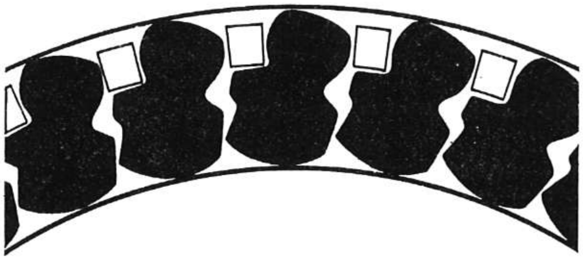

Fig. 27 PCE sprags overrunning

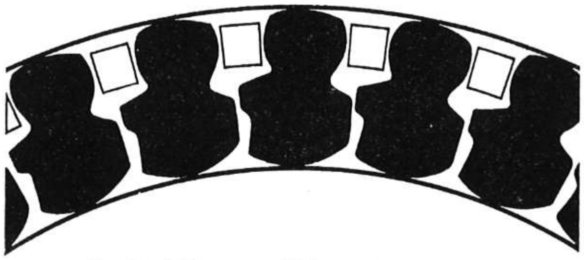

Fig. 28 PCE sprags driving with normal load

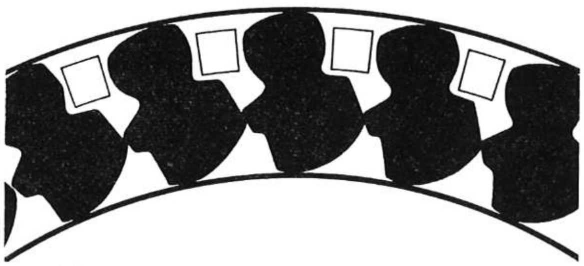

Fig. 29 PCE sprags driving with extreme overload

Regular Engagement Condition (Fig. 28)

The free action arrangement of sprags permits each one to individually position itself so that when load is applied every sprag is wedged in driving condition between races and thus carries its proportionate share of torque.

Overload Imposed Conditions (Fig. 29)

Under extreme overload conditions beyond the designed torque rating of the clutch, the new sprag configuration results in a positive sprag-to-sprag abutment with further sprag motion being prevented by the contact of the flank of one sprag against the flank of the next. This positive stop prevents sprag roll-over. This protects the clutch against damage.

Summary

To summarize, the six basic requirements of clutches for gas turbine drives are as follows:

1 Small size and weight
2 High in torque cpacity
3 Operation at high speeds
4 Withstand torsional vibration
5 Long life
6 Reliable service

Sprag type clutches, Fig. 30, meet these requirements through design and manufacturing achievements that include the use of special materials and processes to keep size small and performance high.

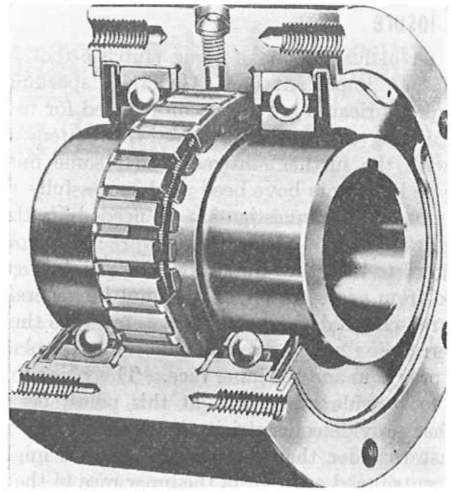

Fig. 30 A typical sprag-type over-running clutch

The use of sprag retainers, combined with proper gripping angle selection, proper material, and correct heat-treating contribute to maximum torque capacity output.

High rotational speeds are achieved in sprag-type clutches through the use of proper spring selection for sprag energization, proper material and heat-treat, and proper sprag design selection, i.e., location of the sprag center of gravity.

Torsional vibration is met through proper sprag selection, proper sprag energizing, and the use of sprag retainers.

The new PCE sprag design was created specifically to prevent rollover from excess overload torques resulting from torsional vibration and impact loads.

Long life and reliable service are inherent characteristics of sprag-type clutches achieved in part from proper PV factor selection, the use of high performance materials, and careful quality control in all stages of production, thorough testing, and constant design improvement.

DISCUSSION

M. G. Moore[1]

An objective paper on over-running clutches is particularly welcome to the gas turbine designer because over the years that the over-running clutch has evolved, he has been confronted with conflicting claims pertaining to shape of sprags, desirability of having a centering member or an energizing spring, or both or neither.

This is an excellent paper, and after reading it I can see how many of the troubles that we have had with sprag-type clutches could have been avoided if some of the features which have been described here were available.

Admittedly, a paper like this cannot cover the entire subject of clutch design, but it is unfortunate that the author was not able to discuss the lubrication of sprag clutches. It would be interesting to know the speed limitation at which lubrication must be changed from grease to oil, and also the speed limitation at which the hydrodynamic losses of the oil are so great that it modifies the action of the sprags. In this connection we have suspected that some of our problems with over-running clutches have been that the influence of the lubricating oil has somehow prevented the proper return of the sprags from their centrifugal throw-out position. The description of the improved sprags which prevent damage from overloading by pushing into each other is particularly worthwhile, and we would like to know if this sprag can also be used with the centrifugal throw-out feature or are the properties of the two incompatible?

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Author's Closure

The matter of lubrication of sprag clutches that Mr. Moore brings up is an important one. Generally speaking, extreme pressure-type lubricants are not recommended for use in sprag-type overrunning clutches. However, this statement must be qualified with the further statement that some mild extreme pressure-type lubricants have been used successfully with sprag-type clutches. More investigation is needed in this area to accurately define the limitations of the variables involved.

With regard to the speed limitation at which lubrication must be changed from grease to oil, this cannot be generalized upon. In most sprag-clutch designs, the sprags stay with the outer race during overrunning and the relative motion takes place between the inner sprag cam and the inner race. This being the case, it is necessary to provide lubrication at this point, besides at the bearings that provide concentricity between the two races.

One must consider that if grease is used, it might be permanently centrifuged away from the inner race to the outer race, leaving the area between the inner sprag cam and the inner race dry. Therefore, this clutch would need periodic lubrication to assure that it is properly lubricated. An additional factor to consider is the centrifuging of oil from the grease, and grease replenishment because of this. Oil is generally preferred to grease. Each application requires its own study. No general rule in terms of speed can be established.

Some sprag clutches have been designed where the sprags are held to the inner race and relative motion occurs at the point between the outer race sprag cam and the outer race. Here centrifuging of the oil from the grease and the frequency of grease replenishment must be considered.

With regard to the speed limitation at which the hydrodynamic losses of oil are so great that it modifies the action of the sprags, the only definite statement that can be made is as follows: To engage a sprag between two races, it is necessary that the spring energizing of the sprags be such as to overcome the lubricant oil film on the races and any centrifugal force effects that may exist on the sprag. Each design requires its own study and I would rather not generalize on this subject.

It is possible to incorporate the centrifugal throwout feature in the PCE sprags described in this paper. This can be done quite easily by locating the center of gravity in each sprag in a position similar to what is shown in Fig. 17 in this paper. If this is done, each sprag will in unison "throw out" of engagement with the inner race at a particular speed. This speed is determined by the amount of spring energizing, location of the center of gravity in the sprag, and the weight of the sprag.