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ВНЕДРЯВАНЕ НА ЦЕНТРОБЕЖЕН САЧМЕН СЪЕДИНИТЕЛ В ЗАДВИЖВАНЕТО НА МЕЛНИЧЕН ВЕНТИЛАТОР В ТЕЦ "БОБОВ ДОЛ"

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РЕЗЮМЕ:
Статията разглежда резултатите от подмяната на дробилковите съединители, използвани в задвижването на мелничните вентилатори на котелния цех на ТЕЦ "Бобов дол", с центробежни сачмени съединители с мощност 800 kW. Посочени са недостатъците на използваните дробилкови съединители от технически и експлоатационен характер. Заснети са осцилограми, които показват не добрите изходни характеристики на дробилковите съединители. Сравнени са с осцилограмите на пусковия процес, осъществен с центробежните сачмени съединители, от които се виждат категоричните им предимства.

Центробежните сачмени съединители са фрикционни механизми, чието управление се осъществява автоматично от центробежните сили. Кинематичната връзка и фрикционният момент при тях се осъщесвява от стоманени сачми, свободно поставени в шест работни камери.

По своя принцип на действие те практически не се различават от различните центробежни съединители, при които момента се предава чрез течности, монолитни тежести с постоянна форма или графитизиран прах.

По своите изходни храктеристики те се доближават до тези на хидросъединителите, като обаче са в състояние да предадат по-голям изхоен момент при еднакви габарити и тегло и осигуряват беззагубна работа в установените режими. Хидросъединителите, в най-добрия случай, работят с к.п.д. 98-99, което при предавана мощност от 800 кW означава непрекъсната загуба от 8-16 кW. В сравнение със съединителите с монолитни тежести или с прахов пълнеж те се отличават с:

- постоянство на изходните параметри;
- голяма плавност на пусковия процес;
- голяма устойчивост на топлинни пренатоварвания.

По експлоатационните си показатели центробежните сачмени съединители са напълно сравними с тези на хидросъединителите, като практически имат равностоен ресурс.

В това отношение те значително превъзхождат другите типове центробежни сачмени съединители - с монолитни тежести и прахово-графитно запълнение.

Добрите си експлоатационни показатели, над 10000 пуска, те постигат благодарение на използването в последните 10 години на висококачествени стомани, за активните си елементи, работещи в подходяща маслена среда. Конструкцията им не е по-сложна от тази на другите типове центробежни съединители и е значително по-опростена от тази на хидросъединителите.

Причини за внедряването на центробежни сачмени съединители в задвижването на мелничните вентилатори на ТЕЦ "Бобов дол" бяха проблемите, които създаваха използуваните до 1994 година прахови пускови съединители тип "Пулвис". Те бяха най-несигурния елемент в задвижването на вентилатора. На практика ремонтният цех се занимаваше предимно с техния ремонт и възстановяване.

След като се установи проблема, на първо време се извърши аналитична проверка на възможностите на използувания асинхронен двигател за задвижване на машината без пусков съединител. Мелничният вентилатор е агрегат, който осигурява подаване на горивна смес от въглищен прах и въздух към пещта на котела. Той едновременно осигурява нагнегяването на необходимото количество въздух и въглища, като смила последните до необходимата едрина. Работният орган на мелницата е цилиндър с диаметър 3,2 m и тегло около 10 t. Голяма част от него е съсредоточено по периферията на цилиндъра, което определя инерционен момент от около 14200 kgm^2. Статичният съпротивителен момент за пусковия период без подаване на въгла е 5 kNm.

Направеният разчет установи, че общото време за развъртане на мелничния вентилатор е 47,58. То е недопостимо голямо,тъй като практически през целия пусков период през него ще тече ток $6\text{-}7I_н$, който е възможно да го извади от строя. Освен това за времето на пусковия процес се товари значително цялата електроснабдителна система, при което, ако не са взети мерки ще се влоши електроснабдяването на останалите консуматори.

След доказване на необходимостта от пусков съединител се потърсиха проблемите в използувания до момента пусков съединител тип "Пулвис".

За установяване на проблемите при експлоатацията на праховите съединители се извърши анализ на съществуващите, който се базира на:

1. Осцилографиране на пусковия процес със съществуващото задвижване, като се заснеха входната и изходна скорост и тока на двигателя.
2. Анализ на най-честите повреди в използваните съединители.
3. Проучване на експлоатационните показатели на центробежните съединители с графитизиран прахов пълнеж.

Практиката в експлоатацията на съединители с графитизиран прахов пълнеж показват:

- непостоянство на изходните им характеристики, които се изразяват в:
- изменение на изходния въртящ момент в пусковия процес;
- липса на повтаряемост на характеристиките при различните пускови процеси.
- голяма чувствителност към топлинни претоварвания;
- бързо износване на активните повърхности и триещите се възли;
- гранулиране, уплътняване и уедряване на пълнежа, водещо до получаване на едри формирования и дебаланс.
- слепване на пълнежа към активните повърхности и блокиране на съединителя.

Част от причините, водещи до горните явления се явяват фрикционно-топлинните явления в зоната на триене. При съединители от разглеждания тип и в конкретния случай, топлинния поток през активните елементи достига от 2 до 2,5 MN/m^2 . Като се има предвид лошите топлопроводни качества на споменатия пълнеж и относително голямата продължителност на пусковия процес, то е логично да се очаква, че в повърхностния слой (мястото на фрикционния контакт) температурата достига до значителни стойности, които водято както до стопяване и уедряване на частиците, така и до трудно предвидими химични реакции. Във всички случаи неизбежно е да се очаква интензивно износване, промяна на зърнометричния състав, химични промени, непредвидими изменения на коефициента на триене, а от там и на изходния въртящ момент.

Ефикасно решение за намаляване на топлинното натоварване и съответно на нежелателните явления, описани по-горе е намаляване времетраенето на пусковия процес. Единственият начин за съкръщаване времетраенето на пусковия процес е увеличаването на въртящия моммент, развиван от съединителя M_c. Тази възможност също е ограничена от възможностите на двигателя.

Фигура 1

От осцилограмата, показана на фиг.1 се вижда, че токът на двигателя в пусковия процес е $2\text{-}2{,}5I_н$, което предполага използването на максимално възможния, "критичния" за асинхронния двигател въртящ момент. Този начин, осигурява относително стабилна работа на съединителя, но има и някои слабости като:

- значителен ток на двигателя по време на пускането;
- опасност от "катурване" на двигателя при евентуална промяна в параметрите на задвижването.

Точно такъв случай на "катурване" на двигателя е показана на осцилограмата на фиг.2.

Фигура 2

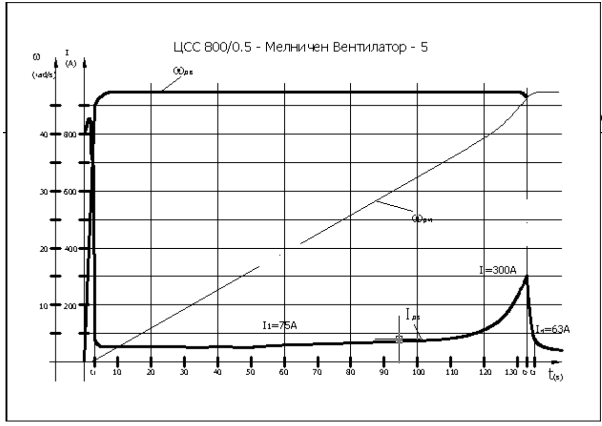
От нея се вижда, че по причини свързани с описаните по-горе процеси във фрикционния контакт, моментът на съединителя нараства, преминава критичния за двигателя момент, при което се наблюдава:

- рязко намаляване скоростта на двигателя;
- значително нарастване на тока на двигателя.

Този случай може да се счита за авариен, тъй като е свързан със значително натоварване на цялата кинематика на задвижването и машината, така и със значителен механичен и токов удар върху двигателя и електрозахранващата система.

Извършеното изследване и негативният опит в експлоатацията на използуваннннните до момент пускови съединител тип "Пулвис" предопредели внедряването на центробежен сачмен съединител (ЦСС). За целта се извърши проектиране на подходящ ЦСС. Изхождаше се от следните съображения:

1. Мелничният агрегат има относително малък начален статичен момент и няма строги ограничения за времето на развъртане.
2. Двигателите са големи и скъпи агрегати, които допускат едно включване на денонощие.
3. Максимално щадене на двигателя, чрез осигуряване на минимално време за ускоряване на двигателя и ускоряване на системата с възможно по-малък ток.



Фигура 3

Пусковият процес на задвижване осъществено от ЦСС и АД с КР протича по следния начин. При включване на двигателя той започва да се ускорява с динамичен момент рамен на пусковия на двигателя $M_п$ С двигателя се завърта и ротора на ЦСС заедно със сачмения пълнеж. Моментът на ЦСС (M_c) нараства с квадрата на входната ъглова скорост (ω_1). При определена ω_1, M_c се изравнява със статичния съпротивителен момент на машината и тя започва да се прививежда в движение. Това време се нарича начално време на развъртане на машината $t_н$. От този момент двигателят се ускорява едновременно с мелничния вентилатор, с различни стойности на ускоренията, определени от динамичните им моменти. Това продължава докато съединителят излезе на естествената характеристика на двигателя. Двигателят престава да се ускорява и момента развиват от ЦСС остава постоянен. При този момент на ЦСС продължава ускоряването на мелничния вентилатор, като размера на това ускорение се определя от динамичния момент $M_д = M_c - M_p(\omega_1)$. Това продължава до изравняване на оборотите на входния и изходния вал на съединителя. След изравняването им ускоряването на РМ се извършва при "твърд" съединител по естествената крива на АД до изравняване момента на машината с този на двигателя.

След проектирането и конструиране същият бе изработен и заложен на мелничен вентилатор № 5.

Съединителят показа плавно, сигурно и безшумно ускорение на цялостната система. Извършеното осцилографиране на пусковия процес (фиг.3) показа следното:

1. Двигателят се развърта до номиналната си скорост за 3-4 секунди.
2. Мелничният вентилатор започва ускорението си, след като двигателят е достигнал номиналните си обороти. Ускорението е плавно, почти линейно, като известно нарастване се забелязва в края на процеса. Това се обяснява с увеличаване на въртящия момент, развиван от ЦСС, при намаляване на относителната скорст на приплъзване.
3. При развъртането си токът на двигателя достига стойност от 800 А, което е за време по малко от 1 секунда. След като двигателят достигне номиналната си скорост токът спада до 75 – 80 А.Тази стойност се определя от изходния момент развиван от ЦСС. Той се подбира така че, двигателят да се щади максимално като токът в целия пусков процес не надхвърля 1,1-1,2$I_н$.Този момент осигурява и голяма плавност на развъртането и сигурност на задвижването, като го предпазва от големи натоварвания.
4. Общото време на пусковия процес е около 140 секунди. То е напълно приемливо за този тип машини и не затруднява технологичния процес.

Получените резултати недвусмиленно показват добрите пускови възможности на ЦСС. За експлоатационните качества на съединителите от типа ЦСС, може да се съди от почти девет годишната безаварийна работа на заложените през 1995 година съединители. До момента в ТЕЦ "Бобов Дол" са монтирани още двадесет и четири съединителя по мелничните вентилатори. Те също удволетворяват условията на задвижването и до момента работят безупречно.

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APPLICATION OF CENTRIFUGAL BALL CLUTCH TO THE DRIVE OF A MILL FAN AT THE “BOBOV DOL” POWER PLANT

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ABSTRACT
The report discusses the results of replacement of ball-bearing clutches, used in the drives of mill fans of the combustion compartment of “Bobov dol” Thermal Power Plant with centrifugal ball clutches of 800 kW power. The disadvantages of the used ball-bearing clutched from a point of technical maintenance are indicated. Oscillograms are prepared, which indicate the low quality initial characteristics of the ball-bearing clutches. They are compared to the oscillograms of the transitional process, done with centrifugal ball clutches. The advantages of centrifugal ball clutches are apparent.

The centrifugal ball clutches are frictional mechanisms, which operation is fulfilled automatically by the centrifugal forces. Their kinematical connection and the frictional momentum is carried out by steel balls, freely placed in six operating chambers.

In their principle of operating, they do not practically differ from the various centrifugal clutches, in which the moment is transmitted by fluids, solid weights with permanent shape or graphitized powder.

In respect of initial characteristics they are similar to those of hydraulic clutches, as though they are capable to translate larger initial momentum at identical dimensions and weight, and ensure loss-free work for the established modes of operation. The hydraulic clutches, in the best case, operate with efficiency of 98-99, which in the case of transmitted power of 800 кW, means continuous loss of 8-16 кW. In comparison to the clutches with monolithic weights or powder filling, they differentiate by:

- constant initial parameters;
- high smoothness of the starting process;
- high stability upon heat supercharges.

In respect of maintenance characteristics, the centrifugal ball clutches are totally comparable to hydraulic clutches, as they practically have an equivalent resource.

In this aspect, they significantly better than other types of centrifugal ball clutches – with monolithic weights and with powder filling.

They achieve the good maintenance indexes, more than 10000 starts, owing to the use of high-quality steels during the last 10 years and active elements, operating in a proper oil medium. Their construction is not much more complicated than construction of the other types of centrifugal clutches and it is considerably more simplified than construction of hydraulic clutches.

The reasons for applying hydraulic ball clutches to the mill drives at “Bobov dol” Thermalo Power Plant were the problems, which were brought about by clutches of “Pulvis” type, used before 1994. They were the less safe element of the fan drive. Actually, mostly repairing and reconstruction of clutches occupied the maintenance department.

After fixing the problem, firstly an analytical check of the possibilities of the utilized asynchronous motor for running the machine without a starting clutch was done. The mill fan is an aggregate, which provides feeding of fuel mixture of coal dust and air into the furnace of the boiler. It provides simultaneously the filling-up of the necessary amount of air and coal, and in the same time grinds the coal to required size of the grain fragmentation. The operating body of the mill is a cylinder with diameter of 3,2 m and a weight about 10 t. Significant part of it is concentrated to the periphery of the cylinder, which defines an inertia momentum of about 14200 kgm^2. The static resistivity momentum for the starting period without a coal feeding is 5 kNm.

The accomplished calculation showed that the common time for initiating the spinning of the mill fan is 47,58. This is inadmissible high, since practically through the whole starting period current flow of $6\text{-}7I_н$ will flow, which may bring it out of order. Moreover, for the time of starting process, there is a significant overloading of the entire electricity supply system, and this may bring to worsening the electricity supply of all other consumers.

After proving the necessity of a starting clutch the issues related to the “Pulvis” type clutch that had been used before were investigated.

With the aim of specifying the problems during the exploitation of the powder clutches, an analysis of the existing clutches was made. It is based on the following:

1. Oscillography of the starting process with the existing drive, the inlet and outlets speeds are measured as well as current of the motor.
2. Analysis of the most frequent damages of the used clutches.
3. Investigation of the exploitation indexes of the centrifugal clutches with graphitized powder filling.

The practice of exploitation of clutches with graphitized powder filling showed:

- instability of initial characteristics, which are expressed by:
  - change of the initial torque in the starting process;
- absence of repetition of characteristics for different starting processes.
- high sensitivity towards thermal overloading;
- fast wearing out of the active surfaces and friction junctions;
- granulation, densification and enlargement of the filling, bringing to obtaining of large forms and disbalance.
- adhesion of the filling to the active surfaces and blocking of the clutch.

Some of the reasons, bringing to the above phenomena, figure out to be the thermal-frictional phenomena in the area of friction. For clutches of discussed type and the particular case, the thermal flow through the active elements reaches from 2 to 2,5 MN/m^2. Considering the bad thermal conduction properties of the mentioned filling and the relatively large duration of starting process, the expectation of a superficial layer (the place of frictional contact), where temperature reaches considerable values, which leads to melting and enlarging of fragments, as well as to unpredictable chemical reactions is logical. In any case, it is inevitable to expect an intense wearing out, change of the grain composition, chemical changes, unexpected alterations of the friction coefficient and therefore of initial starting torque.

An effective solution for decreasing the thermal loading and respectively the undesired above described phenomena, is the reduction of time for starting process. The only way of reducing the time of starting process is increasing the torque, developed by the clutch M_c. This opportunity is restricted also by the capacity of the motor.

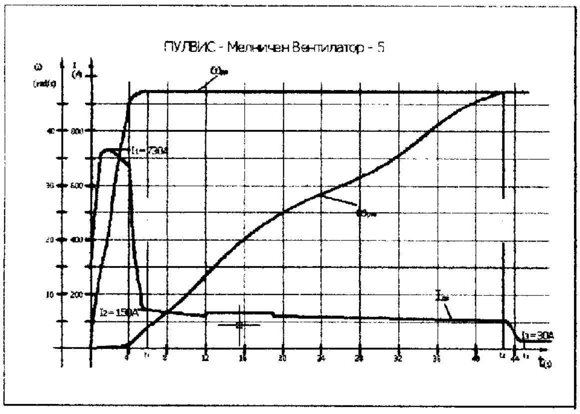


Figure 1

The oscillogram shown in fig.1 shows that the electrical current of the motor at the starting process is 2-2,5$I_н$, which suggests utilizing the maximum feasible, “the critical” for the asynchronous motor torque. This method ensures a relatively stable operation of the clutch, but has some disadvantages, as follows:

- considerable electrical current of the motor at the time of starting;
- danger of “overturning” of the motor while an eventual change of drive parameters takes place.

Exactly the same case of “overturning” of the motor is shown in the oscillogram in fig.2.

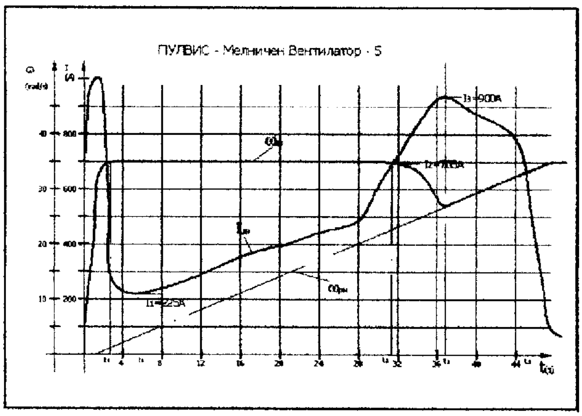
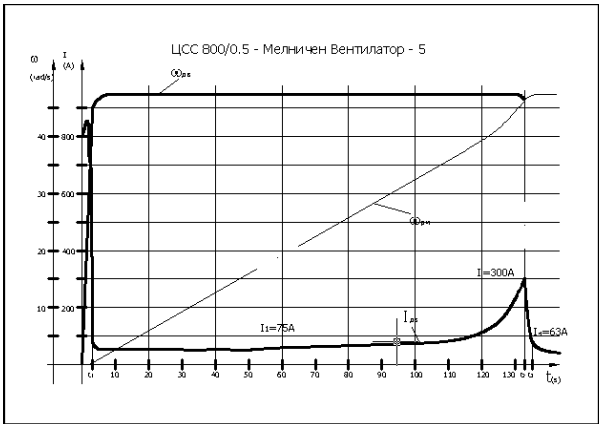


Figure 2

Through the figure is obvious, that because of the reasons connected to the above described processes in the friction contact, the momentum of the clutch increases, passes over the critical for the motor moment, as follows:

- abrupt decrease of the velocity of the motor;
- considerable increasing of motor current.



This occasion may be considered us a accidental one, because of its relation to the significant overloading of the overall kinematics of the drive of machine, as well as to a significant mechanical and current rush upon the motor and the current supply system.

The accomplished research and the negative experience in the maintenance of up-to-now used clutches of the “Pulvis” type, predetermine the application of centrifugal ball clutch (CBC). For this purpose a project for a proper CBC is accomplished. It was initiated by the following considerations:

1. Mill aggregate has relatively small static starting torque and there are no strict restrictions for the time of starting.
2. Motors are large and expensive aggregates, which permit only one switching per day.
3. Maximum care for the motor, by ensuring the minimum time for acceleration of the motor and accelerating of the system by the least possible current.

Starting process of drive accomplished by CBC and asynchronous motor is fulfilled as follows. When switched on, the motor begins to accelerate by a dynamic moment equal to the starting torque of the motor $M_{п.}$. Together with rotations of the motor, the rotor of the CBC also rotates together with the balls filling. The momentum of CBC increases by the square of initial angle velocity (ω_1). At definite ω_1, M_c equalizes to the static resisting moment of the machine and it begins to driven into motion. This time is called initial time for rotation of the machine - $t_н$. From this moment on, the motor accelerates simultaneously with the mill fan, by different values of acceleration defined by their dynamic moments. This continues until the clutch comes to the natural characteristic of the motor. The motor ceases its acceleration and the momentum developed by CBC remains a permanent one. At this momentum of CBC the acceleration of the mill fan proceeds, so the size of this acceleration is determined by the dynamic moment $M_д = M_c - M_p(\omega_1)$. This continues until equalizing of the revolutions of incoming and outgoing shafts of the clutch. After their equalization the acceleration of motor is completed by “solid” clutch according to the natural curve of asynchronous motor until equaling of the momentum of the machine with the momentum of the motor.

After the design and constructing, the clutch was produced and mounted to mill fan № 5.

The clutch showed smooth, safe and noiseless acceleration of the whole system. The oscillography of the starting process (fig.3) shows the following:

Figure 3

1. The motor runs to its nominal velocity in 3-4 sec.
2. The mill fan begins its acceleration after the motor has reached its nominal revolutions. The acceleration is smooth, almost linear, a certain increase is noticed at the end of the process. That is explained with the increase of the momentum

developed by the CBC, during the decreasing of the relative velocity of slipping.

3. In the process of rotating the current of motor reaches a value of 800 A, for a period of time less then one second. After reaching the nominal velocity of the motor, the current drops to 75 – 80A. That value is determined by the outgoing momentum developed by CBC. It is selected in such a manner, as the motor is preserved to the maximum extent and the current supply throughout the starting process is not more than 1,1-1,2I_H. This momentum ensures high smoothness of rotation and safety of drive and, at the same time keeps away from heavy overloading.

4. The total time of starting process is about 140 seconds. It is thoroughly acceptable for this kind of machines and does not make trouble for the technological process.

The achieved results unambiguously present the good starting capabilities of the CBC. The exploitation properties of clutches of CBC type may be judged by the almost nine years of failure-free operation of clutches installed in 1995. Up to now another twenty four clutches are installed to the mill fans at the "Bobov dol" Thermal Power Plant. They complying with requirements of drive and up to now operate in a failure-free mode.

*TEPS – Thermo-Electric Power-Station

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APPLICATION OF CENTRIFUGAL BALL CLUTCH TO THE DRIVE OF A MILL FAN AT THE "BOBOV DOL" POWER PLANT

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ABSTRACT
The report discusses the results of replacement of ball-bearing clutches, used in the drives of mill fans of the combustion compartment of "Bobov dol" Thermal Power Plant with centrifugal ball clutches of 800 kW power. The disadvantages of the used ball-bearing clutched from a point of technical maintenance are indicated. Oscillograms are prepared, which indicate the low quality initial characteristics of the ball-bearing clutches. They are compared to the oscillograms of the transitional process, done with centrifugal ball clutches. The advantages of centrifugal ball clutches are apparent.

The centrifugal ball clutches are frictional mechanisms, which operation is fulfilled automatically by the centrifugal forces. Their kinematical connection and the frictional momentum is carried out by steel balls, freely placed in six operating chambers.

In their principle of operating, they do not practically differ from the various centrifugal clutches, in which the moment is transmitted by fluids, solid weights with permanent shape or graphitized powder.

In respect of initial characteristics they are similar to those of hydraulic clutches, as though they are capable to translate larger initial momentum at identical dimensions and weight, and ensure loss-free work for the established modes of operation. The hydraulic clutches, in the best case, operate with efficiency of 98-99, which in the case of transmitted power of 800 кW, means continuous loss of 8-16 кW. In comparison to the clutches with monolithic weights or powder filling, they differentiate by:

- constant initial parameters;
- high smoothness of the starting process;
- high stability upon heat supercharges.

In respect of maintenance characteristics, the centrifugal ball clutches are totally comparable to hydraulic clutches, as they practically have an equivalent resource.

In this aspect, they significantly better than other types of centrifugal ball clutches – with monolithic weights and with powder filling.

They achieve the good maintenance indexes, more than 10000 starts, owing to the use of high-quality steels during the last 10 years and active elements, operating in a proper oil medium. Their construction is not much more complicated than construction of the other types of centrifugal clutches and it is considerably more simplified than construction of hydraulic clutches.

The reasons for applying hydraulic ball clutches to the mill drives at "Bobov dol" Thermalo Power Plant were the problems, which were brought about by clutches of "Pulvis" type, used before 1994. They were the less safe element of the fan drive. Actually, mostly repairing and reconstruction of clutches occupied the maintenance department.

After fixing the problem, firstly an analytical check of the possibilities of the utilized asynchronous motor for running the machine without a starting clutch was done. The mill fan is an aggregate, which provides feeding of fuel mixture of coal dust and air into the furnace of the boiler. It provides simultaneously the filling-up of the necessary amount of air and coal, and in the same time grinds the coal to required size of the grain fragmentation. The operating body of the mill is a cylinder with diameter of 3,2 m and a weight about 10 t. Significant part of it is concentrated to the periphery of the cylinder, which defines an inertia momentum of about 14200 kgm^2. The static resistivity momentum for the starting period without a coal feeding is 5 kNm.

The accomplished calculation showed that the common time for initiating the spinning of the mill fan is 47,58. This is inadmissible high, since practically through the whole starting period current flow of $6\text{-}7I_н$ will flow, which may bring it out of order. Moreover, for the time of starting process, there is a significant overloading of the entire electricity supply system, and this may bring to worsening the electricity supply of all other consumers.

After proving the necessity of a starting clutch the issues related to the "Pulvis" type clutch that had been used before were investigated.

With the aim of specifying the problems during the exploitation of the powder clutches, an analysis of the existing clutches was made. It is based on the following:

1. Oscillography of the starting process with the existing drive, the inlet and outlets speeds are measured as well as current of the motor.
2. Analysis of the most frequent damages of the used clutches.
3. Investigation of the exploitation indexes of the centrifugal clutches with graphitized powder filling.

The practice of exploitation of clutches with graphitized powder filling showed:

- instability of initial characteristics, which are expressed by:
- change of the initial torque in the starting process;
- absence of repetition of characteristics for different starting processes.
- high sensitivity towards thermal overloading;
- fast wearing out of the active surfaces and friction junctions;
- granulation, densification and enlargement of the filling, bringing to obtaining of large forms and disbalance.
- adhesion of the filling to the active surfaces and blocking of the clutch.

Some of the reasons, bringing to the above phenomena, figure out to be the thermal-frictional phenomena in the area of friction. For clutches of discussed type and the particular case, the thermal flow through the active elements reaches from 2 to 2,5 MN/m^2. Considering the bad thermal conduction properties of the mentioned filling and the relatively large duration of starting process, the expectation of a superficial layer (the place of frictional contact), where temperature reaches considerable values, which leads to melting and enlarging of fragments, as well as to unpredictable chemical reactions is logical. In any case, it is inevitable to expect an intense wearing out, change of the grain composition, chemical changes, unexpected alterations of the friction coefficient and therefore of initial starting torque.

An effective solution for decreasing the thermal loading and respectively the undesired above described phenomena, is the reduction of time for starting process. The only way of reducing the time of starting process is increasing the torque, developed by the clutch M_c. This opportunity is restricted also by the capacity of the motor.

Figure 1

The oscillogram shown in fig.1 shows that the electrical current of the motor at the starting process is 2-2,5$I_н$, which suggests utilizing the maximum feasible, "the critical" for the asynchronous motor torque. This method ensures a relatively stable operation of the clutch, but has some disadvantages, as follows:

- considerable electrical current of the motor at the time of starting;
- danger of "overturning" of the motor while an eventual change of drive parameters takes place.

Exactly the same case of "overturning" of the motor is shown in the oscillogram in fig.2.

Figure 2

Through the figure is obvious, that because of the reasons connected to the above described processes in the friction contact, the momentum of the clutch increases, passes over the critical for the motor moment, as follows:

- abrupt decrease of the velocity of the motor;
- considerable increasing of motor current.

This occasion may be considered us a accidental one, because of its relation to the significant overloading of the overall kinematics of the drive of machine, as well as to a significant mechanical and current rush upon the motor and the current supply system.

The accomplished research and the negative experience in the maintenance of up-to-now used clutches of the "Pulvis" type, predetermine the application of centrifugal ball clutch (CBC). For this purpose a project for a proper CBC is accomplished. It was initiated by the following considerations:

1. Mill aggregate has relatively small static starting torque and there are no strict restrictions for the time of starting.
2. Motors are large and expensive aggregates, which permit only one switching per day.
3. Maximum care for the motor, by ensuring the minimum time for acceleration of the motor and accelerating of the system by the least possible current.

Starting process of drive accomplished by CBC and asynchronous motor is fulfilled as follows. When switched on, the motor begins to accelerate by a dynamic moment equal to the starting torque of the motor $M_{n.}$. Together with rotations of the motor, the rotor of the CBC also rotates together with the balls filling. The momentum of CBC increases by the square of initial angle velocity (ω_1). At definite ω_1, M_c equalizes to the static resisting moment of the machine and it begins to driven into motion. This time is called initial time for rotation of the machine - $t_н$. From this moment on, the motor accelerates simultaneously with the mill fan, by different values of acceleration defined by their dynamic moments. This continues until the clutch comes to the natural characteristic of the motor. The motor ceases its acceleration and the momentum developed by CBC remains a permanent one. At this momentum of CBC the acceleration of the mill fan proceeds, so the size of this acceleration is determined by the dynamic moment $M_д = M_c - M_p(\omega_1)$. This continues until equalizing of the revolutions of incoming and outgoing shafts of the clutch. After their equalization the acceleration of motor is completed by “solid” clutch according to the natural curve of asynchronous motor until equaling of the momentum of the machine with the momentum of the motor.

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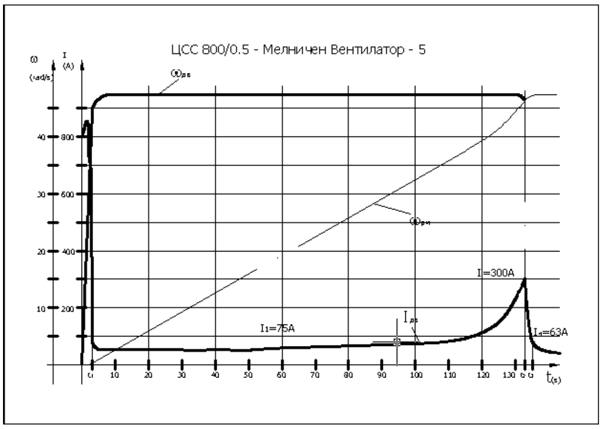

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