CAM PROFILING

Engineering standards
Mechanical retardation cam profile
Servo characteristics
Mechanical Lysteresis
Overspeed cam profiling
Slow to fast braking conversion cam profiles

INTRODUCTION

In the modules on speed and distance controllers, we discussed the retardation and overspeed cams incorporated in the controller to limit the speed of the winder and to warn the Driver, or trip the winder when exceeding the overspeed limit. These cams are incorporated to trip the winder out before it reaches limits whereby it could cause injury to persons and damage the winder, shaft, conveyances and headgear.
The cams are profiled to perform these functions at predetermined speeds and distances, which may vary from winder to winder. You must realize that it is not just a matter of cutting a piece of plate, resembling a cam and fitting it. You must obtain certain information, as stipulated by regulations, to be able to profile, fit and adjust them correctly.
In this module we will discuss and illustrate different methods of cam profiling as follows:

Engineering standards

Man winding
Rock winding
Normal rates of retardation

Mechanical retardation cam profiles
Servo characteristics
Mechanical hysteresis
Overspeed cam profiling

Practical determination of the overspeed cam profile

Slow- to fast-braking conversion can profiles.

ENGINEERING STANDARDS

When profiling cams and installing them, engineering standards must always be adhered to. These standards are the rates of retardation and degree of protection.

Emergency rates of retardation (trip-out condition):

NOTE : The retardation obtained as the conveyance exceeds the theoretical retardation measured at the winder due to the stretch in the rope. The maximum recommended peak rates of retardation at the conveyance, as obtained during decelerometer tests (instrument in conveyance), must not exceed the following rates:

(1) Man cage = 0,5 g = 4,905 m/m²
(2) Rock skip = 0,7 g = 6,867 m/m²

0,5 g – Is acceptable for men but lower values are preferred.
0,7 g – Is very uncomfortable for men and results in injuries.
1, g – Will definitely cause injuries to men.
1,g – 9,82 m/s² which, as you will note, is very high (g = gravitational acceleration)

It must be noted that these are peak rates for retardation inside the conveyance due to the oscillation of the conveyance during a trip-out. These peak rates can be in the order of twice the mean rate of retardation (by "mean rate" we mean the maximum rate of retardation measured at the winder drum). A peak rate of retardation of 5 m/s² must not be exceeded for transporting men under any circumstances.
The mean rate of retardation is obtained when the actual retardation of the winder drums is measured. This is normally half the peak rate attained in the conveyance.

MAN WINDING

The following are the standards for man and rock winding or as per your mine standards:

Emergency mean rates of retardation must be between 2 and 2,5 m/s². If the rate of retardation is higher than 2,5 m/s² for men in the conveyance, the stopping condition will be excessive

If the winder trips at the start of retardation, bear the end of the wind, the winder is travelling at full speed and the brakes are on full-slow braking. It must be noted that the brake times will reduce progressively as the slow-braking cam follower ascends the cam. The rate of retardation must be such that the actual stopping distance is not greater than 60 – 70% of the total remaining distance.

It is not advisable to have an emergency rate of retardation of more than 2,5 m/s², as this will cause discomfort and possible injury to persons.

ROCK WINDING

Emergency mean rates for rock winding are allowed up to 3,5 m/s² or as per your mine standard.

NORMAL RATES OF RETARDATION

Normal rates of retardation at the end of the winding cycle must be in the region of 0,76 to 0,9 m/s² for rock winding, and 0,4 to 0,6 m/s² for man winding.
Recommended conveyance speed in the headgear is 1,2 to 1,5 m/s²

MECHANICAL RETARDATION CAM PROFILES

We will discuss the practical determination of the mechanical cam profile in this part of the module. The mechanical retardation cam controls the servo i.e. mechanical or electronic units. The rate of required retardation must first be determined, as stated in paragraph 11. Once the rate has been decided on, there are three areas that must be looked at, as no two winders respond the same to a signal obtained from a servo or electronic device.
The response lag time is the time it takes the winder to respond to the servo output. During this lag period the winder travels a certain distance. This distance must be considered when determining the total length and height of the retardation cam. Depending on the winder speed, this time could be 3 seconds at fullspeed and 1,5 seconds at lower speeds.

To determine this lag time, a per-recorder is used to simultaneously record the speed/time characteristics of the servo and tacho generator output signals, as shown in Fig. 1
This lag time is indicated by distance (A1 – A2) where "a1" servo time and "A2" tacho generator time. These times throughout the deceleration period are used to determine "S2", namely distance traveled during response lag time.
A table can now be drawn up, giving the following data:
V= the tacho generator velocity. These velocities should be taken in a series of steps from full-speed down to creep-speed, from Fig. 1. Obviously the more steps used, the more accurate will be the cam profile.

S1 = predetermined theoretical stopping distance.

$S1 = \frac{V^2}{2A}$ where "a" is the predetermined rate on deceleration.

S2 = vt
S2 = (U – V)t. This is the response lag distance, "B" being the servo response and "t" being the response lag time as shown in Fig. 1.

St = the total distance to standstill = S1 + S2. This figure must be converted to drum turns in order to plot the cam profile.

SERVO CHARACTERISTICS

The table shown in Fig. 2 is a typical example for a winder requiring a normal rate of 0,98 m/s² and a drum diameter of 4 m.

The determine servo characteristics, a wedge, as shown in Fig. 3.

The circumferential length of this wedge should be as long as possible to ensure accuracy of the readings taken, and could equal the movement of the mechanical cam supporting dial, during normal full-speed travel.

It must be remembered that during the full-speed period, the servo unlatching gear is not actuated. For this test it is necessary to ensure that the unlatching solenoid stays de-energized to hold the servo gear in automatic engagement to ensure automatic retardation.
The method is to allow the winder to accelerate to full-speed and, as the cam follower goes onto the wedge, the speed is gradually reduced (automatically). Every time the winder attains a speed as specified in the table shown in Fig. 3, a mark is made on the wedge at the point of contact.
In this manner the height of the cam, necessary to give the required speed, is determined. The cam profile can now be plotted, using the information obtained, as shown in Fig.4.

MECHANICAL HYSTERESIS

You will now see that when the cam profile shown in Fig. 3 is used in practice, the winder will only begin to retard some distance after then cam follower has begun to rise.
This is due mechanical hysteresis, which is due to the take-up in linkages.
In order to overcome this problem, the point on the cam at which the winder starts to retard is taken, as the height of the cam required to overcome hysteresis. This height is now used in the profile at the start of the cam. This is shown in Fig. 5.
The mechanical retardation cam can now be finally plotted and cut from a suitable metal and tested.

OVERSPEED CAM PROFILING

Overspeed protection must be set to alarm at 10% above full-speed and trip at 15% above full-speed. The cams must be profiled to alarm and trip at these values if, during retardation at the end of the wind, the speed exceeds the determined speeds beyond these margins.
To overspeed trip margin can be reduced to 10% or less in the case of closed loop control where the desired speed can be accurately maintained.
The speed at which the controller will alarm and trip can be determined for any winder by drawing the normal retardation speed distance curve together with a 15% overspeed curve, showing turns or distance against velocity, using the following formula:

Distance from end of wind = $U^2 - V^2$ (rate of retardation must be known)

Where U = initial velocity
V = Creep velocity
A = Normal deceleration
Winder response lag distance = ut (brake delay)
Where U = initial velocity
T = time between trip and actual retardation

Winder Alarm Speed	=	1,1 x u
Winder Trip Speed	=	1,15 x U

This is illustrated in Fig. 6.

The graph in Fig. 6 applies to winder with a crum diameter of 4,0 m, travelling at 15 m/s and having a normal retardation of 0,76 m/s², a creep speed of 0,5 m/s and a response lag of 0,8 seconds.
This information can be obtained form Fig. 7 and the table, Fig. 8 can be drawn up.

PRACTICAL DETERMINATION OF THE OVERSPEED CAM PROFILE

These cams are profiled to shadow the normal rate of retardation initiated by the mechanical cam. The following wedge, as shown in fig. 9 is required:
To employ this method, both conveyances must be taken to midshaft. The Driver now drives the winder away from the mechanical cams at the speeds specified in the table shown in Fig. 2.
With the winder running at the speed required, the wedge is inserted between the dial and cam roller, until the overspeed gap complies with the laid-down standard. A mark is now made on

the wedge at the point of contact with the cam follower, and this height is the required height of the cam for this constant speed.
This method applies to all speeds referred to in the table. With this information the cam profile can be plotted, and a suitable brass cam can be profiled.
Final profiling can be done by filing at certain spots on the cam to give a perfect operation.

SLOW- TO FAST-BRAKING CONVERSION CAM PROFILES

The gradual conversion from slow- to fast braking must commence as soon as the retardation period is initiated.
The full slow-braking time at the start of retardation must be 8,5 sec. And will then gradually be reduced to 1,5 sec. At the bank or creep speed (1,5 seconds will be full fast braking), or as per your mine standards.
A fast-braking curve can be drawn from Fig. 7 and a table as illustrated in Fig. 10 can be drawn up.
To practically determine the profiles of fast braking cams, it is essential to first determine the brake times as in Fig. 10. By knowing these times, the following wedge, as shown in Fig. 11, is used to determine the braking characteristics.
The method to obtain this profile is to position the conveyance at its landing mark, bank or tip. The electrical fast-braking solenoid must be rendered inoperative. Both existing brake cams must be removed, lifting only one brake.
The wedge is inserted until the desired brake time is obtained. Mark the wedge at this point. These brake times must be taken at 90% of the full brake stroke. This procedure is repeated until all the required braking times and corresponding cam heights are obtained. Using this information, you are able to plot a cam profile.
In order to ensure that the cam profile is correct, the winder must now be dynamically tested. All the work done must be entered in the Machinery Record Book.