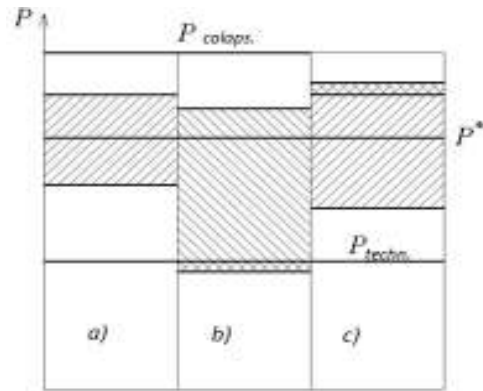


Fig. 5: Arresting device preventer types of working (a): a proper way of preventer working; (b): fatigue breakdowns of preventer; (c): fatigue breakdown of drive line weakest segment

in machine drive line decrease generated loads of all components of the same drive line.

Parasitic loads degree is calculated by K-quality of the observed machine drive line (Artyukh, 2009). Data K changes within the limits of  $0 \leq K \leq 1, 0$  and represents the ratio of work load to overall load. There are also drive lines where  $K \approx 1.0$  (vertical drive line along housing screw of a rolling mill); where  $K \approx 0$  (horizontal drive line along axis of rolling in roll mill stand); where  $K \approx 0.2 \dots 0.5$  (principle line of rolling mill) (Fig. 4).

It is only parasitic loads, not work ones, which should be decreased. When  $K \approx 0$ ; we deal only with parasitic loads and drive lines should be preserved by constantly working shock-absorber preventer (Artyukh, 2000, 2010).

When  $K \approx 1.0$  we deal with only technologic loads (workloads) in drive line. There is nothing to be shock-absorbed. In this case it is advisable to use arresting device preventers which protect drive line from overloading by abruption in kinematic chain. Figure 5 shows 3 working types of arresting device preventer. Such devices change drive line operating characteristics starting with a certain load value called switching off load.

Figure 5a shows a proper way of arresting device preventer work. After destructive load  $P^*$  is easily located between 2 load types - maximum (full) technologic load  $P_{techn}$  and  $P_{colaps}$  which is a destructive load for the weakest component of drive line. Such a preventer can snap into action only in an overloading situation. This device is out of its components fatigue breakdowns as well as breakages of drive line weakest segments.

Figure 5b shows a lack work effectiveness of arresting device preventer. Its components have low fatigue strength so switching loads field is out of the gap between  $P_{techn}$  and  $P_{colaps}$  loads. Such preventers work both under overloading and after a

certain period of working (generating fatigue damages). For example, breshpindle pilger mill is an arresting device preventer which collapse on the fifth or seventh working day without overloading. Figure 5c shows arresting device preventer set on the drive line with low fatigue strength. In this case switching loads field is out of the gap between P techn and the strength which corresponds to fatigue failure of the weak spare part. Such preventer fails to guarantee the safety of all drive line components. In this situation it is advisable either to increase endurance of the weakest part or to reduce switching loads field of arresting device preventer by its constructive improvement.

Engineering preventer we should strive to perform option a) on Fig. 5. It can be accomplished by increasing the fatigue strength of drive line components as well as by decreasing a switching load spreading via preventer improvement.

In drive lines with intermediate values of data K first of all we should increase K using shock-absorber preventer and then decrease full load by arresting device preventer.

### **CONCLUSION**

Machine operating characteristics (i.e., load-deformation curve) determine drive line load degree. Operating characteristics have limitations on full (maximum) loads (i.e., endurance). It is also should be noted that it is necessary to know influence quantity values (energy or deformation).

The generated loads in drive line are determined by placing influence quantity values on operating characteristics. By changing drive line operating characteristic by dynamic components; it is possible to manage machine loads accumulation, decreasing them up to the safest degree. The type of machine security system depends on drive line data quality K: using shock-absorber preventer, arresting device preventer or a combination of both.

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